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Compiled by P. Wirth, R. Greeley, and R. D’Alli
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TRANSPORTATION AND DEPOSITION OF PARTICULATE MATERIAL ON THE SURFACE OF MARS: INFERENCESS FROM SAND SHEET DEPOSITS IN THE WESTERN DESERT OF EGYPT.

Ted A. Maxwell and Farouk El-Baz, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560

As shown by Mariner and Viking images of the surface of Mars, dunes and other eolian features have suggested the presence of a significant population of saltation-size particles that are available for eolian transport and deposition (Cutts and Smith, 1973; Greeley et al., 1974). Observations of martian duststorms indicate that material in the 1 μm range is extensively redistributed on a planet-wide scale (Arvidson, 1972). In contrast to these observations, however, Viking lander images indicate an apparent deficiency of surficial material in the 1.75 - 2.5 μm size range (Patterson et al., 1977), and theoretical calculations of wind velocities needed for eolian entrainment suggest that sand-size material should not be an important constituent in the martian eolian regime. According to Greeley (1979), three possible explanations for the presence of sand-size material are: 1) the dunes are remnants of a previous episode of a denser atmosphere, 2) the calculations suggesting that sand-size material is in saltation are incorrect, and 3) the eolian features may be formed of agglutinates of smaller grains that act as sand-size material during transport. Based on the size characteristics of sediments from the Western Desert of Egypt, however, it is also possible that these seemingly conflicting lines of evidence are the result of the heterogeneity of eolian depositional environments.

Source materials for many present-day terrestrial deserts are found in previously consolidated sedimentary deposits, which have been subject to fluvial reworking during Pleistocene and Recent times (Folk, 1968). Eolian sands of the Western Desert present one example of this process in that they were derived from highlands to the south, and transported northward by rivers only to be blown back southward by the prevailing winds (El-Baz and Maxwell, 1979). In the Western Desert, however, there is an additional local source of sand grains in the widespread Nubia sandstone that underlies the surficial deposits. Consequently, there is a continuum of particle sizes present that are available for eolian sorting. The characteristics of source materials for martian deposits are much more difficult to specify. The effects of impact, thermal and chemical weathering, and possible fluvial erosion may all play an important role in generation of sand- and silt-size material. Because of our limited knowledge on the nature of martian bedrock, however, the grain size of source materials on that planet remains unknown.

On both Earth and Mars, the size distributions of wind-transported material can be divided into two fractions: 1) Unimodal, saltation-size grains that make up the dune-forming population, and
2) A bimodal population of sand and coarser grains that composes the sand sheet deposits. Locally, material derived from an immediate source will modify both populations in the form of serif deposits. As shown by comparisons of textural parameters, the deposits of these two desert subenvironments can be distinguished on the basis of size and sorting characteristics. Although both the gravity and atmosphere differ on Mars, the basic processes of eolian sorting are likely to be the same. Differences in the martian environment suggest that the size of the saltation fraction may be greater than the Earth’s (Sagan and Esagoni, 1975), and that both wind speeds and net sediment transport rates are greater (Arvidson, 1972; White, 1979). Because of the differing modes of sand sheet deposition (both traction and suspension are likely), these environmental effects may be represented more by sand sheet and associated deposits rather than by relatively homogeneous dune deposits.

Unfortunately, data from the Viking landers are inconclusive with respect to particle size variations at the two locations on the martian surface. Limitations on pixel size and sampling rate of the lander cameras make it impossible to see surface particles finer than about 2.5 φ. Based on an absence of false low frequency components in surface imaging, Patterson et al. (1977) suggested that there is a deficiency in the medium to fine sand size range (1.75 to 2.3 φ). On the basis of grain counting in the footpad of Viking Lander 2, Zimmer et al. (1977) also suggested a depletion of fragments less than -1 φ in diameter. Consequently, there is an apparent bimodal sediment distribution among the < 5mm size material at both sites. Grains greater than a few millimeters are abundant on the surface, with finer material (less than ~2.5 φ) forming intervening areas, and possibly the drifts.

The deficiency of sand-size material has been explained as the result of particle break-up due to reduced atmospheric density (the so-called "Kamikaze" particles of Sagan et al., 1977), or a debris-flow origin for material near the landers (Shultz et al., 1979). Based on sorting characteristics of Western Desert sands, however, it is also possible to consider this size distribution as the result of the sand-sheet mode of deposition transferred to the martian environment. On Mars, the larger gap between modes of granules and fine silt-size material may be the result of the much higher wind speeds and wind speed variations present at the martian surface.

References
