The composition of the Martian surface materials was determined by the Viking landers at two locations separated by over 6000 km (1). Although analysis was limited to the fine material at both sites because of difficulty in locating centimeter sized rocks, a variety of surface textures were sampled, ranging from unconsolidated fines to aggregated crusts and clods (2). Among all of the samples collected at both sites there is a remarkable similarity in composition (1). This compositional similarity, both locally and between the two sites, has been interpreted to indicate that the Martian fines have been homogenized on a hemispheric or global scale (1).

An indirect estimate of the composition of any Martian region can be made using the thermal emissivity, derived from Viking Orbiter Infrared Thermal Mapping (IRTM) observations (3). The thermal emissivity is determined from the diurnal variation of the differences between the brightness temperatures measured at each of the four surface-sensing IRTM bands centered at 7, 9, 11 and 20 μm. These spectral differences result from the fact that Mars differs from a blackbody due to non-uniform surface temperatures, non-unit surface thermal emissivity and absorption and emission of atmospheric dust. Each of these effects have different diurnal signatures which allow them to be separated (3).

A detailed diurnal analysis has been done for a limited number of locations, including the two landing sites (4). This study showed that the thermal emissivity of the surface in the regions surrounding the two landing sites were very similar at all wavelengths.

A global estimate of the emissivity can be obtained using only noontime observations, when emissivity and atmospheric dust are the only significant contributors to the spectral differences. Figure 1 shows the 20 μm brightness temperature (T_{20}) differenced from the 7 μm temperature (T_{7}), plotted as a function of albedo, for three separate latitude bands. These observations have been corrected to remove the atmospheric dust contribution using the dust amounts determined from the diurnal analysis of individual areas of known albedo (4). It is apparent from the figure that there is an excellent correlation between the emissivity and albedo of all of the Martian surface studied.

There are numerous physical properties which affect the thermal emissivity, including composition, grain size, packing and temperature gradient in the surface (5, 6 and many others). On Mars, the dominant effects are composition and grain size (3). Grain size variations could contribute to the observed decrease of emissivity with decreasing albedo because both the emissivity (6) and the albedo (7) generally decrease with increasing particle size. However, if grain size was the principal cause of the emissivity variation, there should be a correlation of emissivity with thermal inertia. No such correlation has been observed.

A more likely cause for the observed correlation is the mutual dependence of albedo and emissivity on composition. The observed variation in emissivity could therefore result from a compositional difference between high and low end-members, with intermediate albedo surfaces being mixtures of the two end-members (4). Near-infrared reflectance data also show a difference between high and low albedo materials (8), but lack the spatial resolution to measure intermediate albedo values.

Returning to the question of composition at the two landing sites, it is very important to note that they have very similar albedos (0.26 at Lander 1 and 0.25 at Lander 2). Given the globally observed correlation between albedo and emissivity, the similarity of the emissivities at the two sites is, therefore, not surprising. Furthermore, if the thermal emissivity is controlled by composition, then the close similarity in composition of the two sites would also be expected from the similarity in emissivity. These observations therefore suggest that the uniform bulk composition of the fines at the two landing sites is an artifact of sampling material of similar albedo. The variation of emissivity, and presumably composition, with albedo suggests that the bulk composition of the fines may be different at other locations; being composed of different fractions of a
limited number of constituents. It is therefore possible that the Martian fines have not been globally homogenized, but instead have compositions which are variable and depend strongly on the local source rocks and geologic processes.

REFERENCES


Figure 1. The observed variation of $T_7-T_{20}$ with albedo after the atmospheric dust contribution is removed. The remaining $T_7-T_{20}$ differences, which are due to thermal emissivity, show a strong correlation with albedo. Note also the uniformity of the surface between $-30^\circ$S and $60^\circ$N.