
Earth-based telescope reflectance spectra (0.3–2.6 μm) of numerous small (200–400 km diameter) regions as well as the integral disk of Mars were obtained in 1969, 1973, and 1976 using photoelectric filter photometry (1, 2), photometric imaging (3) and CVF IR spectroscopy. Each of the spectra show distinct electronic absorption bands that contain information about surface mineralogy.

Bright areas and dust clouds. The 1973 bright area (fig. 1) and dust cloud (fig. 2) spectra are very similar between 0.3 and 1.1 μm. Each has an intense absorption feature at the blue-UV end of the spectrum with slope changes at 0.50–0.57 and 0.6 μm, and a weak absorption band centered between 0.83 and 0.90 μm. The blue-UV feature is slightly more intense in the dust cloud spectra than in the bright area spectra, which is probably due primarily to scattering properties of suspended dust vs. surface powder. Also, the weak 0.83–0.90 μm band is centered closer to 0.9 μm in the dust cloud spectra than in the bright area spectra.

The 1969 bright area spectra (0.3–1.1 μm) (fig. 3, spectra 1–3) are similar to the 1973 bright area and dust cloud spectra, except that the blue-UV absorption feature was not as intense in 1969 and a weak absorption band was centered near 0.93–0.97 μm instead of between 0.83 and 0.90 μm. Several percent variations in the intensity of the blue-UV feature and the variable appearance of weak bands at 0.83–0.90 μm and 0.93–0.97 μm have been observed in spectra of the bright area Arabia during previous oppositions (1), and it suggests a temporal variation in surface mineralogy in at least some bright areas.

The intense blue-UV absorption feature with slope changes at 0.6 μm and 0.50–0.57 μm is characteristic of the spectrum of soils containing several percent ferric oxide. The intense blue-UV absorption arises from a pair of 02+→Fe3+ charge transfer bands centered near 0.34 μm (1t1u→2t2g) and 0.40 μm (6t1u→2t2g). The slope changes at 0.6 μm and 0.50–0.57 μm arise from Fe3+ interelectronic transitions at 0.62 μm (6A1g→6T2g), and 0.53 μm (Fe2O3) – 0.45 μm (FeOOH) (6A1g→6A1g, 6F2g). A third (weaker) absorption band occurs at 0.84 μm (Fe2O3) – 0.89 μm (FeOOH) due to the 6A1g→6T1g transition in Fe4+. The absence of the 6A1g→6T1g band and the strength of the blue-UV feature in the 1969 spectra indicates that the ferric oxide content of the average soil in those areas did not exceed 6% (4). The occurrence of a band at 0.83–0.90 μm and stronger...
blue-UV feature in the 1973 bright area and dust cloud spectra suggest that the average ferric oxide content of these soils was a few percent higher than in the 1969 areas. The ferric oxide in the 1973 dust cloud material was apparently more hydrated than the soils on the surface in the 1973 bright areas, as indicated by the differences in the centers of the \( \text{Fe}^{3+}\) band (5).

The occurrence of the 0.93-0.97\(\mu m\) band in the 1969 spectra indicates the presence of pyroxene in the surface soil (6). This band is also apparent in some of the 1969 dark area spectra (see below), but not in the 1973 bright area or dust cloud spectra. We interpret these observations as evidence for a multicomponent soil in at least some bright areas: (1) a fine-grained dust that contains several percent ferric oxide and no detectable pyroxene; and (2) a more coarse-grained pyroxene-bearing soil. The fine-grained component comprised the 1973 dust clouds, and it effectively masked any ferrosilicates that may have been contained in the 1973 bright areas. In the 1969 bright areas the ferrosilicate masking was less effective.

Dark Areas. The 1969 (fig. 3, spectra 4-7) and 1973 (fig. 4) dark area spectra differ substantially from the bright area spectra in several important ways. The dark area spectra show a strong broad near-infrared absorption feature that extends from 0.8\(\mu m\) longward. The shape of the near-ir feature varies from spectrum to spectrum, indicating regional variations in surface mineralogy. An intense blue-UV feature appears in the dark area spectra, as in the bright area spectra, but it is significantly less intense. Note that the blue-UV feature is stronger in the 1973 dark area spectra than in the 1969 dark area spectra. The level of atmosphere dustiness was greater in 1973 than in 1969, and the stronger blue-UV feature was probably due to greater contamination by the ferric oxide-bearing dust.

Relative reflectance spectra of the dark areas (fig.5) reveal that the near-ir absorption features are composites of bands centered near 0.87\(\mu m\), 0.93\(\mu m\), 0.96\(\mu m\), and 1.05\(\mu m\) in various proportions. The 0.87\(\mu m\) feature appears only in spectra with strong blue-UV features, and it is probably due to contaminant dust. The 0.93 and 0.96\(\mu m\) features are most likely due to pyroxenes, while the 1.05\(\mu m\) band is probably due to olivine or basaltic glass (6). For most of the areas observed, olivine (or glass) is more abundant than pyroxene. The abundances of magnetite and ilmenite are difficult to estimate, although they probably do not exceed \(\sim 10\%\).
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Infrared spectra. Infrared spectra of the integral disk of Mars taken during 1976 (fig.6) reveal the 0.83-0.90μm ferric oxide band and 0.90-0.96μm pyroxene feature. An absorption band at 1.22-1.25μm is tentatively attributed to feldspar. This feature was observed in 1969 infrared spectra of the bright area Arabia and dark area Syrtis Major (fig.7) but the feature was much stronger in the Syrtis Major spectrum, considering the differences in albedo. The coappearance of the feldspar and pyroxene bands in the spectra, and the relative weakness of the feldspar band in the bright area spectrum suggest that the feldspar is probably contained in the more coarse-grained ferrosilicate soil than in the fine-grained dust. The occurrence of feldspar in the dust component cannot of course be ruled out, however. Future higher-spatial resolution infrared spectra should resolve this. Other features in the 1976 integral disk spectrum (fig.6) are the broad H₂O ice absorption bands at ~1.6μm and ~2.0μm, superimposed on the narrower CO₂ bands at ~1.6μm and ~2.0μm. Higher spatial resolution spectra are needed to determine the origin of the ice features.

The Earth-based spectra reveal that reflectance spectra measured from orbit could provide information on regional variations in petrology and surface ice distribution on a scale of several kilometers.

References

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