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ANALYSIS OF PYROXENE ABSORPTIONS OBSERVED IN MARTIAN DARK REGIONS

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Introduction. We have investigated the mineralogy of the Martian dark regions by analysis of the pyroxene Fe^{2+} absorption band near $1.0\mu m$ in a set of VIS/NIR reflectance spectral images. The data used for these analyses were selected from a larger set, extending from 0.44 to $1.02\mu m$, obtained during the close 1988 opposition [1] and covering substantially all of Mars south of $40°N$. This data set is being used in regional mapping of spectral parameters related to surface mineralogy. Martian dark regions are of interest in reconstructing the geologic history because they contain exposures of unaltered or little-altered basaltic crustal material; mapping differences in composition among dark regions could reveal regional or temporal variation in magmatic activity or mantle source composition. Two types of dark regions are seen, with the pyroxene band present and absent; where present, the inferred composition is in the range pigeonite-augite to very high-Fe, low-Ca pyroxene, with a two-pyroxene mixture possible.

Continuum. An important issue in determining the depth and center of spectral absorption bands is the continuum, defining the limits of the band. With our data ending just beyond $1\mu m$, the long-wavelength end of the $1\mu m$ band was not well constrained. In order to obtain band parameters from our data, we constructed a continuum based on the brightness/continuum slope relation in other martian telescopic spectral observations [2,3] extending over the full range of the 1-micron band. A variety of continua were tried, yielding similar results.

Derived Band Center and Depth. The band center in the $1\mu m$ region was determined by dividing the $0.75\mu m$-$1.01\mu m$ segment of each spectrum by the linear continuum and fitting a quadratic curve to the divided spectrum. The band center was taken to be the minimum of the quadratic fit. Band depth was computed for all spectra using the same presumed band center of $0.95\mu m$; tests showed that band depth changed little with presumed band center over 0.92-$0.97\mu m$. No correlation was seen between computed band center and band depth within the limits of our analysis. When only dark regions having pyroxene bands were considered, the band center ranged 0.92-$1.0\mu m$ (mean $0.96\mu m$) and the depth 0-10% (clustered near 8% for low-latitude dark regions). Note that pyroxene bands with centers beyond about $1.0\mu m$, if they occur, cannot be determined from these data. The range in band center suggests a variation in pyroxene composition, which will be investigated with regard to regional correlations. Acidalia Planitia (20-$40°W$, 30-$70°N$) is a dark region which shows no pyroxene band; this result is consistent with a weaker or longer-wavelength band characteristic of basaltic glass. Oxia Palus, an equatorial dark region showing spectral characteristics similar to Acidalia, has slightly longer band centers (0.99-$1.0\mu m$) and lesser band depths than other dark regions.

Band Center and Mineralogy. If we assume that the band is due to one optically dominant pyroxene, following Cloutis and Gaffey's relation [4] the composition associated with a band center near $0.96\mu m$ ranges from moderate in calcium and iron to very iron-rich *(Figure 1)*. According to Adams' work [5], this band center suggests a pigeonite-augite composition with >10% Ca, but his data are sparse in this region. A two-pyroxene mixture is not excluded and may be likely for material with the observed band center. High-Mg, low-Ca,Fe pyroxenes are excluded by both systems for our entire range of band centers (0.92-$1.0\mu m$). The band center and inferred pyroxene composition are consistent with those reported for other telescopic spectra [3] and Phobos 2 ISM data [6]; the ISM data show notably deeper bands, likely due to less spectral mixing with surrounding regions at the instrument's higher spatial resolution.

References:
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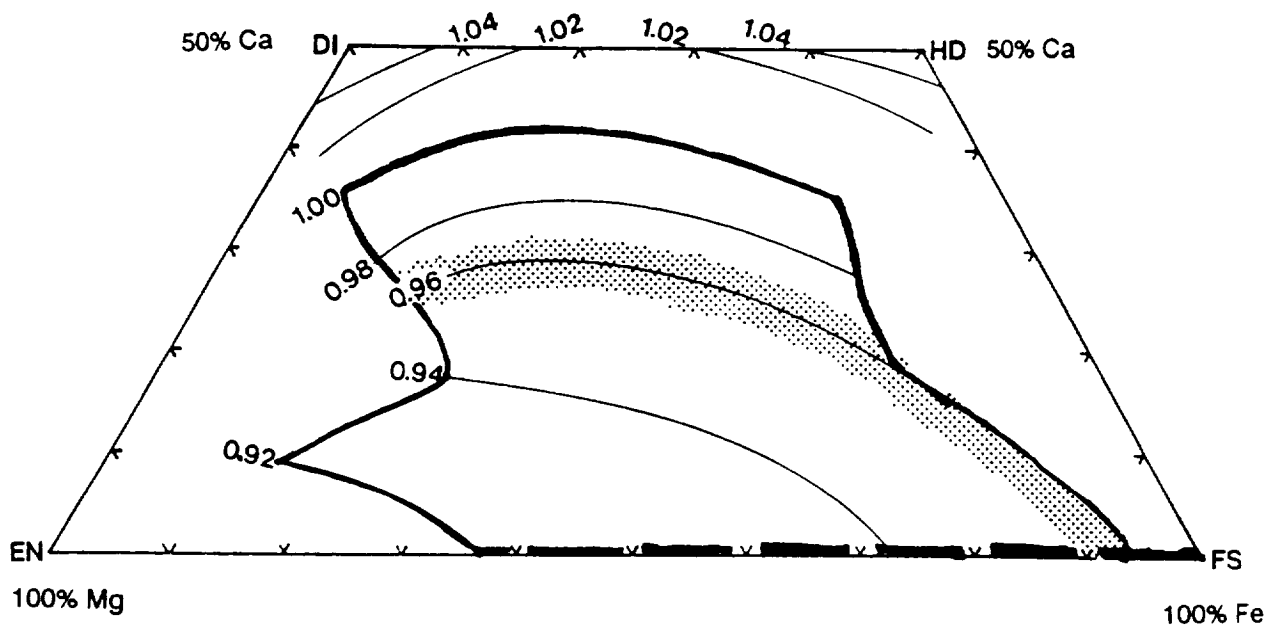
Figure 1. Range of inferred martian pyroxene compositions shown on pyroxene tetralateral. Heavy line outlines compositions based on full range of pyroxene band centers observed in our data (0.92-1.0μm), stippled area is for most commonly occurring band centers (near 0.96μm). These interpretations are based on the assumption of a single optically dominant pyroxene for each spectrum. Based on figure 15 of Cloutis and Gaffey, 1991 [4].