Fig. 2. Venera 13 color panorama for the surface of Venus. (Upper panel) This reproduction is similar to that originally published (*11*) and is comparable to the actual appearance of the scene at visible wavelengths. The orange hue is due to the diffuse incident radiation from which blue radiation has been efficiently removed by the thick Venus atmosphere. (Lower panel) The same color panorama data reprocessed to remove the effects of the strongly colored incident radiation. This image represents the surface of Venus as it would appear in "white light" illumination, that is, without the interference of an atmosphere.

face material, we have examined the reflectance properties (0.4 to 0.8 μm) of various basaltic materials from room temperature to 500°C at the Reflectance Experiment Laboratory at Brown University (*26*). Only minor spectral changes were observed for materials with very little original coloration, such as the unoxidized basalt and black cinder measured at room temperature. Dramatic spectral changes, however, occur for oxidized basaltic materials that contain a significant ferric component.

Shown in Fig. 1C are a series of reflectance spectra for the ferric oxide hematite. The electronic transition (crystal field) Fe^{+3} bands, seen near 0.65 and 0.86 μm of the room temperature spectrum, weaken for the hotter samples. As sample temperature increases, the Fe-O charge transfer absorption edge moves toward the near-infrared wavelengths. Visually, hematite is almost black at 500°C. All of the oxidized basaltic material exhibits the same color change with temperature. The ferric absorption edge that normally occurs in the visible (causing the red coloration) shifts to longer wavelengths, removing the spectral contrast in the visible. At 500°C, the dark ferric materials are red only at near-infrared wavelengths. Reflectance spectra of the basaltic samples at 500°C are shown in Fig. 1D and are compared to the Venera spectra. For the temperatures of Venus, the high reflectance of the Venusian surface near 0.9 μm is not consistent with the characteristics of ferrous minerals. Basaltic material with a ferric component is most consistent with the measured surface spectra. Since these results indicate that near-infrared measurements are the key to distinguishing ferric and ferrous material, comparable unprocessed data from other Venera missions may provide important information.

In summary, analysis of the Venera 13 multispectral images shows the rocks and soil of the Venusian surface to be dark and without significant spectral contrast in the visible portion of the spectrum. These data agree with previous values of spectral reflectance measured in the visible by the Venera 9 and 10 wide-angle photometers. Since laboratory reflectance measurements of basaltic materials at high temperature indicate that both ferric- and ferrous-bearing materials are without strong color at visible wavelengths, resolution of the oxidation state of iron in the basaltic materials of the Venusian surface requires additional information at longer wavelengths. Reflectance data for the surface of Venus in the near-infrared from the Venera 9 and 10 wide-angle photometers indicate an increase in reflectance beyond about 0.7 μm. At the surface temperatures of Venus, common ferrous basaltic material does not exhibit an increase in reflectance in the near-infrared, whereas basaltic materials that contain significant ferric components, such as hematite, have an absorption edge in the near-infrared and exhibit such an increase in reflectance at longer wavelengths. The comparison of laboratory data with the Venera 9 and 10 spectra thus suggests that oxidized materials exist on the surface of Venus. This may indicate a distinctly oxidizing environment for the surface of Venus.

If an atmospheric composition similar to that of the troposphere is assumed for the near surface [CO_2, 96.4% by volume; CO, 7.2 parts per million (ppm); H_2O, 20 to 160 ppm; SO_2, 130 ppm; and S_2, 13 parts per billion], thermodynamic considerations predict the mineral composition of the surface to be reduced and to contain the ferrous-bearing mineral magnetite (*27*). The visible data for the surface would be consistent with this composition. The near-infrared data for the surface, which suggest the presence of the more oxidized ferric mineral hematite, however, are not consistent with the thermodynamic equilibrium predictions. At least two explanations for these observations are possible. First, the Venera 13 surface contains primary oxidized material, but the surface mineralogy has not reached equilibrium with the more reducing atmospheric environment. Second, the atmospheric conditions at the surface are in fact oxidizing. Future experiments and considerations, including the possibility of metastable phases, should focus on the resolution of this problem.

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