

## The Emissivity of Pyrrhotite/Basalt Mixtures at Venusian Temperatures

S.T. Port<sup>1\*</sup>, A. Maturilli<sup>2</sup>

<sup>1</sup>University of Arkansas, Fayetteville, AR, 72701; ([saraport@email.uark.edu](mailto:saraport@email.uark.edu))

<sup>2</sup>Planet. Res., DLR, Rutherfordstrasse 2, 12489 Berlin, Germany

**Introduction:** An abrupt decrease in emissivity has been observed on several highland regions on Venus [1-3]. Researchers have suggested that perhaps a loaded dielectric can cause the low emissivity signal [1-3]. Pyrrhotite (Fe<sub>7</sub>S<sub>8</sub>), a common mineral in basalt, has been discussed as a possible source [3], and could be the dielectric mineral. However, the emissivity of a loaded dielectric has never been obtained at Venusian temperatures. Using the spectrometer at the DLR we studied the emissivity of varying concentrations of pyrrhotite in basalt at the NIR atmospheric windows on Venus.

**Methods:** Experiments were completed in the Planetary Emissivity Lab at the DLR. The tested samples were basalt, 98 vol% basalt – 2 vol% pyrrhotite, 80 vol% basalt – 20 vol% of pyrrhotite, and pyrrhotite. All samples were ground and sieved to 212-280 μm. We used a Bruker Vertex 80V spectrometer to obtain the emissivity of various mineral mixtures at three different temperatures representative of Venus: lowlands (460°C), mid-elevation (420°C), and highlands (380°C). The observed wavelengths were between 0.85-2.5 μm. After the completion of the experiments all samples were analyzed with an XRD to observe any changes to their composition.

**Results:** The emissivity of basalt decreases from 380°C to 420°C, but increases to a greater emissivity than the spectra obtained at 380°C when heated to 460°C. Pyrrhotite has a lower emissivity than basalt between ~1.3-1.75 μm, with the lowest recorded emissivity being 0.76-0.79, depending on the temperature. As temperature increases the spectra shifts to higher emissivity and shorter wavelengths. In the 98 vol% basalt – 2 vol% pyrrhotite mixture the emissivity decreases from 380°C to 420°C, then increases to a higher emissivity at 460°C. The emissivity obtained at 420°C and 460°C have lower emissivity than the basalt spectra taken at the same temperatures. The spectra obtained at 380°C is the only one that has a higher emissivity than its corresponding basalt spectra. Overall the emissivity of the 80 vol% basalt – 20 vol% pyrrhotite was higher than the corresponding basalt spectra. Though pyrrhotite and basalt have very different spectra, the basalt/pyrrhotite mixtures spectra did not diverge in shape from the basalt spectra.

XRD analysis revealed the formation of pyrite, magnetite, and hematite in the pyrrhotite sample after heating. Pyrrhotite, nor the previously mentioned minerals, could not be detected in the basalt/pyrrhotite mixtures.

**Discussion:** Though the sample was in a vacuum, some oxygen was still present which resulted in the formation of iron oxides. The loaded dielectric theory does not hold for pyrrhotite mixtures with 20 vol%. The only two instances where the emissivity decreased was in the 98/2 mixtures heated to 420°C and 460°C. The lack of pyrrhotite and the increase in emissivity in the 80/20 mixtures points to the formation of some mineral with a lower dielectric constant than pyrrhotite. The shifts in the pyrrhotite spectra was either caused by a change in temperature, composition, or both. The drop in emissivity at 420°C in the basalt and basalt/pyrrhotite mixtures is due to a mineral that is present in the basalt and is not related to pyrrhotite.

**Conclusion:** Our results demonstrate that mineral and mineral mixtures play an important role in emissivity. The emissivity of pyrrhotite/pyrite/iron oxide mixtures have a very distinct emissivity and can be distinguished from basalt between 0.9-1.25 μm. The data obtained here can be used to compare with similar data collected from future orbiters sent to Venus.

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