TELESCOPIC SPECTRA OF MARS LINKED TO VIKING LANDER MULTISPECTRAL IMAGES AND LABORATORY ANALOGS

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We have analysed telescopic spectra of Mars taken at the Mauna Kea, Hawaii Observatory during 1969 and 1973 (1,2). We tested the ensemble of telescopic spectra to determine if the data were consistent with mixtures of a small number of surface materials. Our approach utilized previous methods (3) to calibrate and infer composition of multispectal images using a spectral reference library.

In contrast to the six broad spectral bands of the Viking Landers each telescopic spectrum consisted of 21 spectral measurements from 0.350um to 1.100 um. The 1969 and 1973 data sets contained 7 and 24 spectra respectively, each normalized to 0.56 um. The 1969 and 1973 data sets were independently fit to the following equation:

$$G_L R_{t\,L} = \sum_{n=1}^{N} F_{em} R_{rl\,L} + E_L \qquad (1)$$

to determine gains (G_L) at each wavelength L and fractions of telescopic endmember spectra F_{em}. $R_{t\,L}$ and $R_{rl\,L}$ were the normalized reflectance of the telescopic spectra and reference library endmember spectra respectively for wavelength L. N is the number of endmembers necessary to model the telescopic spectra such that the least squares fit of the data to equation 1 results in errors E_L near the level characterized by the instrumental noise. The gains (G_L) are a composite gain that includes both instrumental and atmospheric attenuation.

We found that 99.7% of the spectral variation present in the 1969 and 1973 telescopic measurements was consistent with that resulting from two spectral endmembers. Using the same spectral reference library as was used for analysis of the Viking Lander images (3), we determined the best reference analogs for the telescopic spectra to be the same as those determined in the Viking multispectral image analysis (e.g. an Hawaiian palagonite (H34) and an andesite (T2BB) from Arizona were the best analogs). The similarity in spectral endmembers given the independent analysis of high resolution telescopic spectra and Viking Lander images suggests a consistency in spatial and spectral scales; i.e., we infer the same compositional surface at a coarse spectral resolution and high spatial resolution (Viking Lander images) as we infer at a high spectral resolution and low spatial resolution (telescopic spectra).

Our analysis has separated the telescopic data sets into a spectral variance and mean component. Mixtures of surface materials are inferred from the spectral variance contained within the telescopic data sets because surface composition is assumed to vary spatially. The differences in mean components between data sets leads to calibration gains necessary to make data sets comparable. The resulting gains (Fig. 1) necessary to calibrate the 1969 normalized telescopic spectra to the equivalent normalized reflectance of our reference library were similar to the gains necessary to calibrate the 1969 telescopic data to the 1973 telescopic data. We interpret these gains to imply temporal changes in instrument/atmospheric conditions. Since the shapes of the two gain curves are similar, we conclude that the mean shapes of these curves are related to changes in the terrestrial and

martian atmosphere over the observation periods.

Past studies (2,4) have interpreted subtle absorption features near 1.0um from single telescopic spectra as an indication of pyroxene. However, pyroxene, as expressed in a 1.0um absorption band, is not a necessary component to model the spectral variance of the telescopic spectra. That is, the spectral endmember that corresponds to rock does not have the best developed 1.0um absorption band, and, there is no regular decrease in a 1.0 um band as the fraction of the dust endmember increases. An alternative explanation is that the apparent 1.0 um absorption in certain spectra is an artifact of gains contributed by instrumental and/or atmospheric factors (Fig. 1). An analysis of additional telescopic spectra, including the more recent data that extends to 2.5um is needed to test this hypothesis.

References

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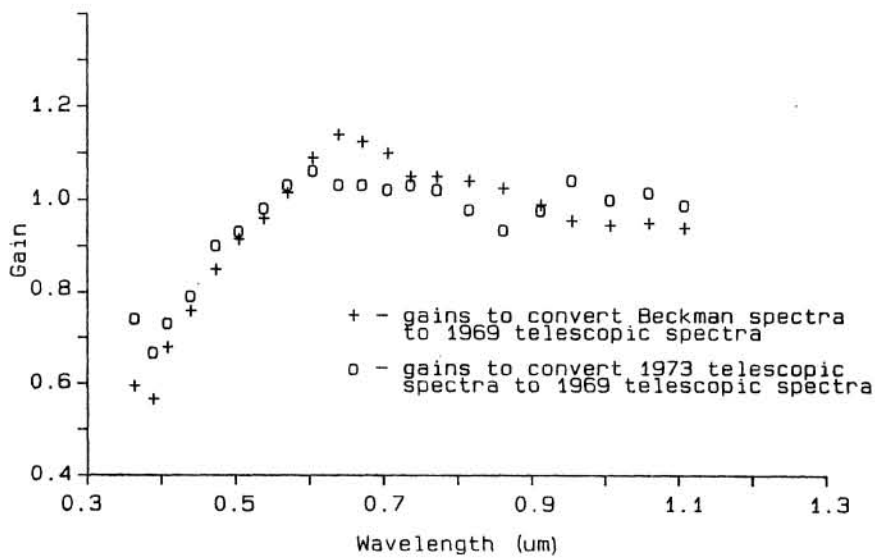

Figure 1. A derived set of gains using equation 1 to a) calibrate reference spectra (Beckman 2K-DA spectrometer) to telescopic spectra and b) calibrate 1973 telescopic spectra to 1969 telescopic spectra. The similarities between the curves are interpreted to imply instrumental and/or atmospheric effects implicit in the telescopic spectra.