MULTI-SPECTRAL THERMAL INFRARED OBSERVATIONS OF MARS: IMPLICATIONS FOR COMPOSITIONAL VARIATIONS; **Philip R. Christensen,** *Department of Geology, Arizona State University, Tempe, AZ 85287.*

Thermal-infrared spectroscopy provides a powerful tool for determining the composition of planetary surface materials. Virtually all geologic materials have thermal-infrared spectral features associated with the fundamental vibrational motions of the major ionic groups in the crystal structure. The vibrational frequency of these motions varies with both the ionic composition and crystal lattice structure, providing a direct means of identifying the composition of many geologic materials (1-6). Viking Infrared Thermal Mapper (IRTM) data have been reexamined for clues to the composition of the martian surface. These four-channel, broadband data provide a crude means of studying compositional differences on Mars that are both unique and complementary to visible and near-IR data obtained from Earth and from spacecraft.

The spectral variation in emissivity can be determined by measuring the emitted energy in each of the four surface-sensing IRTM bands (7, 9, 11, and 20 μm) and comparing the observations to blackbody emission. Unfortunately, several mechanisms, in addition to variations in emissivity, can result in a non-blackbody character of the emitted energy. These include non-uniform surface temperatures due to mixtures of rocks and fine materials and the effects of suspended atmospheric aerosols, primarily dust and water ice (8). A detailed discussion a method for separating these effects has been presented previously (8). In summary, best approach is to collect data from a single area at multiple times of day and use the differences in diurnal characteristics of each effect to separate them. This technique, however, requires diurnal coverage generally beyond that obtained by Viking. A simpler approach that is tractable using IRTM data is to select times of day for which emissivity differences dominate the spectral signature. Using data shortly after sunrise and preceding sunset greatly reduces the effects of non-uniform particle size (9). Atmospheric effects can be minimized by utilizing clear-period data and avoiding observations near midday when surface-atmosphere temperature contrasts are the largest.

The emissivity in each of the four IRTM bands was determined using data acquired during northern spring season and binned at a spatial resolution of 1°x 1° in latitude and longitude. For each bin the brightness temperature, defined as the temperature required for a blackbody to emit the measured energy, was determined for each wavelength band. The highest of these brightness temperatures was assumed to be equal to the kinetic temperature, resulting in an assumed emissivity of 1 for that band. Emissivities in each of the other bands were then determined by simple ratioing of the observed energy. Global data were obtained by utilizing the difference between the period of the Viking orbit and that of Mars, which resulted in a 40°/orbit longitude offset in data acquired at a constant time of day. This mapping strategy provided global coverage in 36 days. Three separate global images were assembled from data obtained in the morning (7.5 to 9.5 H) and three additional images from afternoon data (14 to 17 H). These individual maps were then used to aid in separating surface from atmospheric effects.

The results of this emissivity mapping demonstrate that there are significant spectral variations that can be attributed to differences in surface materials. As has been previously described (8) there is a good correlation in some areas between thermal emissivity and surface albedo. The darkest regions generally have the lowest emissivities, with broadband emissivities as low as 0.9 measured in each band. In most cases the 7 μm emissivities were highest and therefore assumed to be unity. This result is expected from the nature of silicate materials in which major Si-O stretching bands are centered between 8.5 and 12.5 μm and emissivity maxima are generally observed at the Christiansen frequency between shortward of 8 μm (5). In some areas, however, the emissivity at 7 μm was substantially

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lower than at 9, 11, or 20 μm, suggesting a non-silicate material. Possible candidates include carbonates, which have been proposed for dust aerosols based on Earth-based, airborne spectral measurements (10). Any further speculation on the presence of these materials, beyond their possible existence, is not warranted at this time. The IRTM data do, however, suggest that composition variations exist and that certain types of materials may be restricted to specific areas.

Perhaps the most intriguing observation is the presence of localized regions of materials with strong absorption features in the 11 μm IRTM band. These areas are preferentially associated with major volcanic constructs, including Olympus Mons, the three major Tharsis volcanoes, Elysium, and Alba. Several possible candidate materials exist, including clay minerals (5) and water ice (11,12). Clouds are certainly observed associated with these features, and cannot be ruled out. However, in each case the region of strong 11 μm absorption is relatively localized and has relatively sharp boundaries. These characteristics not necessarily typical of martian clouds and hazes. Unfortunately, the data analyzed to date do not allow a definitive separation of these, and other, possibilities because of a perverse lack of overlap in crucial areas between data collected at different times of day and at different seasons. Analysis of additional data will hopefully allow a discrimination between these significantly different possibilities.

In summary, the IRTM multi-spectral data provide a means of investigating composition variations in martian surface materials that has not been fully exploited to date. Despite their broadband nature, these data demonstrate the presence of significant absorption features clearly associated with surface materials. Compositional variations are, in some cases associated with other differences, such as albedo. In other areas the emissivity and albedo are poorly correlated, suggesting that materials with similar visible and near-IR reflectance spectra may still differ compositionally.

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