THE SEARCH FOR IGNEOUS MINERALS AT THE VIKING LANDER SITES;
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The Viking mission to Mars clearly advanced our understanding of the characteristics of the Martian surface. On the other hand, not a great deal of information has yet been extracted about the mineralogy of surface materials from Viking data. The Orbiter experiments largely provided information on physical properties; even the Orbiter color imaging data are of use primarily to map variations in color from place to place. The Lander experiments provided information primarily on soil chemistry (X-ray data), together with some information on the reactive characteristics of the soil (biology data) that can be interpreted in terms of models of soil mineralogy. The only experiment designed to detect minerals directly was the magnetic properties experiment. The Viking Lander six channel (0.4 to 1.1 micrometers) images offer the best data in terms of mapping variations in broad spectral reflectance properties of materials about the landing site.

We generated cubic spline fits to the six channel data by substituting spline basis functions for the spectral reflectance terms inside the integrals describing the Lander camera detector outputs (1). Since the basis function coefficients (e. g. polynomial coefficients) are not wavelength dependent, they can be extracted from the integrals, leaving a vector of known sensor outputs, a matrix of terms involving products of known terms, including solar irradiance, camera transfer functions, and calibration constants, and a vector of unknown coefficients. Simple matrix techniques can then be used to solve for the coefficients. The coefficients can then be used to construct a continuous function describing the spectral reflectance term. The basis function technique takes advantage of both the spectral breadth and pattern of the camera transfer functions, providing more information than can be obtained by six point estimates of reflectance. We generated these functions for each pixel for a number of six channel scenes at regular wavelength intervals and used the data to generate an "image cube". Typically, images in 16 to 31 wavelength channels were generated, making a synthetic "image cube" analogous to spectral images to be returned by imaging spetrometers on the Galileo and MGCO missions.

The six channel data and resultant functions cannot, of course, be used to pick out fine spectral detail in the data because of effects related to spectral resolution and aliasing. On the other hand, we find that the 16 to 31 synthetic images allow new methodologies of data analysis and new information to be gleaned from the data. For example, the images have been displayed in movie form, starting with the blue end of the spectrum and moving toward longer wavelengths with subsequent frames. In addition, spectra have been generated from given pixels or groups of pixels. Both reflectance image cubes and cubes normalized to the response from various patches of soil were generated and examined.

Movies of the normalized image cubes demonstrate a number of contrast reversals between soils and certain rocks. Typically, large, angular rocks are brighter than the soils at shorter wavelengths and darker at longer wavelengths, consistent with the observations of Strickland and Singer(2). We compared the reflectances of various planar surfaces for a large angular rock at the second Lander site to the reflectance of a nearby soil patch. The different rock planes correspond to distinctly different reflectances. Those planes oriented closest to the plane of the soil surface are the brightest at shorter wavelengths and darkest at longer wavelengths as compared to the soil. Thus, while one cannot ignore changes in spectral reflectance due to local lighting and viewing geometry variations, these results clearly indicate that at least this rock exposes materials that have color, albedo, and scattering properties different from the soils.

Extracted spectra show that selected rocks do indeed show less evidence of oxidation (Fe+3) relative to soil spectra and more evidence of Fe+2 in mafic mineral absorption near 1.0 micrometer. There are still spectral indications of some Fe+3, consistent with thin, wavelength dependent, semi-transparent rock coatings, as suggested by Singer(3). The soils, on the other hand, have signatures consistent with strong Fe+3 related absorptions (darker in the blue, and brighter in the infrared). While earth-based spectral observations have shown these compositional relationships for large regions on the planet (>250 km), this is the first direct evidence for the presence of mafic minerals in discrete rocks on Mars. The presence of Fe+2 silicate minerals, and the angular appearance of many rocks, combined with the geological setting of the landing sites, suggest that at least some rocks within the Lander fields of view are hard, crystalline igneous rocks.

REFERENCES

1. F. Huck et al. (1977) J. Geophys. Res., 82, p. 4401-4411.

2. E.L. Strickland and Singer. (1981) LPSC Abstracts, 12th, pp. 99-1001.

3. R. Singer. (1980) LPSC Abstracts, 11th, p. 1045-1047.