SAND ON MARS: THE PROPERTIES OF DARK INTRACRATER DEPOSITS

Kenneth S. Edgett and Philip R. Christensen
Department of Geology, Arizona State University, Tempe, AZ 85287

Dark features on the floors of craters (≥ 25 km diam.) are common on Mars. Previous investigations indicated that they are related to aeolian sedimentary processes, and most are made up of unconsolidated, sand-sized material, with little incorporated dust or rocks [1-6]. In the present study, the highest quality and resolution *Mariner 9* and *Viking* orbiter images and *Viking* Infrared Thermal Mapper (IRTM) data were analyzed in order to provide new information about the properties of dark intracrater features. The IRTM data were carefully constrained: only data taken directly from the dark intracrater features were used, and the effects of atmospheric dust, clouds, surface frosts, etc. were avoided. The principal results of this study relate to three subjects: the particle size of martian dunes, the regional differences in the physical nature of the dark intracrater features, and the composition of the dark materials.

Mars Dune Particle Sizes: Thermal inertia (I) (units: 10^{-3}cal cm^{-2} sec$^{-1/2}$ °K^{-1}), at martian atmospheric pressures, can be used to estimate the effective particle size of unconsolidated materials [7-9]. Excellent thermal data were found for four thick, continuous, intracrater transverse dune fields, in the craters Kaiser (46.5°S, 340.5°W; I = 8.0), Proctor (47.8°S, 330.3°W; I = 8.2), Rabe (43.5°S, 325.0°W; I = 8.1) and Moreux (42.1°N, 315.5°W; I = 8.3). The thermal inertias of these dunes correspond to particle sizes ~ 500 to 550 μm, or medium to coarse sand (Wentworth scale [10]). The average terrestrial dune particle size is ~ 300 μm [11], fully 1 phi size [12] smaller than the martian dunes. The possibility that average martian dune sands are coarser than terrestrial dunes is also supported by the determination that the approximate "boundary" between saltation and suspension (where the ratio of the terminal velocity to the wind friction speed = 1) for particles at threshold on the Earth occurs at ~ 52 μm, while on Mars, particles as large as 210 μm might become suspended for short periods of time, leaving coarser particles behind to saltate and form dunes [13, 14]; and the saltation path lengths of particles are greatly increased on Mars due to low atmospheric kinematic viscosity and gravity [15], both factors might leave coarser particles behind to saltate and form dunes. Together, these lines of evidence indicate that average martian dune sands are probably more coarse-grained than terrestrial dune sands.

Regional Differences: Figure 1 shows the geographic distribution of IRTM-derived thermal inertia results for 137 dark intracrater features on Mars. Their mean (± σ) effective particle size is 700 μm ± 40%. There are regional groupings of thermal inertias or effective particle sizes of these features, and each has a different mean and a narrow variation of effective particle size within the region [16]. Their effective particle sizes range from very fine sands (~80 μm in Northern Arabia, NA) to very coarse sands and granules (~2500 μm in Margaritifer Sinus, MS). The regional differences probably result, in part, from differences in the wind regimes [*e.g.* 17]; for example, in the region south of Margaritifer Sinus, strong winds are common and might winnow out fine sands, silts, or clays, while in a region with relatively weak winds, such as Arabia, the finer materials are less easily removed and the intracrater deposits have a lower effective particle size. Regional differences also result from differences in the morphology of aeolian deposits (*e.g.* dunes) that occur on some dark deposits. For example, in Hellespontus (HP) there are thick, transverse dune fields with an effective particle size ~ 500 μm; while in Oxia Palus (OP), most of the dark features are composed of small barchan dunes moving across a presumably coarser substrate, so their effective particle size is higher (~2 mm), indicating the combined particle sizes of the dune sand and the coarser interdune surface.

Composition: Measurements of the thermal emissivity of a planetary surface provide a means of identifying mid-infrared absorption bands, the strength and positions of which are known to vary with mineral structure and composition [*e.g.* 18-20]. Dark intracrater features are ideally suited for determination of compositional properties using IRTM thermal emission

INTRACRATER SANDS ON MARS: *K.S. Edgett & P.R. Christensen*

data, because relative to other surfaces on Mars, they are free of dust and rocks which would alter their emissivity characteristics. Carefully constrained, high spatial resolution thermal emission data were found for 16 dark intracrater features. The constraints and methods used were similar to those of Christensen [21]. The data for dark intracrater features show greater absorption in the 11 μm band than the 7 or 9 μm bands, indicative of mafic rather than silicic or carbonate materials.

Summary:

(1) Three lines of evidence suggest that the average martian dune particle size is greater than the terrestrial average dune particle size (Mars: probably ≥ 500 μm; Earth: ~ 300 μm)

(2) There are regional differences in the effective particle sizes of dark intracrater features; these are probably due to differences in wind regime and the amount and morphologic expression of sand deposits on the surface.

(3) IRTM-derived thermal emission spectra indicate a predominantly mafic rather than silicic or carbonate composition for the dark intracrater sands.

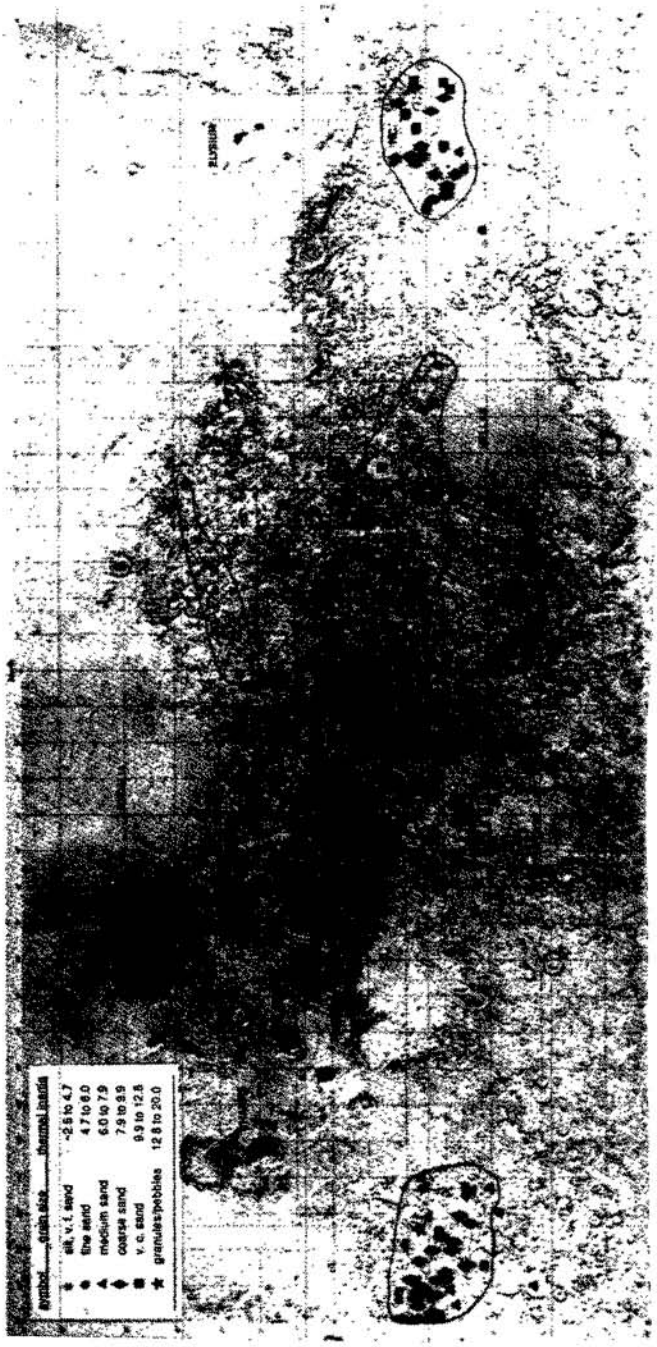

Fig. 1. Thermal inertia (or effective particle sizes) of dark intracrater features show regional clustering. Within each region there is a different mean and a narrow range of variation of thermal inertia among the dark features.

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