FINAL REPORT

ANALOGS OF MARTIAN EOLIAN FEATURES IN SOUTHWESTERN EGYPT
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SUMMARY

This was a proposal to study eolian streaks and associated features in southwestern Egypt as an analog to similar features on Mars. Emphasis was placed on (1) the morphology and patterns of streaks in the Uweinat region, (2) the relationship of topography to streak patterns, and (3) correlation of field and laboratory studies of the desert surface sediments with color and tonal variations seen from orbit. The research objectives were first, to provide the necessary groundtruth information on terrestrial eolian features in order to properly interpret the orbital data, and secondly, to use the interpretations as a basis for investigation of Martian eolian features.

Detailed photogeologic studies of specially enhanced Landsat images, and Gemini through Apollo-Soyuz photographs were used to establish zones within the streaks, and the relationship of streak pattern to topography. These data were correlated with sand size and color, and desert pavement texture as determined from field investigation. Results of this research were applied to Martian eolian streaks by comparing zones of different shading within streaks, and establishing the relationship with topography as seen in Mariner and Viking orbital images.

In addition, our group studied the erosional patterns of the nearby Gilf Kebir plateau of southwestern Egypt to shed more light on the processes of cliff retreat and headward erosion of tributaries. Because of climatic and geomorphic similarities between this area and Mars, the investigation was used to constrain hypotheses for the erosional modification of Martian canyons as well as the wind transport of eroded material.

The research program started on September 1, 1978 and ended on February 29, 1980. Additional work related to this research has since been consolidated under the NASA research grant number NSG-7188 entitled "Morphologic Studies of the Moon and Planets."

RESULTS

Several studies of both comparative planetology and martian eolian features were completed under this grant. Individual topics of investigation included 1) wind streaks, 2) yardangs, 3) ventifacts, 4) chemistry of grain coatings, and 5) eolian features of the Cerberus region on Mars. A short summary of the results of each topic of research is provided below, as is a list of publications. Also attached are reprints of "Journey to the Gilf Kebir and Uweinat, southwest Egypt, 1978," and "Eolian streaks in southwestern Egypt and similar features on Mars."

1) Wind Streaks

The study of bright and dark streaks in the southwestern desert of Egypt indicated that: (1) the bright streaks are depositional; sand dunes, sand sheets and light-colored lag deposits form most of these 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. This appears to be the case in both the southwestern desert of Egypt and the Cerberus region of Mars.

We concluded that detailed study of the bright and dark streaks in the southwestern desert of Egypt will result in our understanding of: (1) the relationship of brightness levels in Landsat images of the Western Desert and in other arid environments; (2) the causes of differences in color of desert surfaces including the relationship of oxidation to sand reddening and desert varnish development; (3) the relationship between wind regimes and local topography; and (4) the origin and temporal variations of streak patterns on the surface of Mars.

2) Yardangs

The nearly level surface of the Western Desert of Egypt is broken in places by hills, which include inselbergs, volcanic cones and yardangs. Yardangs and inselbergs are the most spectacular erosional landforms in the Western Desert. Yardangs are eroded in soft and hard rocks by a combination of wind and blown sand. The most obvious prerequisites for their existence are strong, unidirectional or reversing winds, and great fetch over barren but continuous rock exposures or slightly consolidated sediments. In the southern part of the Western Desert, these conditions are met on the limestone plateau between Assiut and the Kharga depression, on the floor of the Kharga depression, and wherever lacustrine or sebkha deposits occur. The critical morphological criteria in distinguishing a yardang from an inselberg are that it is streamlined, and its length greatly exceeds its width--by a ratio of 3:1 or more, whereas most inselbergs are irregular and equant.

3) Ventifacts

An expedition to Egypt in 1978 revealed an abundance of quartzite and basalt rocks that have been pitted and fluted by wind erosion and deflation of the desert surface. These pitted rocks are internally homogeneous, show no internal holes or vesicles, and are considered an important but neglected type of ventifact. They bear a striking resemblance to the pitted and fluted rocks seen by the Viking Landers, rocks that have generally been interpreted as vesicular

basalts only slightly modified by wind erosion. Wind tunnel studies of the air flow over and around nonstreamlined hand specimens from the Western Desert show that windward abrasion coupled with negative flow, secondary flow, and vorticity in a unidirectional wind can explain the complex arrays of pits and flutes. These field and laboratory observations suggest that the pitted rocks at the Viking Lander sites are also ventifacts, and thus the Martian surface may be far more wind eroded than previously thought.

4) Chemistry of Grain Coatings

Sand samples were collected from several locations in the Western Desert, but only five sites were selected for detailed study based on results of previous mineralogical analyses. The five representative samples are from the oases of Dakhla, Faiyum, Kharga, and Siwa and the Great Sand Sea. These sand samples were sieved and separated into quarter phi units (0.00 to 4.00 + pan) and a representative part of each size fraction was mounted in Lakeside 70 (~ 1.54). The grain mounts were examined using a polarizing microscope and 100 grains were counted per mount.

The analyses establish a prolonged time of eolian transport and show that the longer the transport distance the more prevelant the rounded and subrounded quartz grains. They also show that samples taken from depressions that enclose the Western Desert oases have less quartz grains and more carbonates and other components as compared to the Great Sand Sea sample. This mixing also reduces the overall degree of roundness of the samples, but has little effect on overall color.

Our studies show that the reddening observed in the southernmost parts of the desert can basically be attributed to the kaolinite/hematite coatings on the grains rather than to the composition of the sands. Such reddening may be analogous to the causes of reddish color, due to iron oxides, on the surface of Mars.

5) Eolian Features of the Cerberus Region

As is seen from comparisons of Mariner 9 images obtained in 1972 and Viking Orbiter 1 images obtained in 1978, several changes have occurred in the Cerberus region of Mars. Changes in the boundary of the low albedo feature resulted in an increase of the total area of Cerberus by slightly more than 1%, although the southwestern boundary had shifted as much as 90 km. Relative darkening of Cerberus has resulted in a more uniform tone, and is accompanied by the disappearance of dark filamentary markings. Although several bright streaks within Cerberus changed in length, neither lengthening nor shortening of the streaks predominated. However, changes in streak direction indicate a clockwise rotation of mean streak azimuth between 1972 and 1978. These changes in the outline and appearance of Cerberus can best be explained by eolian redistribution and removal of bright material during major dust storms. Volcanic flow fronts which show through the albedo feature indicate that the ocntrast between Cerberus and the surrounding light plains is not due to a difference in lithology, but to the distribution of surficial deposits. Because of local topographic influences on the regional atmospheric circulation patterns, it is probable that Cerberus will retain a similar appearance and location.

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