

THE COMPOSITION OF MARTIAN AEOLIAN SANDS: THERMAL EMISSIVITY FROM VIKING IRTM OBSERVATIONS. *Kenneth S. Edgett and Philip R. Christensen*
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Aeolian sands provide excellent surfaces for the remote determination of the mineralogic composition of martian materials, because such deposits consist of relatively well-sorted, uniform particle sizes and might consist of chemically unaltered, primary mineral grains derived from bedrock. Dark features on the floors of martian craters are controlled by aeolian processes [1-4] and many consist largely of unconsolidated, windblown sand [3, 5-7].

Measurement of the thermal emissivity of geologic materials provides a way to identify mid-infrared absorption bands, the strength and positions of which vary with mineral structure and composition [*e.g.*, 8, 9]. The *Viking* Infrared Thermal Mapper (IRTM) had four surface-sensing mid-IR bands, three of which, the 7, 9, and 11 μm channels, correspond to absorption features characteristic of carbonates, silicic, and mafic minerals, respectively [10]. In this study, the highest quality IRTM data were constrained so as to avoid the effects of atmospheric dust, clouds, surface frosts, and particle size variations (the latter using data obtained between 7 and 9 H); and selected for dark intracrater features such that only data taken directly from the dark feature were used, so as to avoid thermal contributions from adjacent but unrelated materials [6, 7, 11]. For any given dark feature, only 3 coincident channels were available, because of the placement of the 7 and 9 μm IRTM detectors. Relative emissivities were computed for each IRTM spot by assuming that the highest of the three brightness temperatures (T_B) is the closest to the surface kinetic temperature (T_K). The radiance of each band at T_K is calculated using Planck's function. The relative emissivity is the ratio of the radiance at $T_B(\lambda)$ to the radiance at $T_K(\lambda)$ [12, 13]. Three-point emissivity spectra of martian dark intracrater features were compared with laboratory emission spectra of minerals and terrestrial aeolian sands convolved using the IRTM response function to the four IRTM spectral channels.

Results: Three-point spectra for 10 dark intracrater features for which the IRTM data met our strict constraint criteria are shown in Fig. 1. The vertical bars indicate the wavelength-dependent uncertainty due to detector sensitivity ("noise"). The numbers in Fig. 1 indicate the latitude and longitude locations of the relevant craters. Figure 2 shows four-point IRTM-convolved laboratory spectra of hand specimen-sized minerals and granular aeolian sands; the dotted lines indicate the shape of 3-point spectra where the 9 μm band is not present, for comparison with the results in Fig. 1. If the solid minerals of Fig. 2 were ground into sand-sized particles, their spectral shapes would remain about the same, but the relative depth of absorption features would be diminished [14]. The sand samples (with approximate major mineral abundances) include: (1) 100% quartz from Coral Pink Dunes, S.W. Utah, (2) 80% basalt, 20% quartz from the Moses Lake Dunes, Washington [15], (3) 100% basalt pyroclasts from aeolian drifts near Sunset Crater, Arizona, (4) 50% feldspar, 50% pumice from dunes in Christmas Lake Valley, Oregon [16], and (5) 100% pumice sand from an aeolian tuff in the Jemez Mts., New Mexico [see 17]. Also in Fig. 2 are three relative IRTM-derived 4-point spectra of portions of the martian regions Arabia, Syrtis, and Isidis [from 11] for comparison.

Discussion: The laboratory-derived spectra of calcite, quartz, and olivine show the shift in deep absorption features from 7 to 9 to 11 μm . Six of the martian spectra in Fig. 1 have a 7 μm observation, in all cases it is higher than the 11 and 20 μm emissivities, indicating a general lack of carbonate sand. Also in Fig. 1 there are 4 spectra with a 9 μm observation, which in all cases is also higher than the 11 and 20 μm emissivities, indicating that quartz cannot be a dominant mineral in these deposits. Feldspars, as well as quartz, have a 9 μm absorption feature which can be seen in the mineral and aeolian sand spectra in Fig. 2, but it is less-pronounced than the quartz feature. If only the spectra with 7 μm observations are considered, they appear to match very well with the 3-point spectra of basaltic and feldspar-rich dune sands in Fig. 2. In the cases where a 9 μm observation is present, the 9 μm emissivity is not only the highest, but the 11 and 20 μm emissivities are nearly equal; thus the best fit to these is the olivine spectrum, suggesting a dominance of ultramafic materials. Basalt (mafic) sands

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have shallow absorptions in 9 μm , but only ultramafic sands would have deeper absorptions near 11 μm . We note, however, that where a 9 μm observation is not available, we cannot be completely certain that more silicic materials are not present. We also note that many of the martian spectra in Fig. 1 resemble 3-point spectra for terrestrial sand samples where silicic materials (e.g., quartz, pumice) are present in amounts up to 50%.

Conclusions: Mafic and ultramafic minerals and rock fragments may be the dominant materials comprising some of the windblown sands on Mars, but the presence of minor amounts of silicic minerals such as quartz cannot be ruled out when only the IRTM-derived thermal emission results are considered. The *Mars Observer* Thermal Emission Spectrometer (TES) will provide higher spatial and spectral resolution data with which to determine both the composition and mineralogic abundance of martian aeolian deposits.

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