EVIDENCE FOR A GLOBAL COMPOSITIONAL DICHTOMY ON MARS

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The north-south morphologic and age dichotomy is a profound aspect of Mars geological history. Yet there has been limited evidence for compositional variations which correlate with this geometric division. This has been interpreted by many to indicate that each major surface unit on Mars are globally distributed, largely homogenized, and generally unrelated to the underlying crust. Recent evidence, however, has shown that this is not the case: there is significant regional and local compositional variation around the planet (e.g. Bell et al. JGR 95 1990; Singer et al. Bell AAS 22 1990; Singer and Miller LPI 92-02 1991; Muehle et al. JGR 98 1993; Mereney et al. JGR 1993; Mereney et al. Icarus submitted, 1993). The manifestations of these variations in remotely-sensed data are often subtle. We conclude, however, that a global compositional pattern is emerging. This result is based on the synthesis of various recent results by us and others, with emphasis on a series of visible and near-IR (0.4 - 1.0um) spectral images obtained by us during the 1988 apparition (Singer et al. LPSC XXI 1990).

In summary, both high and low albedo materials currently exposed in the ancient highlands show more bulk crystalline hematite, implying weathering or other alteration which proceeded further towards equilibration than in most of the lowlands. This may be a consequence of exposure age, but might also be related to differences in geologic processes and/or climate. Northern plains low-albedo regions, such as Acidalia Planitia and the southern Palus, are also different in their mass composition than observed low-albedo regions on older terrains. Near-IR Fe²⁺ pyroxene bands are observed centered between 0.92 and 0.99um for highland exposures, while Acidalia, a large rocky plain in the northern lowlands, does not show a band minimum shorter than 1um (where our data end). Various interpretations are possible for Acidalia, but we cannot yet choose among these with available data.

What is clear, however, is that there is now evidence for compositional differences which correlate with the long-known global morphologic dichotomy on Mars. We can also conclude that: a) the surface of Mars has not been completely resurfaced and homogenized by aeolian action; b) not all heavily weathered deposits are the same as each other or the global dust. Arvia, in particular, appears compositionally different from the highland region; c) the composition of at least some of the basaltic lavas in the northern plains differs markedly from those to the south.

High Resolution K-Band Spectroscopy of Mars during 1990 and 1993

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High spectral resolution telescopic observations of Mars were obtained during the 1990 and 1993 oppositions from Maui's Keck Observatory. During 1990, the RTF-CGS spectrometer was used to observe ten 500-km regions at a spectral resolution of 1200-1500 from 2.10 to 2.47um [1]. These data were obtained simultaneously with near-IR imaging spectroscopic measurements discussed elsewhere [2]. During 1993, the UKIRT CGS spectrometer was used to obtain multi-pixel slit images of Mars at a spectral resolution of 1500 from 2.04 to 2.46um. The 1990 data range from 500-1000 km spatial resolution and encompass about 70 spectra in total. Flux calibration (within ±20%) of both of these data sets has been performed using IR standard stars.

Many interesting absorption features can be seen in these data sets. Most prominent are the strong CO₂ K-band branch near 2.05um and a weaker CO₂ band near 2.15um. Also, a broad band in the 2.3 to 2.4 um region can be seen and is attributed to atmospheric CO₂. The presence of these features in our flux calibrated data will allow us to accurately model the relative contributions of the Martian atmosphere and surface. As well the presence of both strong and weak absorption bands may allow us to quantitatively derive dust opacity during both oppositions [2,3].

Less prominent absorption bands are also seen in the data, and these features are tentatively assigned to mineralogical silicates or rocks on the surface and in the atmosphere. These bands are seen in both the land and water-exposed regions. These data sets have been published in Table 1, along with the so-called "scopoline" bands observed by Clark et al. during the 1988 opposition [4]. There is enough overlap among the data sets from different oppositions to indicate that the features observed outside the Martian atmospheric CO₂ region are probably real and are probably due to Martian basaltic and/or bicarbonate-bearing minerals, as proposed in [4]. Features observed inside the CO₂ region require additional modeling of adequately separate the gaseous and solid mineralogical components (i.e., 5). There is evidence in a few of the spectra for weak features near 2.20 and 2.35um, consistent with previous interpretations of weak pyrohliptoidite and/or bicarbonate absorptions in these regions in [4,6]. More specific mineralogical inferences from all of these data will be possible only after more detailed modeling and understanding (not "removal") of Mars atmospheric absorptions.

Search for Small Scale Ferric Oxide Mineral Deposits on Mars

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In preparation for the arrival of Mars Observer, we have begun a program of systematic examination of the Viking Orbiter multispectral imaging data for evidence of color anomalies indicative of ferric oxide mineralization. The motivation for this study is the interpretation of color images obtained by the Viking orbiter. The spatial extent of the Viking orbiter data is limited, so that it is necessary to search for smaller scale anomalies at or below the resolution of the Viking orbiter data. The spatial resolution of the Viking orbiter data is limited to about 300 km. A distinct coloration is associated with the absorption edge of Fe²⁺ in hematite at 0.53um, and coincides with the Viking green filter center wavelength [4,5].