

EFFECT OF ALUMINUM SUBSTITUTION ON THE REFLECTANCE SPECTRA OF HEMATITE

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INTRODUCTION

Terrestrial remote sensing makes extensive use of multispectral imagery. Geologic units or terrains frequently are found to be delineated in false color representations or band ratio images. Generally, ground truth is required to identify dominant minerals and rock types in a particular unit. In some cases, regional rock types are known, and spectral units can be correlated with known spectra from laboratory experiments.

Iron oxides and oxyhydroxides are a class of minerals important in remote sensing applications. Spectra of supposedly pure iron oxides and oxyhydroxides are prevalent in the literature, although usually the compounds studied are not well-characterized as to chemical purity, particle size and shape, and other factors which may affect their spectral behavior. In addition to pure compounds, it is also important to know the extent impurity-ion substitution in these minerals affects their spectral properties. In the natural environment, aluminum substitution for ferric iron is likely to occur. Sommer and Buckingham (1981) report that the near-IR crystal field band of hematite and goethite shifts to longer wavelengths with aluminum substitution. On the other hand, Evans and Adams (1980) concluded that aluminum content does not have a significant effect on the reflectance spectra of synthetic gels containing ferric iron and aluminum. We report here some results of our study of the changes in the spectral properties of hematite due to aluminum substitution.

EXPERIMENTAL

Our approach was to conduct parallel synthesis of hematite and aluminous hematite under nominally the same conditions so that in as much as possible, aluminum content was the only variant in the starting materials and procedures. Briefly, two solutions were prepared from iron and aluminum sulfate salts; one had Al/Fe = 0 and the other Al/Fe = 0.25. Addition of excess base caused a precipitate to form. After repeated washings with neutral water, they were hydrolyzed in neutral water at $\sim 100^{\circ}\text{C}$. The precipitates were again washed, then dried in air, and finally heated in air at $\sim 560^{\circ}\text{C}$.

The diffuse reflectance spectra were recorded on a Cary-14 configured with a 9-inch diameter integrating sphere.

RESULTS AND DISCUSSION

The diffuse reflectance spectra of the two powders are shown in the

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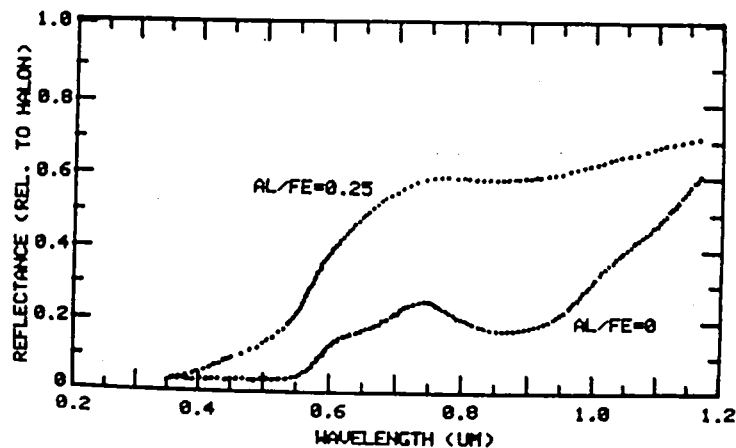
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figure for the region between 0.35 and 1.20 μm ; they are labeled according to the Al/Fe ratio. They are very different in their spectral signatures; visually, the Al/Fe = 0 powder is a very dark red while the Al/Fe = 0.25 powder is tan. The spectral features for the Al/Fe = 0 powder correspond to those for hematite, and X-ray diffraction confirms this phase. The near-IR based minimum for the Al/Fe = 0.25 powder is shifted longward by about 0.02 μm and is much more shallow; this powder is amorphous to X-rays so we cannot confirm the phase by this method. The longward shift of the band minimum is in agreement with Sommer and Buckingham (1981). The Al/Fe = 0.25 powder is considerably more reflective shortward of $\sim 0.55 \mu\text{m}$ where the Al/Fe = 0 powder is very strongly absorbing. This is important since the visible slope and the red shoulder are often used in the construction of false color and band ratio images.

In conclusion, our studies confirm the findings of Sommer and Buckingham (1981) that the reflectance spectrum of hematite can be modified (very strongly for our case) by aluminum substitution. Thus, the aluminum content of target media should also be considered as a variable in the interpretation of their spectral properties.

REFERENCES

- Evans D. L. and Adams J. B. (1980) Amorphous gels as possible analogs to martian weathering products. Proc. Lunar Planet. Sci. Conf. 11th, 757-763.
- Sommer S. E. and Buckingham W. F. (1981) The role of geological surfaces in determining visible-near infra red spectral signatures. IEEE IGARSS, June 8-10, Washington, D. C., 603-607.



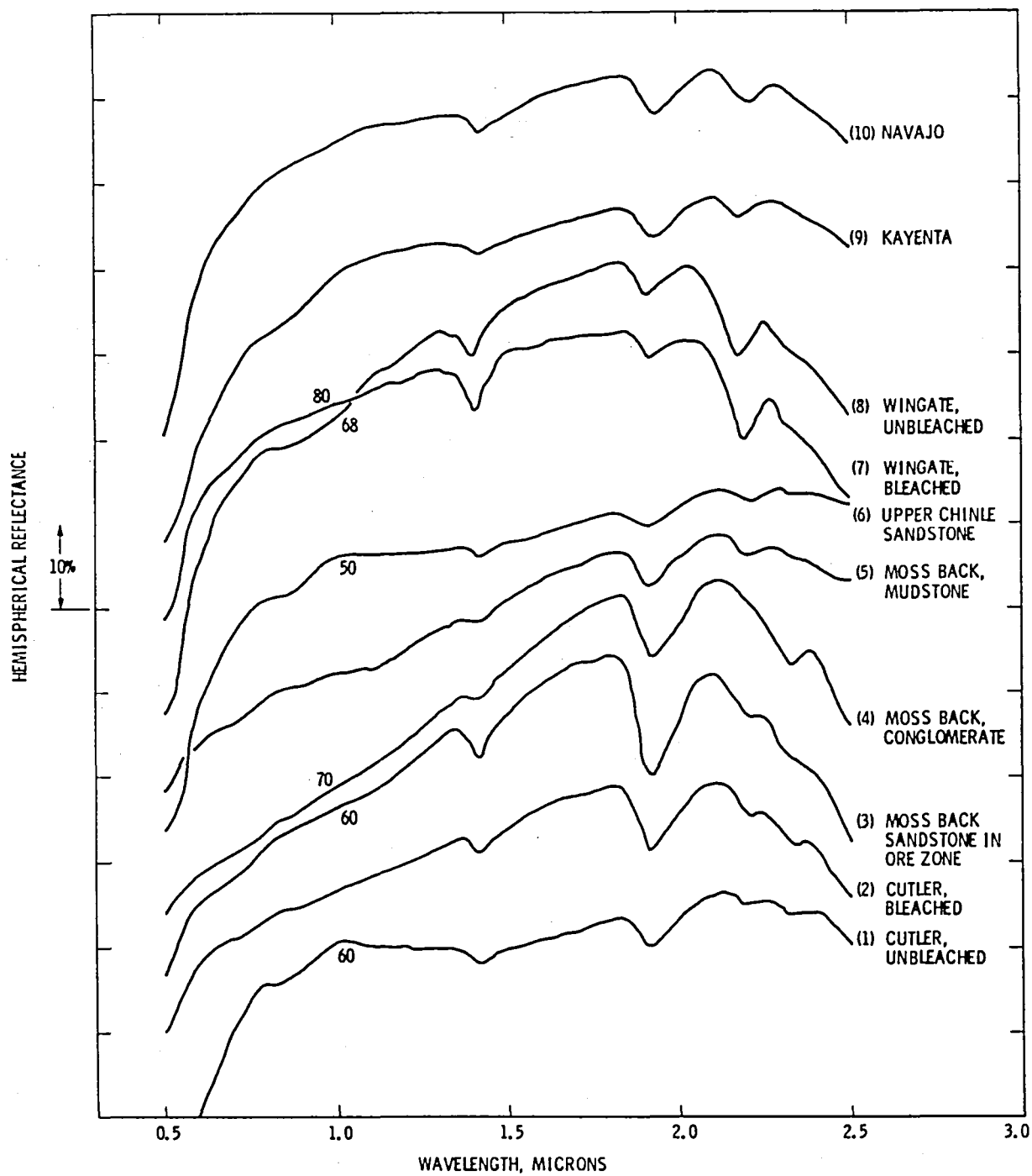


Figure 1

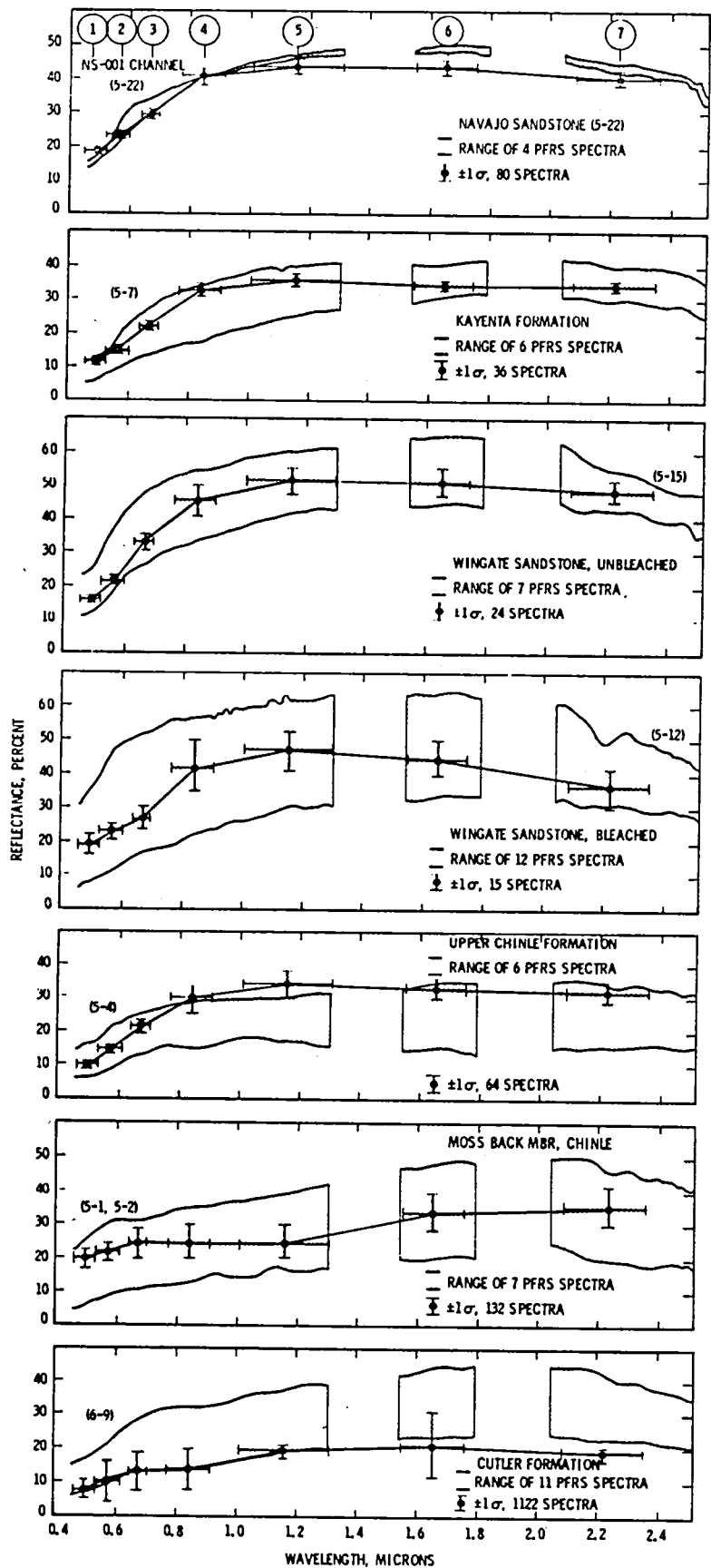


Figure 2