

JOURNEY TO THE GILF KEBIR AND UWEINAT, SOUTHWEST EGYPT, 1978

F. EL-BAZ, L. BOULOS, C. BREED, A. DARDIR, H. DOWIDAR,
H. EL-ETR, N. EMBABI, M. GROLIER, V. HAYNES, M. IBRAHIM,
B. ISSAWI, T. MAXWELL, J. McCAULEY, W. McHUGH,
A. MOUSTAFA AND M. YOUSIF

A multidisciplinary group of sixteen scientists visited the southwestern desert of Egypt to verify interpretations of Earth-orbital photographs. The two-week journey started at Kharga Oasis and proceeded south-southwest to Bir Tarfawi, west to the Gilf Kebir plateau, and then to Gebel Uweinat, on the border between Egypt, Libya and Sudan. Members of the expedition discovered sites of prehistoric human settlements ranging in age from approximately 3000 to perhaps 200 000 years ago. The condition of plant remains in the Gilf Kebir area indicated a prolonged period of dryness of up to 20 years. However, a cloud mass observed on a weather satellite image in mid-December 1977 may have provided rainwater for numerous plants in the Uweinat region. The geological findings, including prospects for economic mineral deposits, were valuable. Fluvial and aeolian erosional patterns were studied at Gilf Kebir and also at Uweinat. Many of the desert landforms display similarities to those recently identified on Mars. Correlations of features in the Egyptian desert with those on the Martian surface will help us to a better understanding of surface processes on both Earth and Mars.

I. NARRATIVE OF THE JOURNEY

FAROUK EL-BAZ

THE MAIN purpose of this two-week expedition was to verify in the field interpretations of tonal variations and surface patterns observed on Earth-orbital photographs. On Gemini and Apollo-Soyuz photographs and LANDSAT images, the Gilf Kebir plateau displays many interesting fluvial landforms (Plate V), which must have been formed during wetter periods in the past. Furthermore, patterns of light- and dark-coloured wind-formed features in the Uweinat region (Plate V) appear very similar to those shown on Mariner and Viking photographs of Mars (El-Baz, 1977: 77-80). The investigation of these features was included in a research project conducted jointly by Cairo's Ain Shams University and the Smithsonian Institution. In addition, as scientific adviser to President Anwar Sadat of Egypt, I needed to complete the investigation of the development potential of the Western Desert by the reconnaissance of its southwestern part. In preparing this report on the expedition, we follow the scheme of the paper that reported results of a similar expedition made 40 years ago (Bagnold *et al.*, 1939).

This part of the Libyan Desert is a desolate wasteland. Gebel Uweinat is 670 km as the crow flies from Kharga Oasis (Fig. 1), the nearest point where supplies may be purchased. Dependable desert vehicles are therefore essential for

→ Dr Farouk El-Baz is Research Director, Center for Earth and Planetary Studies at the National Air and Space Museum of the Smithsonian Institution.

We are indebted to Dr El-Baz for providing financial help from his research fund for the production of the plates which illustrate this paper.—*Editor.*

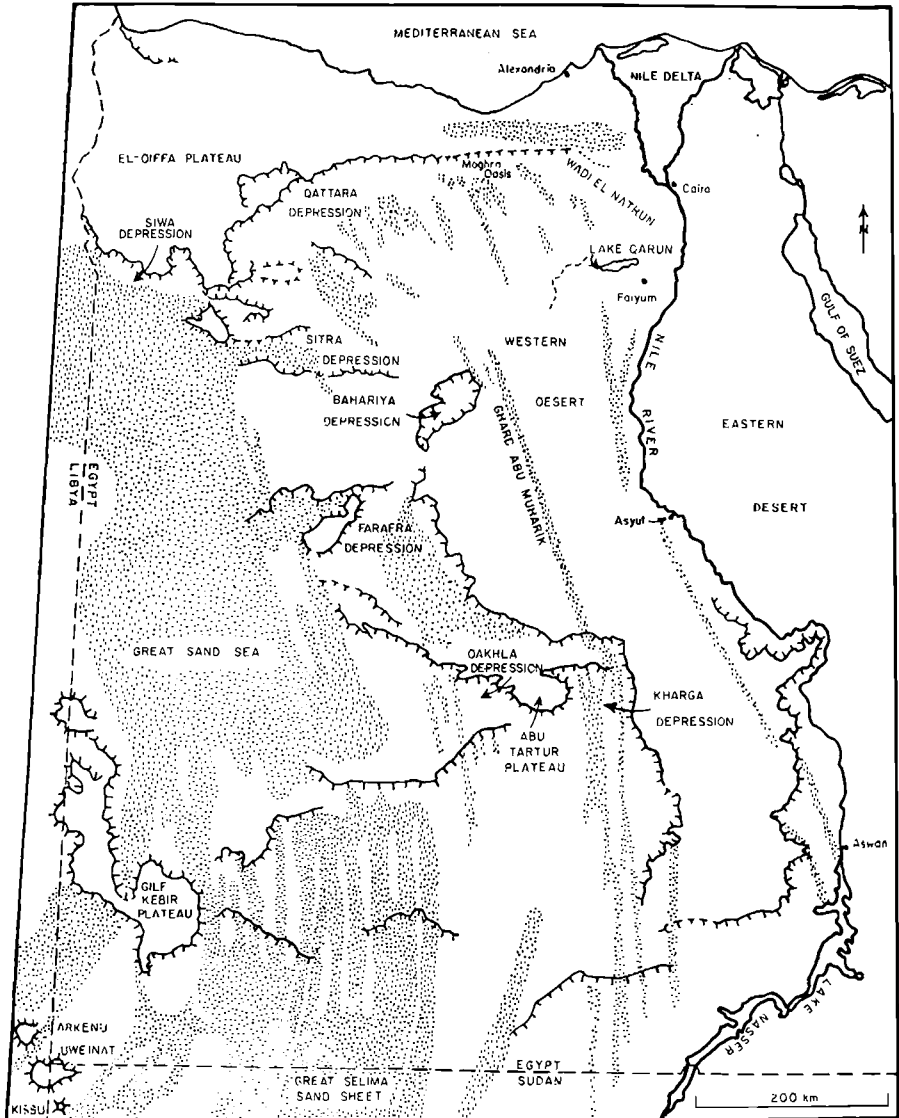


Fig. 1. Map of Egypt west of the Nile showing major oases and scarp and the distribution of dune fields and other sand deposits (modified from Gifford et al., 1979)

the transport of personnel, water, petrol, food and camp equipment, and these were provided by the Geological Survey of Egypt. The convoy consisted of six Soviet Gaz jeeps, two 4.5-ton tanker trucks for water and petrol, and a 12-ton lorry loaded with food, oil barrels and camp equipment. In addition we used two Volkswagen Type-181 vehicles from research projects sponsored by the National Geographic Society. This fleet of vehicles was necessary because of the considerable number of scientists involved in the interdisciplinary expedition. The scientific group consisted of seven American and nine Egyptian specialists in the fields of geology, geography, Quaternary geology, archaeology and botany.

Those from America were: myself; Carol Breed, Maurice Grolier and Jack McCauley, from the US Geological Survey; Vance Haynes, from the University of Arizona; Ted Maxwell, from the Smithsonian Institution; and William McHugh, from the University of Nebraska and GAI Consultants, Inc. The Egyptian group comprised: Bahay Issawi, Atef Dardir, and Mohamed Ibrahim, of the Geological Survey of Egypt; Hassan El-Etr, Nabil Embabi, Hamed Dowidar, Adel Moustafa, and Mahmoud Yousif, from Ain Shams University; and Loutfy Boulos, from the National Research Centre. In addition Hatim Farid, science editor of Cairo's *October Magazine*, joined the party. Sixteen employees of the Geological Survey of Egypt supported the expedition as drivers, mechanics, cooks, etc., making a total of 33 people in all.

Our expedition benefited greatly from the knowledge gained by 13 previous journeys to Uweinat from various localities in Egypt. We were especially fortunate to have Bahay Issawi, who was the last to map the region (in 1971) as our field guide. By the use of maps, conventional navigation, and Earth-orbital photographs, we endeavoured to establish accurately our locations throughout the trip. In addition, we performed an experiment of navigation by NASA satellite tracking. On one of the Volkswagen vehicles, we carried a transmitter that sent signals to the Nimbus 6 satellite as often as three times daily (Plate VIa). The signals were retransmitted by the satellite to the Goddard Space Flight Center at Greenbelt, Maryland, where the location of the transmitter was calculated and plotted.

On the morning of 24 September 1978, the American contingent assembled in Cairo, and proceeded to the offices of the Geological Survey of Egypt to meet with our Egyptian colleagues. The group spent much of the day studying maps and photographs of the route and sites to be visited. The following paragraphs summarize the activities of subsequent days in the desert.

25 September: We left Cairo at 9.15 a.m. by air and, during the flight to Kharga, we observed and photographed many interesting features, particularly the danger to fertile land from encroaching dunes (El-Baz, 1978) which is very evident between Faiyum and Asyut (Plate VIb). At Kharga we met the jeeps which had arrived a day earlier, and along the road caught our first glimpse of the Kharga yardangs, or what Bagnold (1939) and other British explorers called 'mud lions': wind-sculpted lacustrine deposits with blunt fronts and aerodynamically-shaped bodies. While at Kharga, we visited the Hebis Temple, northeast of the town (Plate VIc).

26 September: Leaving Kharga, we drove west to Dakhla along the asphalt road built in 1963 (avoiding various barchan dunes marching across it), and at the 60-km mark turned south-southwest into the open desert, aiming for Tarfawi West, a locality east of Bir Sahara (Fig. 2). Scattered conical and pyramidal hills reminded me of an earlier speculation on whether the ancient Egyptian engineers designed the pyramids after these wind-resistant forms. About 70 km from the asphalt road, we stopped to study a large petrified tree, noting the sand grains deeply lodged in grooves in its surface—an early instance of the power of the sand-moving winds (Plate VIId).

27 September: Proceeding towards Bir Tarfawi, we visited what Vance Haynes referred to as 'Site 1', where a patch of oxidized peat outcropped along an ancient dry lake-shore (Plate VIIa). The determined age of gastropods and snails embedded in the dry lake bed, and the abundant associated artefacts in these strata, indicated that this site supported human settlements at least 30 000 years ago. At Bir Tarfawi the water at the well dug by the General Petroleum

Company of Egypt was reached at a depth of 2 m (Plate VIIb). In this area, narrow and closely-spaced tyre tracks, identified by our Egyptian colleagues as those made by the vehicles used by Prince Kemal el Din Hussein in 1925, were still visible in the moderately coarse lag gravel, although not in fine sand. In the Bir Tarfawi sand sheets, coarse grains overlie finer particles. The sand colour was closest to A17 on the Apollo–Soyuz colour wheel (equivalent to Munsell colour 7.5YR 6/6; see El-Baz, 1977: 49–55). Southwest of camp, we sampled a barchan dune that appeared redder than the surface lag, and here we found implements estimated by both Haynes and McHugh to be about 8000 years old. A few inches in the soil below, Vance Haynes found pieces of ostrich eggshell. That evening and for a few nights we feasted on ducks brought from Kharga, which provided a pleasant change from the more usual desert fare.

28 September: From the Tarfawi West camp, we headed east to Qaret el Maiyit (Arabic for ‘hill of the dead’, because of a human skeleton discovered there). Here the exposed granitic rock displayed a long down-wind tail of dark material surrounded by light-coloured sand on either side. Weathered orthoclase from intervening pegmatite veins in the granite gave this tail a reddish tone. Here again, the effects of wind erosion were evident in the abundance of vortex pits on exposed rock surfaces. Near Qaret el Maiyit were large sandstone and granitic blocks arranged in crude circles which we assumed to mark an ancient human settlement (Plate VIIc). Continuing east, we crossed the old Darb el Arba’in caravan route, which was nearly 20 km wide where we intersected it, and nearby we examined the mineralized products (mostly silica and iron) of what may once have been a hot spring or geyser. A Geiger counter check for radioactive minerals was negative. Driving on, we were surprised by the sight of a camel caravan emerging from the distant mirage about 10 km southwest of Bir Kiseiba. The five camel drivers were just as astonished to see us. Their 60 camels were loaded with *atrun* (Plate VIIIa) which they had carried from Ma’atin in the Sudan, and they told us that this evaporite, mostly trona (sodium sesquicarbonate), was used to tenderize chewing tobacco packed at Esna on the Nile. Continuing south towards El Shab, we encountered at Bir Kurayim a ‘ghost settlement’ established there by the Egyptian Desert Development Organization in 1964. Badly placed along shifting sands, the settlement contained buildings of galvanized metal and glass now half filled with sand, structures ill-adapted to the desert (Plate VIIIb).

29 September: Turning now towards the Gilf Kebir, we first drove north for 32 km to a block of conglomerate protruding from the featureless plain and erected on it a 2 m high cairn to guide other drivers (Plate VIIIc). In this section, the heavy vehicles stuck frequently in patches of soft sand, and to free them we used metal channels similar to the sand tracks used by Bagnold and later by the British Army during World War II. Close to Black Hill, one of the major landmarks along our route, we noticed that the tracks made by the Bahay Issawi expedition seven years earlier were now covered by a barchan dune. We camped that night near the hill.

30 September: With the morning light we studied a field of small yardangs near our camp, several being 2 m high and exhibiting a straight windward face (Plate IXa). At a distance of 244 km from Tarfawi West, the car tyres started to expose very red soil a few centimetres below the surface sand or lag deposit, and here and there we encountered iron and manganese concentrations in the form of strata or nodular masses. These again exhibited vortex pits and hollows drilled by the wind. As we approached the southeastern scarps of the Gilf Kebir, we headed towards Bagnold’s 1938 camp and observed that his tracks around the end of the

1-km longitudinal dune were now covered by that dune's extension. The western side of the dune had also partly submerged the 1938 camp site (Plate IXb), while wooden boxes at the site showed the effects of wind erosion: a piece of wood 13 cm thick on the nailed side was only 2 mm thick at the exposed surface. After sampling the dune sand and remembering the pioneers who erected the camp, we took photographs of each other at this historic site.

1 October: From a base camp established at the entrance to Wadi Wassa near the southeast tip of the Gilf Kebir (Fig. 2; Plate XVIIa) we headed northward to Wadi Mashi. To navigate we used enlargements of LANDSAT and Apollo-Soyuz photographs and the map drawn by Ronald F. Peel in 1938 (pers. comm.). We were all very impressed by the accuracy of that map. On the top of the Gilf Kebir, William McHugh discovered a new archaeological site where implements were strewn near core blocks of quartzite from which they had been chipped (Plate IXc). Geologists studied the fluvial landforms and the erosional effects of wind action as the archaeologists studied the site and excavated to 30 cm below the surface. At Wadi Mashi we noticed a smooth dome of basalt; the columnar rock was dense and fine-grained inside, but pitted by wind action on outer surfaces. Back at camp it was obvious that more time was needed for further investigation of wadis of the Gilf Kebir, and we agreed to divide the expedition into two groups. The larger, of 21 people, stayed at the Gilf to investigate Wadis Bakht and Ard el Akhdar, while ten scientists and two drivers proceeded to Uweinat.

2 October: The Uweinat party headed west within Wadi Wassa, noting that the floor of this wadi showed evidence of an alternation of wet and dry cycles. In places, four generations of mud had accumulated in brief wet periods, but from the condition of the scanty vegetation, Loutfy Boulos, the team's botanist, estimated that it had not rained for approximately 20 years. Giant sand ripples, 10–30 m long, and with truncated flat tops, covered the wadi floor. We left the Gilf Kebir through a pass 10 km north of Wadi Firaq, where kaolinized material was exposed at the base of the cliffs. Running south towards the Peter and Paul Hills, we suddenly found ourselves traversing dark volcanic rocks (basalts and trachytes), with aprons of alluvium and colluvium. Maars (explosion craters) appeared, with quartzitic layers standing on edge and marked crater rims, but no volcanic rock exposed within (Plate Xa). By nightfall we had arrived at the north entrance of a small unnamed valley just west of Karkur Talh in the Uweinat complex, 243 km from the Gilf Kebir camp site.

Meanwhile the Gilf Kebir party spent this day at Wadi Bakht (Plate XVIIa). McHugh, Embabi and Maxwell began work at Oliver Myers's neolithic site in upper Wadi Bakht, while McCauley and Breed spent the morning examining the relative effects of wind and water erosion in the lower part of the wadi. Pebbles and cobbles of friable sandstone on the floodplain showed abundant evidence of wind erosion in the form of delicate, etched projections along bedding planes aligned with the wind. In the afternoon, studies were made in the upper wadi of the archaeological site; the relationships of falling and rising dunes, yardangs and ripples; and the structure of a very large granule ripple, together with surveys of the local topography.

3 October: Exploring the northern slopes of Gebel Uweinat, we were again much impressed by the evidences of wind erosion. The predominantly north wind had sculptured the rock into eerie shapes resembling frozen dinosaurs and other giant animals. Exposed rock surfaces were all pitted, and where sand grains are trapped in these pits, they swirl round in wind gusts, enlarging the cavities.

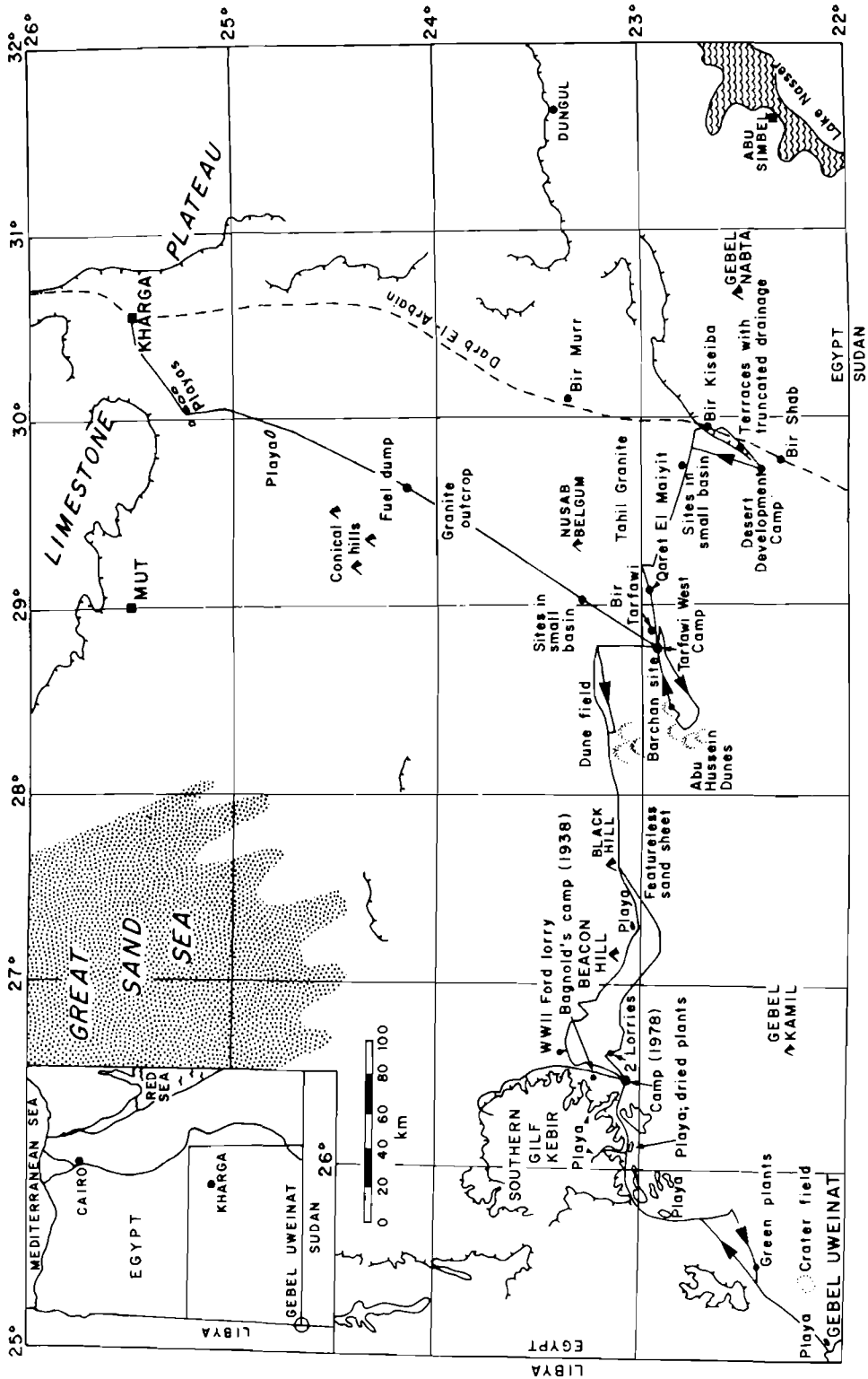


Fig. 2. Route map of the 1978 journey to the Gifl Kebir and Uweinat, southwestern Egypt

Pits, often aligned in rows, graded into fluted surfaces. As Maurice Grolier and I studied these effects, petrologists sampled the Uweinat granites, structural geologists examined the fracture patterns, Loutfy Boulou collected plants, and Vance Haynes photographed rock engravings. Haynes also found a camel saddle perched on an *Acacia* tree. We later drove south into Sudan and examined the dark apron about Ras el Abd (Arabic for 'head of the slave'). This apron, like others studied on Earth-orbital photographs, was much darker than the surrounding materials. Around the hill we noted a well-preserved alluvial fan formed by a rainfall in the not too distant past.

Meanwhile at the Gilf Kebir, Maxwell completed the topographic profiles while McHugh and others continued excavation and collection at the archaeological site in Wadi Bakht. McCauley, Embabi and Breed drove westward through Wadi Wassa to the route marked by Bagnold's petrol cans, and turned south, re-marking some very old tracks. Some 7.4 km south, they built a boulder pile marked with the name and date of the expedition, and a request to future explorers to note the condition of their tracks relative to the much older tracks in terms of wind erosion and gulying. A little further south they collected pitted quartzite from the top of a conical hill.

4 October: Before loading the cars at sunrise at Uweinat, I examined the two *Acacia* trees at the northwestern ridge of Karkur Talh. The stem of one had been partly removed by termites (Plate Xb). On the other, the leaves on the top two branches appeared much drier than those on lower ones, suggesting a fall in the level of the watertable and some consequent water starvation in those upper parts of the tree needing a higher osmotic pressure for water to reach them. On quartzitic surfaces we noticed numerous *magals*, natural cavities in this impervious rock which preserve collected rainwater, sometimes for a whole season. Leaving Uweinat for the Gilf Kebir, we sampled an exposure of grey granite and conglomerate around it, a natural setting for radioactive element concentration. The last objective of the day before rejoining the Gilf party was the broad sand streak just east of Gebel Babein, samples of which I required for comparison with samples from other parts of the Great Sand Sea collected earlier, to study sand-reddening with time (El-Baz, 1978). The sand had here accumulated into a giant whaleback dune with gentle slopes and no slip faces.

On this day, the entire Gilf party was occupied in Wadi Ard el Akhdar (Plate XVIIa), where McHugh excavated sites while Maxwell conducted topographic surveys. McCauley, Breed and Embabi investigated the relationships of a fanglomerate wedge to the eroded lake beds at the narrow constricted neck of the wadi, now occupied by the so-called 'blocking dune'. Later they were joined by Vance Haynes and Loutfy Boulou, who had returned from Uweinat.

5 October: At the Gilf Kebir, camp was broken and we headed back eastward towards Bir Tarfawi, passing relics of World War II on the way: a dismantled British army truck, with pieces strewn in the sand. The engine hood had created a micro wind-flow producing an 8-m sand tail in its lee. Making a stop to cool the jeep engines, we found ourselves on a ferruginous sandstone layer in which hematite was exposed as a thinly-laminated red layer of unknown depth (we dug to over 40 cm without reaching its base). This red layer contained dark brownish-black nodules of iron and manganese oxides. We drove for 11 km over this iron ore, which we estimated to lie some 150 km west of Bir Tarfawi. Collecting petrol at Bir Tarfawi, we turned north for Kharga.

6 October: On arrival at Kharga around midday, a group assembled to study the barchan dunes and their invasion of roads, telephone lines, cultivated fields, houses, wells and even whole settlements. It was apparent that the great efforts of the local villagers to combat their advance, by planting *Tamarix* and *Acacia* trees, for example, slowed down but did not halt the advance of the dunes. At an evening meeting with local geologists, hydrologists, engineers and agricultural experts, we discussed the findings of the expedition, and the pros and cons of large-scale agricultural development in the New Valley province. Underground water supplies appear still to be plentiful, but the irrigation schemes are wasteful of the water. Available data did not allow a resolution of the much argued question of whether or not the underground water supply is being replenished from the south and west, but the preponderance of igneous and volcanic intrusions at the southern and southwestern borders of the Western Desert indicates, if inconclusively, that the water supply is not now being effectively replenished.

7 October: The scientists again split into two groups, one heading for the plateau north of the Kharga Depression, the other south to Baris Oasis (Fig. 9). On the plateau, further wind-sculptured forms were studied, for here the wind had carved yardangs in extremely hard crystalline limestone. Below, within the depression, we observed the alignments of mounds marking ancient springs set along north-south trending faults. Fault boundaries are marked by *Tamarix* trees and growths of reeds in the salty soil, while the remains of irrigation canals built in Roman times and lined with palm-tree trunks were clearly apparent. Evidence of active soil erosion by wind was pronounced everywhere. At Ain el Shurafa, Vance Haynes estimated that nearly 24 m of soil had been removed by the wind during the last 3000 years, a mean rate of 8 mm per annum, and the resultant sand accumulations were ubiquitous. Little remains, for example, of Dakhkhin, across from Ain Gaga, which was a major oasis when photographed by Beadnell in 1909. After studying the stratigraphy of the scarps around the Kharga Depression, we visited the 'Bagawat' complex, a desert market place with numerous facilities built by the Egyptian architect Hassan Fathy (Plate Xc); in the evening a seminar was held to discuss the findings of the expedition and their implications.

8 October: The morning was spent in sorting samples and separating those to be left at Kharga, for one of the results of the expedition was to interest the local unit of the Geological Survey in keeping samples from all expeditions at the newly-established Kharga Museum. On the afternoon flight back to Cairo, the lighting was perfect for a view of the enormous field of yardangs north of Kharga, possibly the largest such field in the world. We reached Cairo at sunset, ending a most interesting and highly successful journey.

Acknowledgements

Numerous organizations and individuals contributed significantly to the success of this expedition. We should like to acknowledge the financial support of the following institutions: Ain Shams University, Cairo, for providing food, photomosaics and some camping needs; the Egyptian Air Force, for providing an aircraft to transport the scientists from Cairo to Kharga and back; the Geological Survey of Egypt, for making available the necessary vehicles, petrol, support personnel and camp equipment; Goddard Space Flight Center, for providing the transmitting apparatus and the satellite tracking data; and the New Valley Government, for providing the space for lodging, meals, and lectures and

seminars at Kharga. International travel was also financially assisted by several organizations including: the National Air and Space Museum (for T. Maxwell); the University of Arizona (for V. Haynes); the National Science Foundation (for F. El-Baz); the Smithsonian Foreign Currency Program (for C. Breed and J. McCauley); and the US Geological Survey (for M. Grolier). The NASA Planetology Program Office covered salary costs for C. Breed and J. McCauley during the expedition.

References

- Bagnold, R. A. *et al.* 1939 An expedition to the Gilf Kebir and 'Uweinat, 1938. *Geogr J.* **93**, 4: 281-313
- El-Baz, Farouk 1977 *Astronaut Observations From the Apollo-Soyuz Mission*. Smithsonian Studies in Air and Space, Number 1. Washington, DC: Smithsonian Institution Press.
- El-Baz, Farouk 1978 The meaning of desert color in Earth-orbital photographs. *Photogrammetric Eng. and Remote Sensing* **44**, 1: 69-75.
- Gifford, A. W., Warner, D. M. and El-Baz, F. 1979 Orbital observations of sand distribution in the Western Desert of Egypt. NASA SP-412, 219-36.

II. QUATERNARY GEOLOGY AND ARCHAEOLOGICAL OBSERVATIONS

VANCE HAYNES

IN RECENT years, new and important Palaeolithic and Neolithic discoveries have been made in the southern part of the Western Desert of Egypt. Of particular significance are the sites at Tarfawi West, Bir Tarfawi, Gebel Nabta, and in Wadi Bakht in the Gilf Kebir (Myers, 1939; Wendorf *et al.*, 1976, 1977). New discoveries made on this trip (see following section by McHugh) can be interpreted in the light of the previous work and will add valuable data about this little-known area. While in the field, archaeological sites and playa deposits were recorded in our dead reckoning log along with any observations pertinent to Quaternary geology. A number of sites and deposits were examined in more detail, as time permitted.

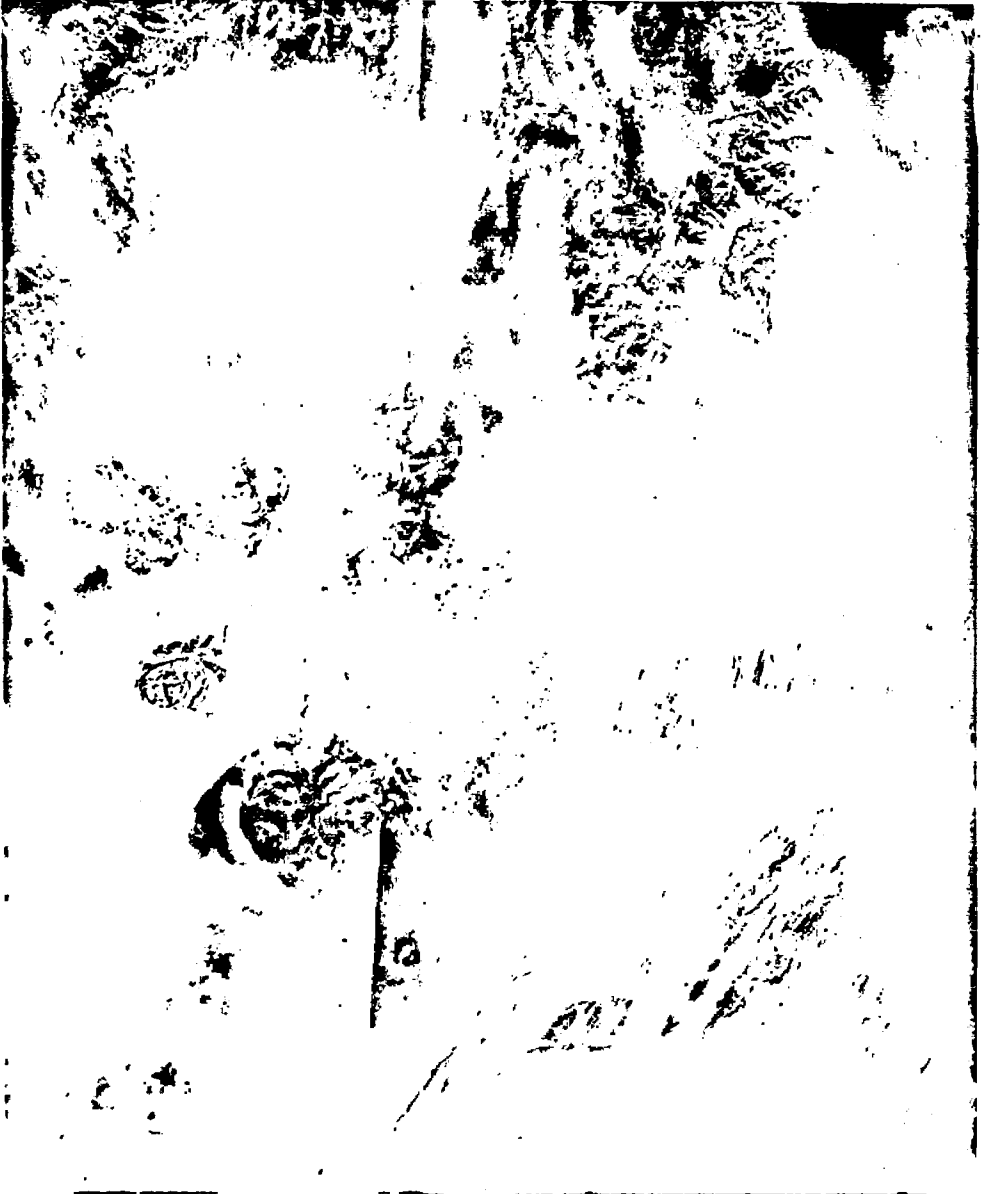
Bir Tarfawi region

Playa deposits were first encountered along the Kharga-Dakhla road between 50 and 60 km from Kharga. These occur in deflational basins around the base of the Abu Tartur plateau. Larger playas to the west, in an area known as El Zayat, are being considered for agricultural development with groundwater irrigation. A small playa was recorded along our route 40 km south-southwest of the Kharga-Dakhla road, and 130 km further to the southwest is the 'dike area' where Schild and Wendorf (1977) excavated Mousterian artefacts associated with ancient dune deposits. The archaeology and geochronology of Bir Sahara and Bir Tarfawi have been reported by Wendorf and others (1976; 1977).

A small basin about 50 km northeast of Bir Tarfawi contains several concentrations of Neolithic hearth stones and artefacts scattered over the floor of

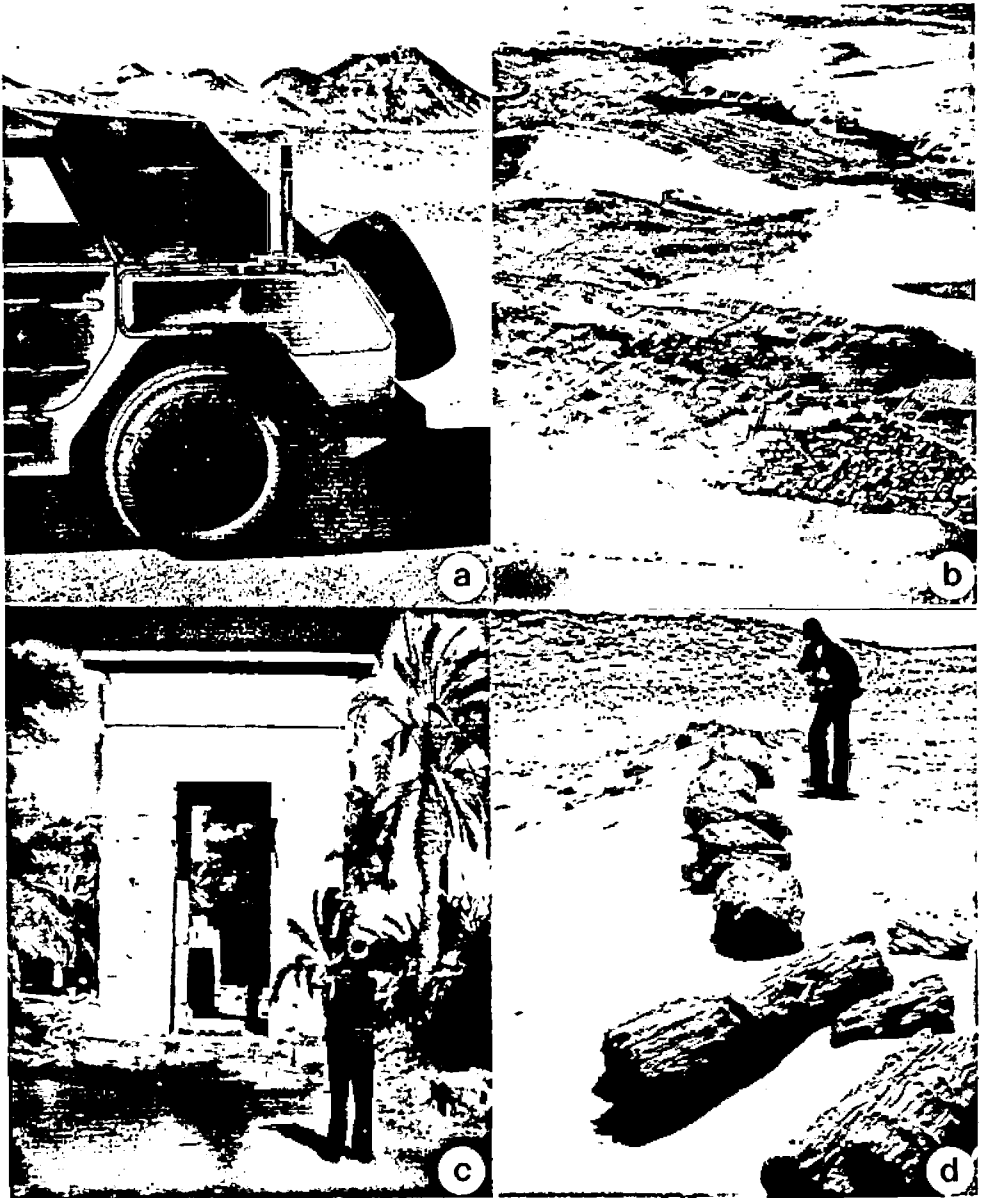
→Professor Vance Haynes teaches in the Departments of Geosciences and Anthropology of the University of Arizona, Tucson, and has devoted eight field seasons to study in the Western Desert of Egypt.

PLATE V



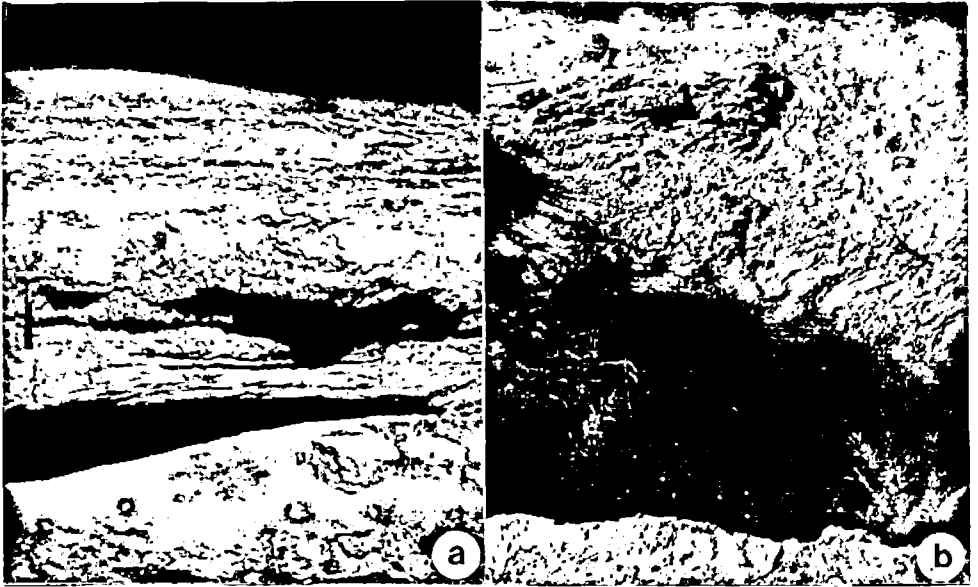
The southern Gilf Kebir, upper right, and Gebel Uweinat, lower left of centre, as seen in a four-image mosaic from LANDSAT satellite (see also Plate XVII(a))

PLATE VI



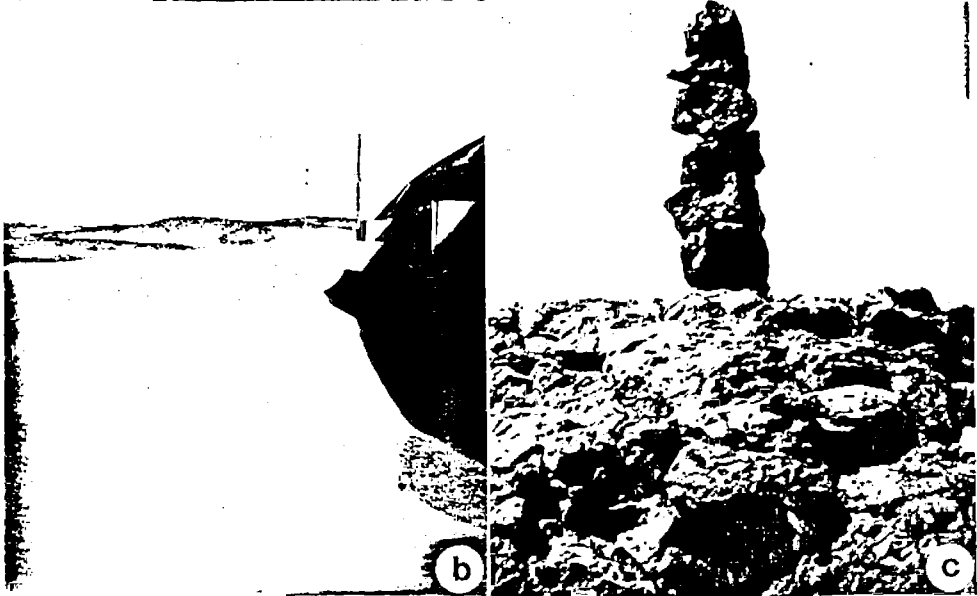
(a) Transmitter antenna on the rear bumper of a desert vehicle; (b) dunes encroaching on fertile land west of the Nile; (c) entrance gate to Hebis Temple at Kharga; (d) petrified tree

PLATE VII



(a) Site of oxidized peat near Bir Tarfawi; (b) water hole at Bir Tarfawi; (c) blocks marking prehistoric 'house' near Qaret el Maiyit

PLATE VIII



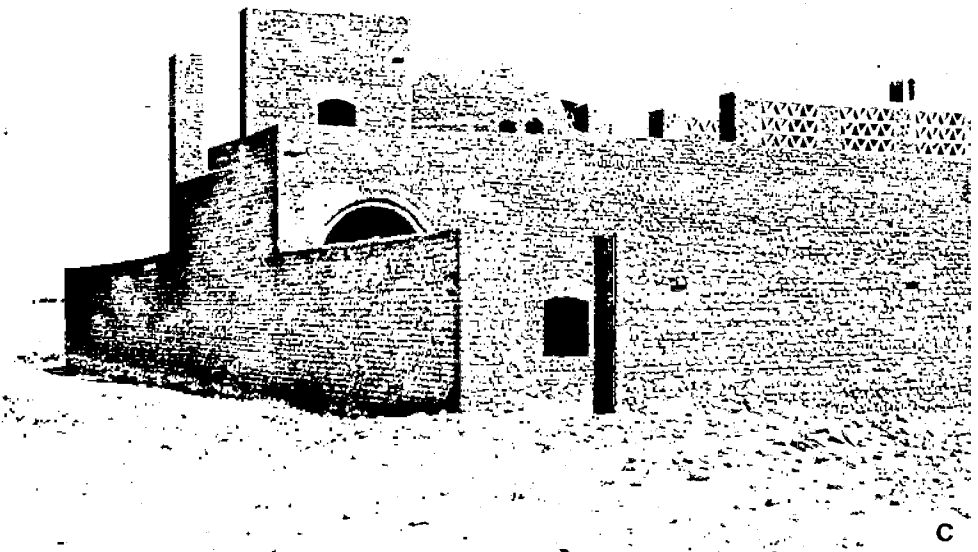
(a) Caravan of irona-laden camels; (b) dune at the side of a building at Bir Kurayim; (c) cairn erected on top of the 'yamama conglomerate' rock

PLATE IX

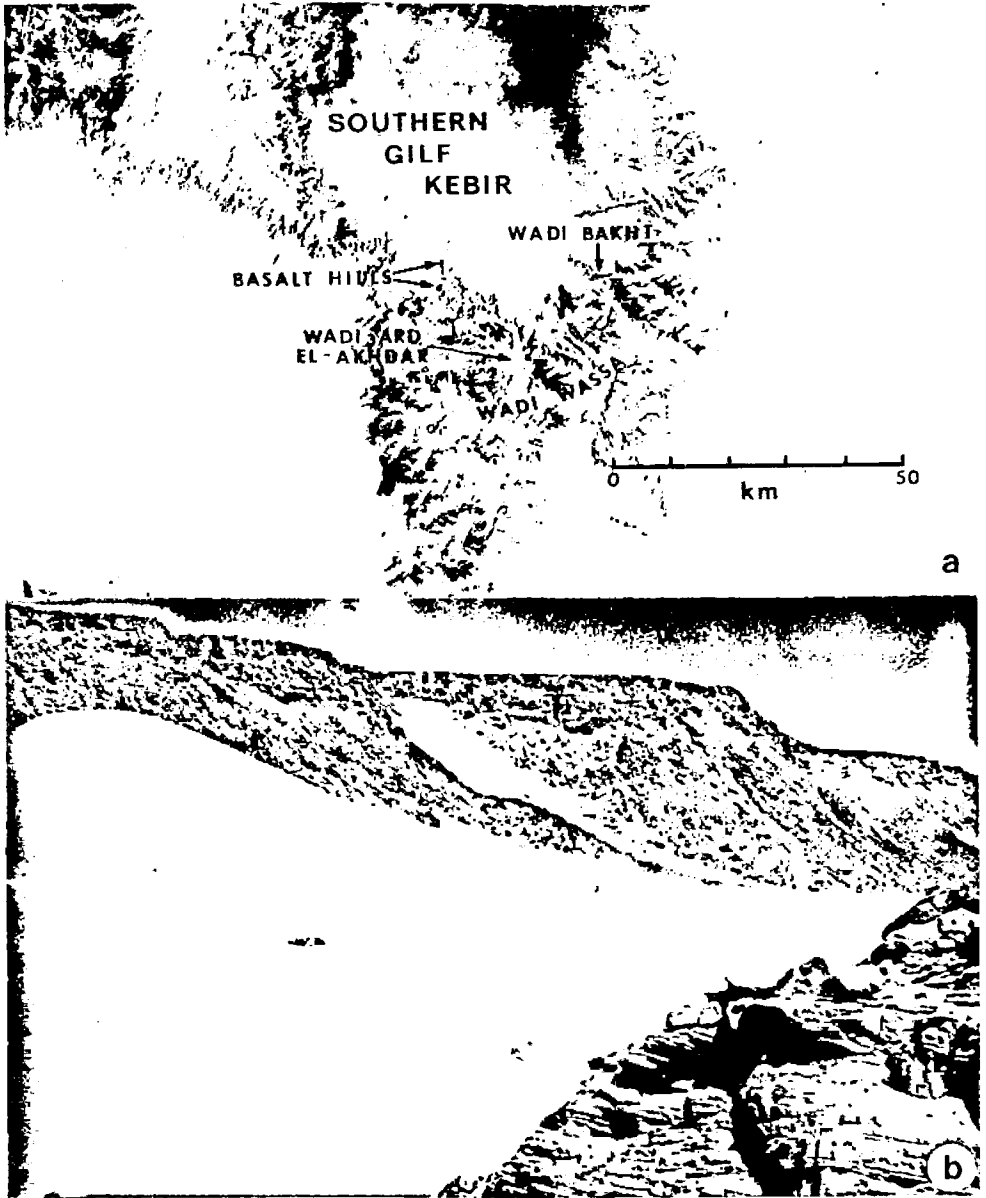


(a) Blunt-faced yardang near Black Hill; (b) Bagnold's 1938 camp at Gilf Kebir; (c) digging implements at reduction site discovered on top of Gilf Kebir

PLATE X



(a) Rim of explosion crater northeast of Gebel Uweinai; (b) Acacia trees near Karkur Talh;
(c) part of Bagawat structure north of Baris Oasis



(a) Enlargement of a LANDSAT mosaic showing the southern Gilf Kebir; (b) playa deposits exposed at breached natural dam in Wadi Bakht