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COMPARISON OF DESERT FORMATIONS IN SOUTHWESTERN EGYPT WITH SIMILAR FEATURES ON MARS. Farouk El-Baz and Ted A. Maxwell, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560

Study of photographs taken from space followed by observations in the field indicate that the Western Desert of Egypt provides a natural laboratory that is suitable for the interpretation of wind-blown features on Mars. Although many desert regions on Earth have been used to make comparisons with Mars, the Western Desert represents a unique analogy because of: (1) existence of dry valleys and lakes, which indicate a wetter climate in the geological past; and (2) present-day extreme aridity and the predominance of erosion and movement of surface materials by wind action. Both conditions are prevalent on Mars.

Numerous circular granitic mountains abound in the southwestern corner of Egypt (fig. 1), particularly near the borders with Libya and Sudan. The largest of these mountains is called Uweinat after the Arabic word meaning water springs, because of the natural groundwater wells on its southwestern side. To the northeast of Uweinat is the Gilf Kebir, a plateau that is topped with a layer of hard, iron-rich quartzite.

A joint American-Egyptian field expedition was planned to both the Gilf Kebir and Uweinat during September-October 1978. In addition to the maps and conventional navigation equipment, we used NASA satellite tracking signals to plot the route of the expedition and to locate sampling sites (fig. 1). The expedition started by air from Cairo to El Kharga. From this oasis, we used desert vehicles to travel southwesterly to Bir Tarfawi, westerly to Gilf Kebir, then southwesterly to Uweinat, and return. The traveled route totaled 2500 km.

Figure 1. Left, sketch map of Egypt showing the route of the expedition that was tracked by Nimbus 6 satellite; Right, Landsat view of the Gebel Uweinat-Gilf Kebir region in southwestern Egypt.
The southeastern border of the Gilf Kebir plateau exhibits deep canyons incised into the quartzite and the underlying fine-grained sandstone. These canyons were clearly formed by water erosion under wetter climatic conditions, which prevailed over 8,000 years ago. The canyons appear to be morphologically similar to martian canyonlands.

The Gilf Kebir canyon systems consist of branching distributary valleys that extend 10-30 km into the plateau. Field observations indicate that there are no drainage networks on top of the plateau. The heads of investigated canyons are characterized by steep cliffs with channels less than 30 m long on top of the plateau. In photographs taken from space, these canyon heads appear as flat-floored, circular depressions similar to the heads of tributary canyons on the south side of Ius Chasma of Mars (fig. 2).

The importance of cliff sapping (the undercutting of less resistant layers of rock and subsequent collapse of the cliff face) was suggested by Bagnold as early as 1933 (ref. 1). This idea is supported by the lack of drainage patterns on top of the plateau, and the possible presence of water springs half-way up the cliffs. Similar erosional processes may also apply to the martian cliffs (ref. 2).

The mouths of the Gilf Kebir canyons have been highly affected by wind activity. As on Mars, no deposits of the ancient stream channels exist as they do in more humid climates. The ancient running-water deposits of the Gilf Kebir canyons have long been buried by the wind-blown sand sheet that butts against the plateau edges.

From the area surrounding the Gilf Kebir to the Uweinat Mountain region, wind-blown features predominate. On the large scale, light- and dark-colored streaks occur everywhere. The light-colored streaks appear to be extensions of the longitudinal sand dunes of the Great Sand Sea to the north.
Orientations of these dunes and streaks indicate prevailing winds from the northeast.

In the Uweinat region, dark-colored streaks occur in the lee of topo-

Figure 3. (a) Spindle-shaped dark streak in the lee of Uweinat Mountain, Egypt. (b) Dark streak south of Hagar El-Garda, Libya. (c) Dark streak in the lee of a crater in the Cerberus region of Mars. (d) View, looking south, of the dark streak in the lee of Garet El-Meit, southwestern Egypt.
graphic barriers; the largest streak is southwest of Uweinat itself (fig. 3). This mountain stands 1200 m above the surrounding sandy plain. Under the prevailing wind from the north-northeast, this mountain ring creates a flow pattern that is similar to those observed on Mars (ref. 3). This pattern is also similar to those generated by laboratory experiments to simulate the flow of wind around martian craters (refs. 4 and 5). The morphological similarities between the terrestrial and martian dark streaks are clearly illustrated in figures 3a-c.

Field investigations of the northern part of the Uweinat dark streak indicate that its surface is strewn with irregular chips of dark rock. These chips or flakes are usually a few centimeters in diameter. They appear to be fragments from the Uweinat Mountain rocks. Between the dark-colored chips are smaller, lighter-colored fragments and sand grains. However, the color of the larger fragments dominates, giving the area a dark color both in the field and in space photographs.

The importance of local material to dark streaks in southwestern Egypt is also demonstrated in the lee of Garet El-Meit hill (fig. 3d). This streak is composed of 5-7 mm granitic pebbles eroded from the hill itself. This surface is surrounded on either side by a light-colored sand sheet. Because of their large size, the dark pebbles of the streak are less likely to move about due to the more frequent sand-moving winds. Consequently, the shape of the streak will change mainly in response to the shifting of the light-colored sand on both sides.

Mariner 9 and the Viking orbiters photographed numerous, alternating light and dark streaks and streak bundles on Mars, particularly in the Cerberus and Elysium Mons regions. Similar streaks and streak bundles abound to the east of Uweinat Mountain. In both cases the streaks emanate from

Figure 4. (a) Streak and streak bundles east of Uweinat Mountain; dark areas are probably exposed rocks, and light areas are most likely sand deposits. (b) Streaks and streak bundles in the lee of craters and knobs in the Cerberus region of Mars.
crater rims and isolated knobs (fig. 4), and the knobby material protrudes through the surrounding terrain on a line that is oblique to the prevailing wind.

Our study of light and dark streaks in the southwestern desert of Egypt indicates that: (1) the light streaks are depositional; sand dunes and/or sand sheets form most of the light streaks; (2) the dark streaks are erosional products of high mountains and hills; they represent virtually sand-free areas; and (3) the morphology of both light and dark streaks is controlled by the flow of the wind around topographic highs. These findings have significant implications to the interpretation of streaks on Mars.

The similarities between features of the southwestern desert of Egypt and wind-blown patterns on Mars are not limited to the views from orbit, but extend to small-scale surface features. In the Uweinat Mountain-Gilf Kebir region, numerous vistas were encountered that appeared very similar to views telemetered by the Viking landers. The distribution of blocks, rock size population, and sand accumulations behind larger rocks are very similar in both cases.

An additional feature that warrants special attention is the prevalence of pits or holes on exposed rock surfaces in the southwestern desert of Egypt. These hollows appear suspiciously similar to what are interpreted as "vesicles" in the rocks of Viking 2 landing site. Vesicles are formed in volcanic rocks as gases are trapped in a fast-cooling hot lava. Thus the martian rocks were interpreted as vesicular basalts.

In the dry, wind-dominated environment of southwestern Egypt, small pits are believed to have formed by wind vortices. The ability of the wind to create vortex pits has been established by laboratory studies (ref. 6). The wind in the Western Desert of Egypt is so fierce that it is quite capable of plucking individual grains from the rock fabric, thus creating small holes in their place.

Larger holes in the rock appear to form by the erosive action of sand grains, which become trapped in the smaller holes. Thus, once a pit is
formed it gets increasingly larger by the passage of time. These holes occur in all encountered rock types, including fine-grained and dense basalts, trachyte, granite, quartzite, sandstone, and in solid hematite. Because of this, it is possible that what are called "vesicles" in the martian rocks are wind-formed pits.

References