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ABSOLUTE CALIBRATION AND ATMOSPHERIC VS. MINERALOGIC ORIGIN OF ABSORPTION FEATURES IN 2.0 TO 2.5 μm MARS SPECTRA OBTAINED DURING 1993; James F. Bell III (NRC/NASA Ames, Moffett Field CA), James B. Pollack (NASA Ames), Thomas R. Geballe (JAC/UKIRT, Hilo HI), Dale P. Cruikshank (NASA Ames), and Richard Freedman (Sterling Software, Palo Alto CA).

For over twenty years the origin of weak absorption features in the spectrum of Mars near 2.3 μm ("K" Band: 1.9-2.5 μm) has been debated. This spectral region contains gaseous absorption features predominantly from CO₂ and CO on Mars as well as from molecules like H₂O, CO₂, CH₄, and CO in the telluric and solar atmospheres [e.g., 1-4]. Putative mineralogic absorption features in Mars spectra at these wavelengths have been interpreted as evidence for specific Mg-bearing clay silicates or amphiboles [5,6] and bicarbonate-bearing minerals such as scapolite [7]. Spectra from other wavelength regions have been used to infer the existence of smectite clays on Mars based on features in the visible and in the mid-IR [e.g., 8-10] and to place limits on the abundance and distribution of anhydrous and hydrous carbonate-bearing minerals [e.g., 11-14].

We obtained new high resolution (R ≈ 300 to 370) reflectance spectra of Mars during the 1993 opposition from Mauna Kea Observatory using the UKIRT CGS4 spectrometer. Fifty spectra of 1600-2000 km surface regions and a number of standard star spectra were obtained in the 2.04 to 2.44 μm wavelength region on 4 February 1993 UT. S/N in the raw data ranged from 30 to 300. Near-simultaneous observations of bright standard stars were used to perform terrestrial atmospheric corrections and an absolute flux calibration. Using the known magnitude of the stars and assuming blackbody continuum behavior, the flux from Mars could be derived. To derive radiance factor values (observed flux / expected Lambertian flux) we assumed that the solar continuum flux followed an empirically-derived relationship [15] and we used the technique of [16] to derive the expected Lambertian flux at Mars. The absolutely-calibrated spectra exhibit a S/N precision of from 35 to 90 depending on the radiance factor of the region observed. The errors on the absolute flux level are from 6 to 10% (1σ) and those on the radiance factor values are from 8 to 12%, assuming a 5% uncertainty in the absolute flux distribution of the Sun.

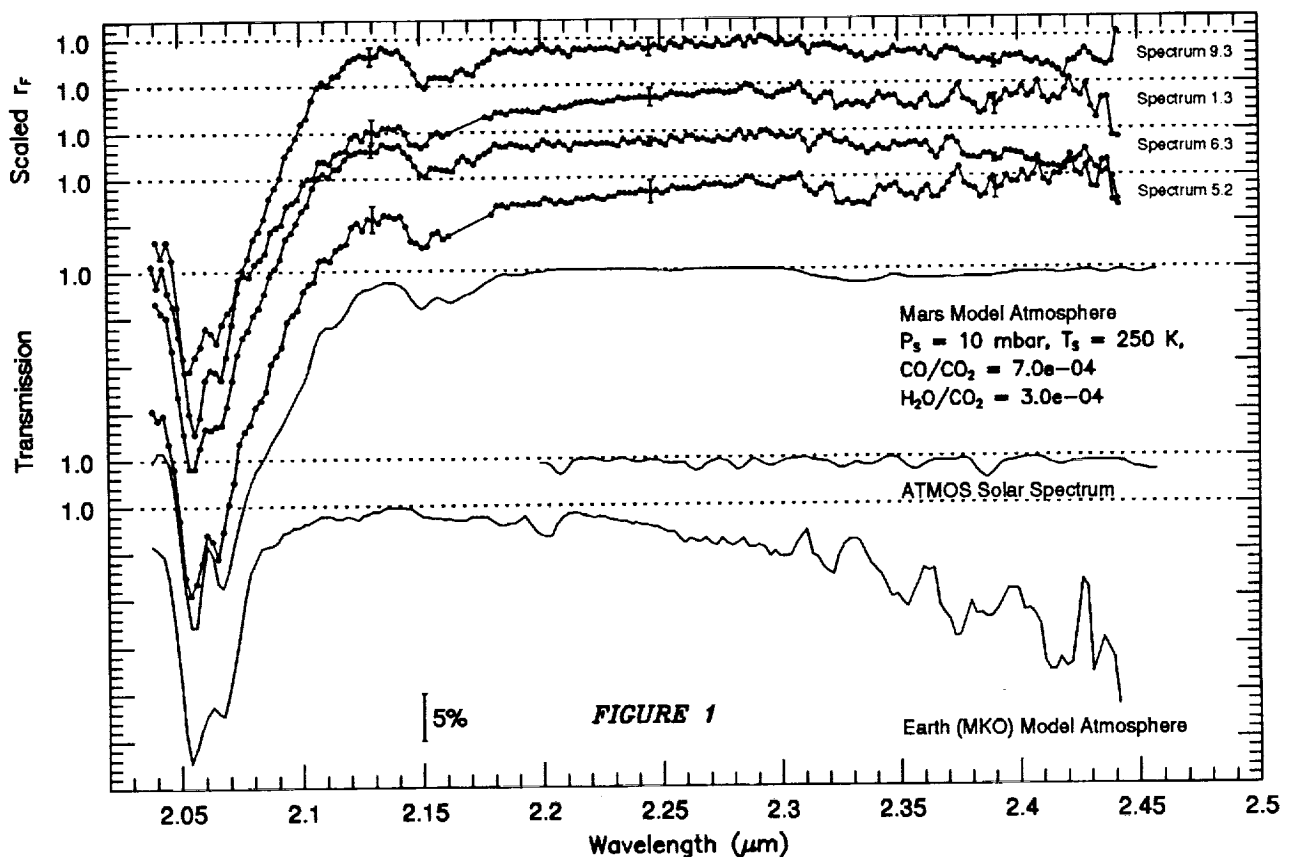
A radiative transfer model [17] and the HITRAN spectral line data base [18] were used to compute atmospheric transmission spectra for Mars and the Earth in order to simulate the contributions of these atmospheres to our observed data. Also, we examined the ATMOS solar spectrum in the near-IR [19] to try to identify absorption features in the spectrum of the Sun that could be misinterpreted as Mars features. Scaled radiance factor spectra are shown in Figure 1, along with Earth and Mars model atmospheric spectra and the solar spectrum for comparison.

Eleven absorption features were detected in our Mars spectra. Six were attributed all or in part to Mars atmospheric CO₂ or CO (2.052, 2.114, 2.151, 2.331, 2.356, and 2.365 μm). Four others were interpreted as evidence for telluric (H₂O, CH₄) or possibly solar/stellar spectral contamination (2.316, 2.384, 2.414, and 2.432 μm). One band at 2.297 μm appears to be mineralogic in origin. Three of the bands (2.331, 2.356, and 2.365 μm) appear to have widths and depths that are consistent with additional, non-atmospheric absorptions, although a solar contribution at these wavelengths and at 2.297 μm cannot be entirely ruled out.

Our data provide no conclusive identification of the mineralogy responsible for the absorption features we detected. However, examination of terrestrial spectral libraries and previous high spectral resolution mineral studies [e.g., 20, 21] indicates that the most likely origin of these features is either CO₃²⁻, HCO₃⁻, or HSO₄⁻ anions in framework silicates or possibly (Fe, Mg)-OH bonds in sheet silicates. If the latter is correct, then an explanation for the extremely narrow widths of the cation-OH features in the Mars spectra as compared to terrestrial minerals must be

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devised. One possibility involves dehydroxylation [22], but this situation has not yet been fully examined spectroscopically. Unfortunately, we can provide no conclusive resolution of the debate over scapolite on Mars. Our data [23] apparently confirm earlier observations by [7] that there are subtle, narrow absorption features in the Martian K band spectrum that cannot be explained solely by atmospheric absorption. We do not favor assigning a specific mineralogy at this time based on these bands because (a) our understanding of the spectral nature of many other minerals at such high spectral resolution is lacking; (b) we cannot be certain that the stellar and solar spectra are not introducing artifacts; and (c) placing stringent constraints on surface mineralogy from spectrally limited data may not prove consistent with other observational, geologic, or geochemical constraints gleaned from previous spacecraft and telescopic data.



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