THERMAL INFRARED OBSERVATIONS OF MARS FROM PALOMAR MOUNTAIN

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During the opposition of 1993, we obtained imaging and spectrographic observations of Mars in the thermal infrared. We have analyzed this data using a thermal model for the planet to remove contrast caused by diurnal temperature variations. Ratio spectra show that while most locations on the disk appear to behave as blackbodies, a few locations (notably Acidalia) show definite absorption features. We are currently in the process of determining whether the spectral features seen in Acidalia are caused by dust in the atmosphere or by non-unit emissivity of surface materials and will report our findings.

Images and spectra were obtained using the newly-developed SpectroCam-10 instrument on the Hale 200" telescope at Palomar Observatory. Images were taken using a set of six wide band filters centered at 7.9, 8.8, 9.8, 10.3, 11.7 and 12.5 microns at three times over the course of the night of 11 January, 1993. Spatially resolved slit spectra with a wavelength resolution of 100 between 7.5 and 13.5 microns were also obtained covering the entire disk. Seeing on the night of the observations in this spectral region was about 0.75", corresponding to a resolution of 350 km on the surface of Mars at the sub-Earth point.

To analyze the data, we have developed a thermal model that uses finite difference techniques to solve the time-dependent one-dimensional heat diffusion equation for surface temperatures and then blackbody radiances over the entire planet on a 2 x 2 degree grid. The inputs to the model are thermal inertia, albedo, and geometry of insolation at each grid point. Running the model with a spatially uniform thermal inertia of 6.5 E-3 cal cm^(-2) s^(-1/2) K^(-1) and an average albedo of 0.21, we produced synthetic "average" Mars images. The actual images were then divided by the "average" images to remove most of the center-to-limb brightness gradient and reveal more subtle surface features. Many well-known features are readily apparent in such ratioed images, including Syrtis Major, Hellas, Sinus Meridiani, Argyre, and Acidalia. Using the Viking-derived thermal inertias and albedos as inputs to the model, a second set of spatially inhomogeneous synthetic Mars images was created. When the observed images are divided by these inhomogeneous images, the results are mostly flat, but a few significant features remain.

In at least one case, we have identified the cause of one of these features to be a change in the albedo of the surface since Viking. However, other features may be related to absorption in the Martian atmosphere, or to non-unit emissivity of materials on the planet's surface. In particular, a spatially confined feature in the location of Acidalia shows a strong absorption at 9 microns and a weaker absorption at 11.5 microns. Qualitatively, this spectrum closely matches a spectrum taken by the Mariner 9 IRIS instrument during the height of the '71-'72 global dust storm. However, optical observations taken by others during the '93 opposition indicate that the skies on Mars appeared clear at this time (D. Parker, personal communication).

In order to understand this apparent contradiction, we are currently pursuing three avenues: 1) We calculate the amount of dust that would need to be in the atmosphere in order to produce features of the depths seen in the spectrum of Acidalia, convert this dust load to a visible wavelength optical depth, and compare that to the lower limit of detectability for localized atmospheric dust in optical images. 2) Disk-resolved polarization meaurements were acquired during the '93 opposition from Tokyo by S. Ebisawa. Using these measurements, it may be posible to distinguish between surface materials and dust in the atmosphere (A. Dollfus, personal communication). 3) We hope to observe Mars again in the summer of 1994. The feature in Acidalia is spatially large enough that it should be visible then if it is still there, despite the smaller apparent size of Mars. A permanent spectral feature in this location would indicate surface origin, while a transient feature would likely be due to dust in the atmosphere. We will discuss results from 1) and 2) above, as well as plans for 3).