OXIDIZED BASALTS ON THE SURFACE OF VENUS: COMPOSITIONAL IMPLICATIONS OF MEASURED SPECTRAL PROPERTIES

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Introduction: Both the reflectance properties and the geochemistry of a few areas on the Venusian surface have been measured by the series of Venera landers. These data, coupled with laboratory reflectance measurements of rocks and minerals at the high temperatures characteristic of the Venusian surface, are used to infer the oxidation state of iron in surface minerals based on observed spectral characteristics.

Reflectance properties of the surface of Venus were measured by the Venera 9 and 10 landing crafts which contained two wide angle photometers, one oriented away from the surface and the other oriented toward it, each with five spectral channels covering the spectral range from about 0.5 to 1.0 µm (1) . The Venera 13 and 14 landers contained multispectral scanners that obtained color panorama images of the surface at three wavelengths in the visible (2). Other experiments on Venera 13 and 14 measured the geochemistry of surface material demonstrating that the surface is basaltic in general character with a FeO content of approximately 9% (3). The mineralogy of the surface is unknown. The oxidation state of surface material is also not certain, although a reducing environment has been suggested from indirect evidence (4). A better description of the current surface environment and mineralogy will set limits to the possible geochemical interactions between surface and atmosphere, essential information for understanding the recent evolution of the planet.

Spectral Reflectance Properties of the Surface of Venus: Five band spectra of the surface obtained by Veneras 9 and 10 are shown in Figure 1 (from 1). The surface at these locations is dark and without significant color in the visible, but exhibits a substantial increase in reflectance beyond 0.7 µm. Possible sources of error in the near-infrared have been seriously considered, and are not expected to alter these measurements substantially. Information from the Venera 13 and 14 panoramas indicate the surface is similarly very dark in the visible (2). Further processing of the panoramas for spectral information (6) has shown both the rocks and soil to be essentially grey (to ± 10%) in these visible channels (wavelengths shown on Figures 1 and 4). Although examination of the spectral character of unknown phases expected for this CO_2 environment have not been completed (e.g. 6),ferric oxides in oxidized basalt would be distinguished by a characteristic ferric absorption edge (7) normally observed near 0.55 µm, as in Figure 2. The combined data for the surface of Venus, however, are not consistent with the typical room-temperature spectra shown in Figure 2 of either unoxidized basalts [which exhibit dark, relatively *flat* continua beyond 0.7 µm, commonly with superimposed ferrous absorption bands] or oxidized basalts [which derive their characteristic 'red' coloration from the ferric absorption edge *near 0.55 µm*].

Laboratory Reflectance Measurements at High Temperatures: The strength, and often energy, of absorption features is known to be affected by temperature. Many measurements have examined low temperatures (7,8) with application to Mars and asteroids. Significant variations also noted at elevated temperatures (e.g. 9) indicate that only high-temperature spectra should be used for interpretation of the Venera data. Recent laboratory (RELAB) measurements have shown this to be critically true for the ferric oxides: the characteristic absorption edge moves more than 100nm to longer wavelengths from 25 to 500°C (Figure 3). This is most likely due to broadening of intense charge transfer absorptions at shorter wavelengths.

Discussion and Conclusions: Venera reflectance data are compared in Figure 4 with high temperature spectra of the same basaltic materials in Figure 2. The dark, flat unoxidized basalts are still inconsistent with the Venera data in the near-infrared. Basaltic material with a ferric component, however, would satisfy both the increase in reflectance beyond 0.7µm as well as the dark, relatively colorless character in the visible. We therefore conclude that basaltic surfaces of Venus represented by these measurements either contain minerals with uncommon characteristics, or, more likely, are relatively oxidized.

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References. 1) Economov et al, 1980, *Icarus, 41*, p65; 2) Selivanov et al, 1983, *KOSM. ISSLED 21*, no.2, p 176, p183; 3) Surkov et al., 1984, PLPSC 14, *JGR,89*, B343; 4) Florensky et al. 1983, LPS XIV p203; 1983 *KOSM, ISSLED, 21*, no.3, p351; 5) Pieters et al., 1985, Bull. Am Astr. Assoc.17, no 3,p722; 6) J. Gooding, Planetary Geology reports (unpublished); 7) Morris et al, 1985, *JGR,90*, no. B4, p3126; 8) Singer and Roush, 1985, *JGR*, in press; 9) Osborne et al., 1978, PLPSC 9th, p2949; Shankland et al., 1979, *JGR, 84*, no. B4, p1603; Parkin et al., 1980, LPS XI, p854.

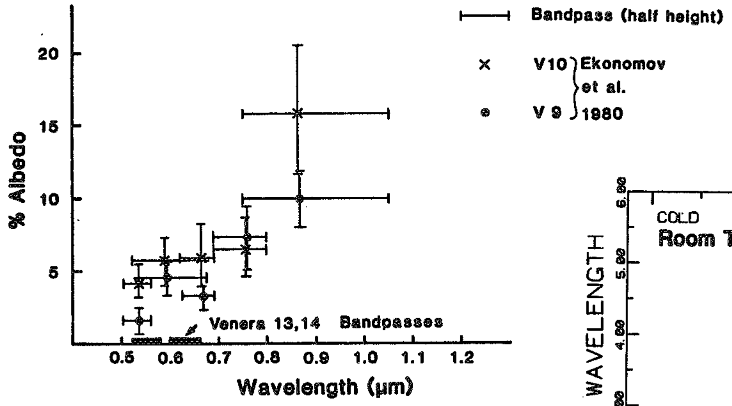

Figure 1. [left] Reflectance properties of the Venusian surface at the Venera 9 and 10 landing sites (from Economov et al., 1980). The bandpasses for the Venera 13 and 14 cameras are shown at the bottom of the figure.

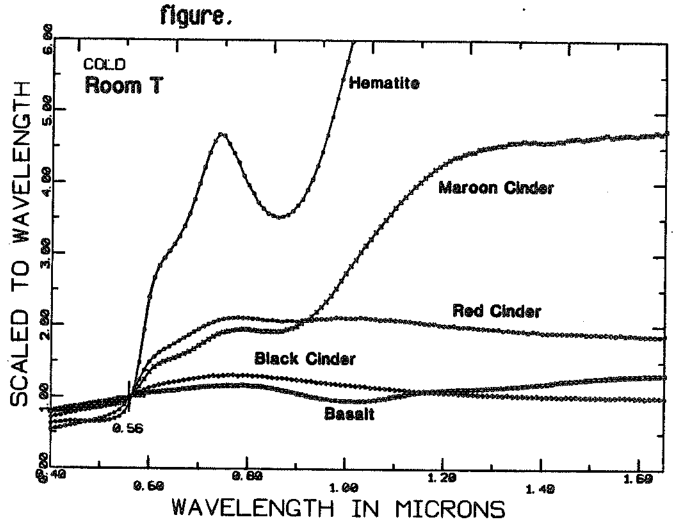

Figure 2 [right]. Reflectance spectra (0.4 to 1.6 µm) of typical basaltic materials at 25°C. The 'Basalt' is a tholeite from Taos, NM; the three cinders are from Mauna Kea, HI. The 'Red Cinder', 'Maroon Cinder', and Hematite exhibit the characteristic absorption edge near 0.55 µm due to ferric iron.

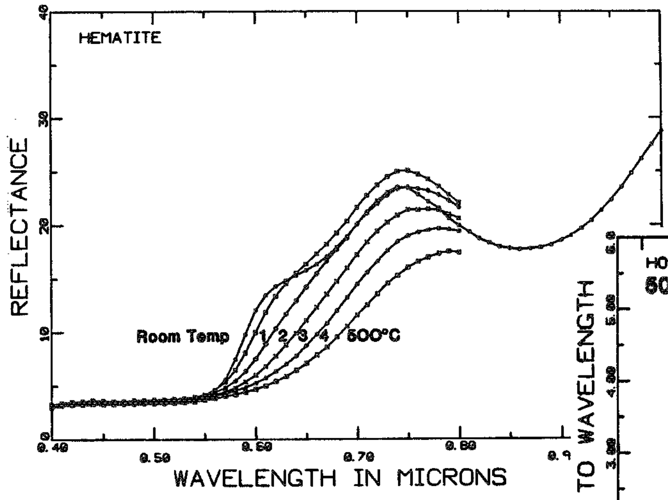

Figure 3 [left]. Reflectance spectra (0.4 to 0.8 µm) of the ferric oxide hematite at temperatures ranging from room temperature (25°C) to 500°C. The trends observed are reversible. [Note wavelength scale is expanded compared to Figs 1,2,4.]

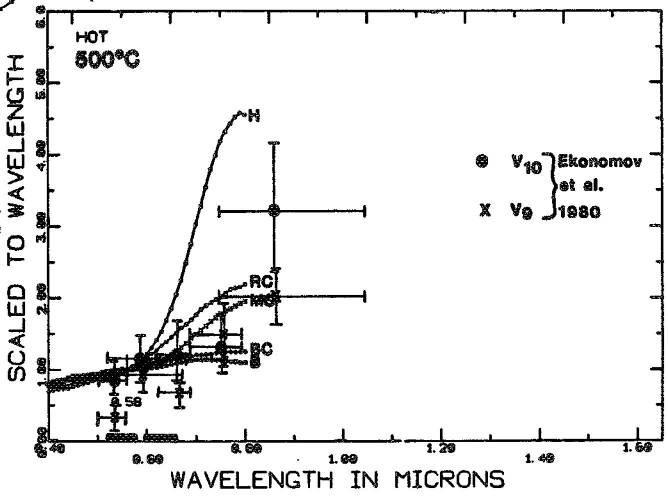

Figure 4 [right]. Reflectance spectra (0.4 to 0.8 µm) of the same basaltic materials at 500°C. Due to the high reflectance in the near-infrared, only ferric containing basaltic material is consistent with the Venera spectra.