

REFLECTANCE SPECTROSCOPY OF PALAGONITE, ALUMINOUS PHYLLOSILICATE, GLASS AND FERRIC OXIDE MIXTURES: IMPLICATIONS FOR SURFACE COMPOSITION OF BRIGHT MARTIAN SOIL; *Gabriele Arnold, Janice Bishop, Ulrich Schade, and Richard Wäsch;* DLR, Institute for Planetary Exploration, Planetary Physics Section, Rudower Chaussee 5, 12489 Berlin, Germany

Laboratory near infrared reflectance spectra of mixtures containing Hawaiian palagonite, aluminous phyllosilicate, and obsidian are studied in order to evaluate the spectral properties of Martian bright soil. Most of the palagonites show an absorption at 2.2 μm indicating a small content of crystalline aluminous clays. Many of the bright regions on Mars also exhibit a weak absorption near 2.2 μm and a band near 0.9 μm that indicates the presence of ferric oxide. Spatial heterogeneities of the spectral properties of Mars have been discussed on the basis of various lithologic models. In order to simulate the appearance of the 2.2 μm Al-OH vibration feature of the crystalline phyllosilicate in glasses diffuse reflectance spectra of fine-grained obsidian and iron-rich bentonite mixtures were studied. In contrast to the palagonite obsidian does not show an absorption band in the near infrared spectrum. In the obsidian-bentonite mixtures a 2.2 μm band with a depth exceeding 1 % spectral contrast appears for mixtures containing 10 wt-% bentonite. This band can also be partially masked by other phases present in the soil. It becomes two times weaker for mixtures containing obsidian with 10 wt-% bentonite and 10 wt-% hematite. The 2.2 μm band is discernible in this ternary mixture with a depth of 1% spectral contrast only if the content of bentonite increases up to 20 wt-%. These spectral analyses imply that the presence of high concentrations of iron-rich crystalline aluminous phyllosilicates can not be excluded in the bright regions of Mars. Laboratory measurements of Mars analog material including salts and other ferric oxihydroxides are under way. Such experiments are essential to understand the nature of the absorption bands in reflectance spectra of the surface material within spectra of some of the bright areas on Mars.

Introduction. The lithological models for the Martian bright regions are based on spectroscopic observations, X-ray data at the Viking lander sites [1] and analysis of SNC meteorites [2]. Recent analyses of ISM data suggest the presence of crystalline aluminous phyllosilicates [7, 12]. Spatial variations of some spectral properties indicate that bright soil does not constitute a single lithology [7]. Interpretation of these spatial variations requires laboratory studies of analog materials. Two major lithologies are proposed as analog materials: ferric montmorillonites including nanophase hydrated ferric oxides [3, 4], and ferric palagonites [5, 6]. Spectral properties of these analogs resemble the spectra of some regions on Mars. Laboratory spectra of palagonite and iron-rich montmorillonite mixtures were analyzed first by Orenberg and Handy [8]. Reported here are the analyses of near infrared reflectance spectra of mixtures containing iron-rich bentonite, hematite and obsidian. Spectral detection of crystalline clays in a highly amorphous matrix is the focus of this work.

Method. The samples were prepared using a jaw breaker and a ball mill. The chemical and mineralogical compositions were obtained from x-ray fluorescence and diffractometry analyses. The particulate samples were dry sieved into a particle size fraction below 25 μm . The hematite particles are below 5 μm . Each mixture was carefully homogenized by stirring. For spectral measurement the samples were filled into 7-mm-deep steel sample dishes and levelled with a straightedge. The reflectance spectra were acquired at 8 cm^{-1} resolution in the range between 1.4 and 10 μm using a Bruker IFS88 Fourier transform spectrometer equipped with a Harrick reflectance attachment, a MCT detector and a multiple sample carousel built at the DLR. The spectrometer and the sample chamber are purged by dry air. This results in similar H_2O concentrations in the spectrometer and the sample chamber, but does not remove the adsorbed water from the samples. Diffuse reflectance of the samples were retioed to those of an infragold standard.

Results and discussion. Fig 1 displays some of the Hawaiian palagonite spectra typically used as Mars analog material in the spectral range between 1.4 μm and 2.5 μm . Fig. 2 shows the reflectance spectra of obsidian, iron-rich bentonite and their mixtures in the same spectral range. The feature at 1.9 μm is due to bound and adsorbed water [9, 4]. The weak 2.2- μm -feature in the reflectance spectra of bentonite and its mixtures is a combination band of structural OH in aluminous phyllosilicates [9, 4]. Recent telescopic observations of Mars [10] as well as analysis of ISM data from the Phobos 2 missions [7] suggest the presence of an absorption band near 2.2 μm . Most of the Hawaiian palagonites also exhibit a weak band at 2.2 μm indicating small amounts of crystalline clays. In mixtures of palagonites with crystalline phyllosilicates these bands are superimposed. In contrast to the palagonite

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obsidian is nearly a gray radiator in this wavelength range. The 2.2- μm -band first becomes detectable for a bentonite content of 10 wt-% in amorphous obsidian (Fig. 2 c). The hematite exhibits an average reflectance of about 8 % in the near infrared. In the spectra of ternary mixtures the 2.2- μm -band is weakened additionally by the presence of hematite. This band is two times weaker for a mixture containing 80 wt-% obsidian, 10 wt-% bentonite and 10 wt-% hematite in comparison to a binary mixture of 90 wt-% obsidian and 10 wt-% bentonite. The 2.2- μm -band becomes discernible with a spectral contrast of 1 % if the content of the crystalline clay exceeds 20 wt-%. On the Martian surface the 2.2- μm -band can also be weakened by other surface soil constituents. Ultra fine-grained, highly absorbing materials would reduce the spectral contrast to even a greater extent. Therefore a band exhibiting spectral contrast of only 1 % in spectra of the Martian bright soil may indicate a higher content of the crystalline component.

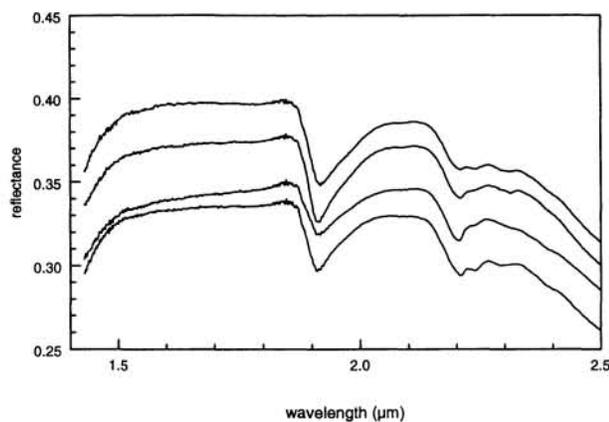


Fig. 1: Reflectance spectra of four different Hawaiian palagonites.

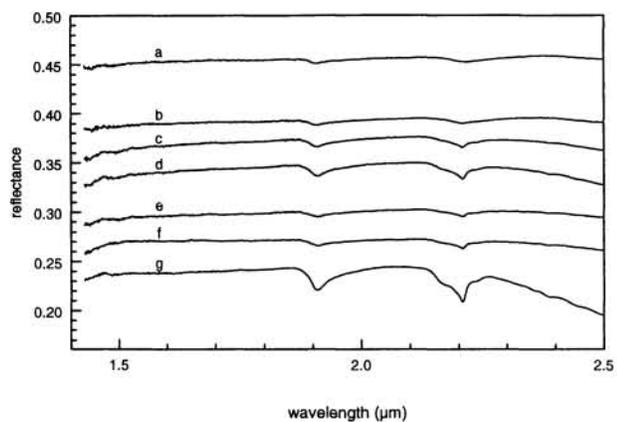


Fig. 2: Reflectance spectra of fine-grained obsidian (a), bentonite (g), 5 wt-% bentonite in obsidian (b), 10 wt-% bentonite in obsidian (c), 20 wt-% bentonite in obsidian (d), 10 wt-% bentonite and 10 wt-% hematite in obsidian (e), 20 wt-% bentonite and 10 wt-% hematite in obsidian (f).

Conclusion. NIR reflectance spectra of Hawaiian palagonites show a weak absorption band at 2.2 μm indicating the presence of crystalline aluminous phyllosilicates. In the spectra of mixture containing obsidian, iron-rich bentonite and 10 wt-% hematite this band appears with a spectral contrast of about 1 % only if the bentonite content exceeds 20 wt-%. The content of crystalline clay in the Martian bright soil may be on the same order where this 2.2- μm -feature appears in the Martian spectra with a similar contrast. The low spectral resolution of the ISM measurements does not allow establishment of the correct wavelength position of this band; however, spectroscopic observations of Mars from 2.04 to 2.44 μm have shown weak narrow bands centered at 2.278 μm and 2.296 μm [11]. The most likely origin of these features is proposed to be either (bi)carbonate, (bi)sulfate anions in silicates (scapolites ?) or (Fe, Mg)-OH features in clays. Ongoing analysis of visible and near infrared reflectance spectra of these materials, and new mixtures containing other ferric oxihydroxides and salts will extend these preliminary results.

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