

SPECTRAL REFLECTANCE PROPERTIES OF SOME BASALTIC WEATHERING PRODUCTS. E. A. Cloutis, University of Winnipeg, 515 Portage Ave., Winnipeg, MB, Canada R3B 2E9, e.cloutis@uwinnipeg.ca.

Introduction: Basalt is one of the most widespread rock types in the inner solar system [1]. It can weather to form a variety of alteration products; the nature of these alteration products are a function of the specific conditions present during alteration, as well as the composition of the initial basalt. Detection of specific alteration products on specific targets (e.g., Mars, asteroid) would enable us to place constraints on the conditions prevalent during this alteration. In order to facilitate detection of basaltic alteration products, the spectral reflectance properties of a number of known basaltic alteration products, which have not been previously characterized are presented here.

Experimental Procedure: The reflectance spectra of the following minerals which form due to the alteration of basalts are presented here: beidellite, gyrolite, halloysite, hisingerite, and iddingsite. Reflectance spectra (0.3-26 μm) of <45 μm fractions of the samples were measured at the NASA RELAB facility at Brown University [2]. The spectra were measured at $i=30^\circ$ and $e=30^\circ$ (0.3-2.6 μm) and $i=30^\circ$ and $e=30^\circ$ (2.6-26 μm) relative to halon and brushed gold reflectance standards. Compositional data was provided by X-ray fluorescence and wet chemistry (for ferrous iron abundance) [3]. Loss on ignition (LOI) was determined by heating the sample to 950°C in air for 60-90 minutes [3] (Table 1).

Sample	Fe ₂ O ₃ wt.%*	FeO wt.%*	Al ₂ O ₃ wt.%*	LOI (wt.%)
BEI101	5.24	0.18	22.74	12.86
HAL001	0.44	0.00	45.46	16.29
HIS001	30.53	0.00	5.71	14.63
IDD001	3.47	5.61	3.61	0.15

- - wt% on a volatile-free basis

Results:

Beidellite (BEI101): Beidellite is a Na- and Ca-bearing smectite group clay mineral. Spectrally, this mineral is relatively featureless. In spite of the significant ferric iron content, iron-associated absorption features near 0.7 and 0.9 μm are very weak. This sample also exhibits low overall reflectance. Beidellite normally contains both OH and H₂O, however absorption bands due to these molecules (expected near 1.4 and 1.9 μm) are weak. It exhibits a fundamental O-H stretching feature near 2.95 μm .

Gyrolites (GYR001 and GYR002): Gyrolite is another Na- and Ca-bearing phyllosilicate, containing both OH and H₂O. Compositional analysis is not yet complete for these samples. Spectrally, the gyrolites exhibit weak to nonexistent iron-associated absorption features (Figure 1). Both samples exhibit OH- and H₂O-associated absorption features near 1.4 and 1.9 μm , as well as strong fundamental O-H stretching bands in the 2.95 μm region.

Halloysite (HAL001): Halloysite is a polymorph of dickite-kaolinite, ideally containing only OH. The ideal composition does not contain any transition series elements, but the sample used in this study only contains a small amount of ferric iron (Table 1). Spectrally, the halloysite exhibits high overall reflectance, and the absorption bands are all attributable to fundamentals, combinations, and overtones of O-H stretching and bending vibrations, as well as an Al-OH associated feature near 2.2 μm (Figure 2). This suggests that this sample contains some adsorbed water.

Hisingerite (HIS001): Hisingerite is a ferric iron-bearing phyllosilicate containing both OH and H₂O. Compositionally this sample contains substantial ferric iron and no detectable ferrous iron. The ferric iron probably accounts for the steep dropoff in reflectance shortward of 0.9 μm , and there is a weak suggestion of a ferrous iron-associated absorption feature near 0.9 μm (Figure 2). It also exhibits absorption bands associated with both OH and H₂O in the 1.4, 1.9, and 2.9 μm regions.

Iddingsite (IDD001): Iddingsite is a common alteration product of olivine. X-ray diffraction analysis showed the presence of olivine, enstatite, and amphiboles, only in this sample. The sample used in this study contains both ferrous and ferric iron and a small volatile content (Table 1). Spectrally, this sample is very similar to a combination of enstatite and olivine, consistent with the XRD results (Figure 2). OH- and H₂O-associated absorption bands are nonexistent at 1.4 μm , and weak in the 1.9 and 2.9 μm regions. In spite of the dark brown appearance of the sample, it appears that the alteration is incipient.

Discussion: The spectra of the various basaltic alteration products are quite diverse. In general the more iron-rich products have lower overall reflectance than low-iron or iron-free samples, although the hisingerite is a notable exception. This suggests that iron content, its oxidation state, and site location all have an impact on overall spectral

reflectance. The presence of ferric iron does seem to result in a greater reflectance dropoff shortward of $\sim 0.8 \mu\text{m}$ (e.g., hisingerite), likely due to metal-O charge transfers [4].

The lack of prominent iron-associated absorption bands in the beidellite and hisingerite spectra suggests that high iron content will not necessarily result in detectable absorption bands. This complements the similar findings of Calvin and King [5].

An Al-OH associated spectral feature is most prominent in the halloysite spectrum near $2.2 \mu\text{m}$. The other Al-bearing samples do not exhibit a prominent absorption feature in this wavelength region, in spite of Al contents similar to halloysite. This suggests that Al site occupancy is a determining factor in the appearance of this band.

The presence of OH- and/or H₂O-associated absorption bands in the 1.4 and $1.9 \mu\text{m}$ appears to be affected by the overall reflectance of the sample. As an example, the beidellite spectrum, whose volatile content (presumably OH and/or H₂O) is similar to hisingerite, does not exhibit prominent absorption bands in the 1.4 and $1.9 \mu\text{m}$ regions. This is likely due to the suppression of absorption bands associated with dark materials [6]. This is similar to the results found for other dark clays [5].

Implications for Mars and asteroids: Calvin [7] suggested that dark clays could account for some Mars dark spectra, as some of their iron-bearing clays do not exhibit 1.4 and $1.9 \mu\text{m}$ absorption bands. The beidellite spectrum also exhibits this type of spectral behavior.

Vilas et al. [8] has suggested that an absorption band seen in the 0.6 - $0.7 \mu\text{m}$ region of some dark asteroids is due to ferric-iron bearing phyllosilicates.

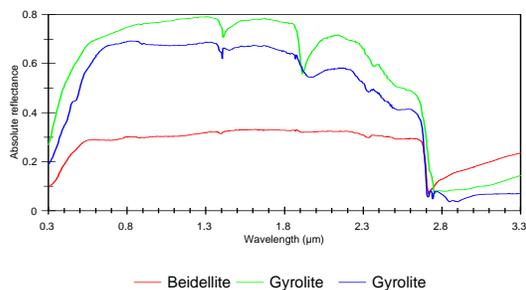


Figure 1. Reflectance spectra of some basaltic alteration products.

While the beidellite spectrum does show an absorption feature near $0.7 \mu\text{m}$, the hisingerite spectrum (containing much more ferric iron, does not. This suggests that the $0.7 \mu\text{m}$ feature in some dark asteroids may be due to only some specific ferric iron-bearing clays and/or some other mineral phase.

Acknowledgements: This study was supported by research grants from the Natural Sciences and Engineering Research Council of Canada (NSERC) and the University of Winnipeg. Thanks to the Smithsonian Institution for providing some of the samples as well as Takahiro Hiroi and Carle Pieters at Brown University for spectral acquisition.

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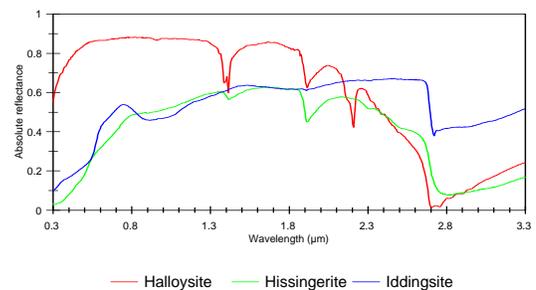


Figure 2. Reflectance spectra of some basaltic alteration products.