

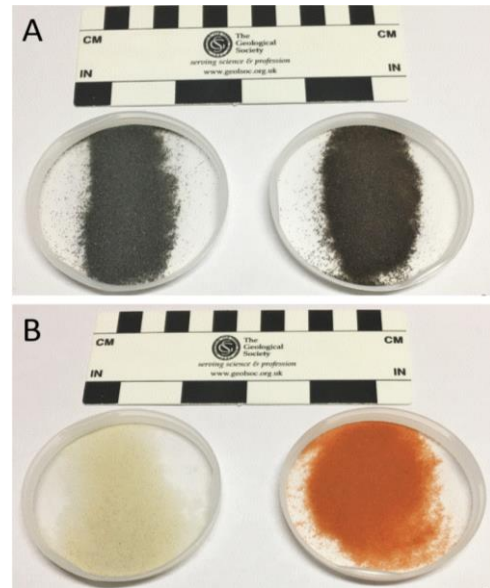
**FERRIC COATINGS AND THEIR EFFECT ON THE SPECTROSCOPY OF SAND GRAINS AS AN ANALOG MARTIAN SOIL.** K. Lapo<sup>1</sup>, M.S. Rice<sup>1</sup>, M. Kraft<sup>1</sup>, S. Mulcahy<sup>1</sup>, and K. Hoza<sup>2</sup>, <sup>1</sup>Western Washington University, Bellingham, WA, lapok@wwu.edu <sup>2</sup>First Mode, Seattle, WA.

**Introduction:** Reflectance spectroscopy is a significant tool that is used to characterize Martian surface mineralogy, but the effects of surface coatings on the spectra of underlying rock are understudied. Ferric dust is ubiquitous on Mars [1] and little is known about how that dust may adhere to rock surfaces or how these coatings affect spectra of Martian rocks and soils. Coatings of loose palagonite dust on basalt non-linearly mask the spectra of the underlying material and spectra of coated surfaces vary with viewing geometry [2]. With the aim of examining these phenomena further, this study employs and expands upon an existing methodology for creating ferric coatings which adheres crystalline goethite and hematite to cristobalite sand [3]. The existing methodology proposes that Fe-O-Si bonds are responsible for the adherence of ferric oxides to sand surfaces [3], making it an ideal method of adhering ferric oxides to silica. This study adheres nanohematite to quartz-dominant sands and expands the method to adhere nanohematite to basalt sand grains (Fig. 1) as an analog for Martian soils. To our knowledge, no study has previously adhered a pure ferric oxide coating to basalt sand or studied the spectral effects of such a coating.

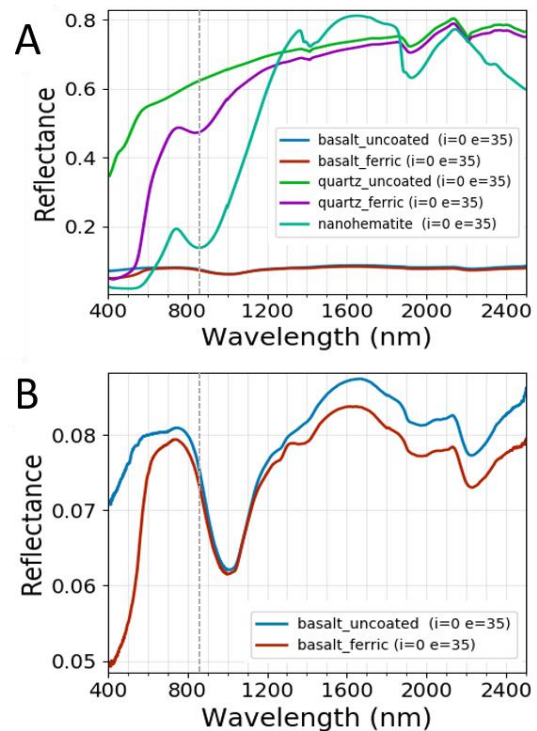
**Methods:** Basalt sand (125-250 $\mu$ m) was made at Western Wash. U. (WWU) by crushing Columbia River Flood Basalt (CRB) from the Grand Ronde Unit.

The ferric coating methodology used in this study was based on [3], which provided an analysis of method variations to adhere crystalline goethite and hematite to cristobalite and quartz sands. A solution of 0.01M NaNO<sub>3</sub> with a pH of 2 was mixed with nanohematite in a custom-built rotator to suspend the hematite in the salt solution. After 24 hours an aliquot of sand was added to the mixture and placed in the rotator for an additional 24 hours. The solution was then decanted from the sand, rinsed with a salt solution matching the initial solution, wet sieved with DI water to remove any unadhered hematite, and dried in an oven.

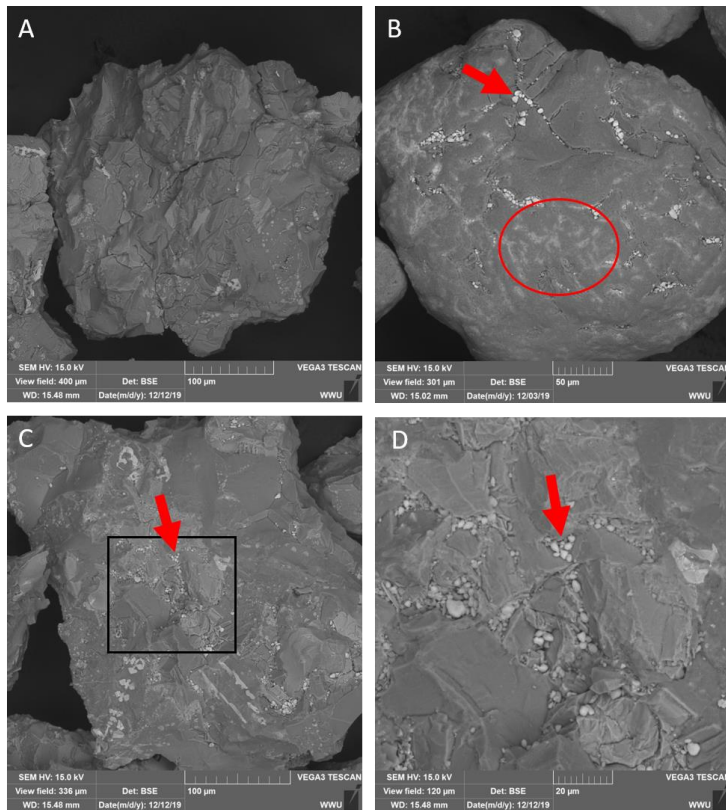
Spectra of all sands were collected using the WWU goniometer and an ASD spectrometer [4]. Coated and uncoated sand grains were analyzed using back-scattered electron (BSE) imaging in a 10 Pa N<sub>2</sub> variable-pressure environment using a Tescan Vega 3 scanning electron microscope. The relative increase in FeO content between coated and uncoated sands was estimated using semi-quantitative energy-dispersive spectroscopy (EDS), using internal standards and a 15 keV beam with an Oxford XMax<sup>N</sup> 80.



**Figure 1:** Visual comparison of (A) basalt and (B) quartz sands. Uncoated sands are on the left and nanohematite coated sands are on the right in both panels.



**Figure 2:** Spectra of sands and nanohematite used to coat the sands at standard geometry ( $i=0$ ,  $e=35$ ). The dashed, gray, vertical line marks the 860nm absorption in hematite. (A) Spectra for all targets. (B) Spectra for basalt sands only to show detail.



**Figure 3:** SEM images [A] Uncoated, angular, lab-produced sand of CRB. [B] Quartz sand with hematite aggregates (red arrow) and diffuse mottled coating (red circle). [C] Hematite-coated sample of CRB sand with hematite aggregates. The black box shows the location of panel D. [D] Detail image of hematite aggregates in the cracks of a CRB sand grain.

**Data:** Preliminary EDS data indicate increases in FeO in coated grains compared to uncoated grains of ~10 wt% for quartz and ~4-5% for basalt sands. BSE images show there is some concentration of hematite as spheroid aggregates in the crevices of individual grains (Fig. 3b, c, d) and EDS shows more dispersed coverage of hematite on some quartz grains (Fig. 3b).

Preliminary spectra were collected for coated and uncoated quartz and basalt sands at two forward scattering geometries ( $i = -50^\circ$ ,  $e = 50^\circ$  and  $i = 0^\circ$ ,  $e = 35^\circ$ ) and two backscattering geometries ( $i = -50^\circ$ ,  $e = -35^\circ$  and  $i = 35^\circ$ ,  $e = 50^\circ$ ). Spectra of coated sand grains show reddening in the visible range (Fig. 2) that is also apparent upon visual inspection of the sands (Fig. 1). Between 700-1200 nm, spectra of coated basalt sand show a stronger absorption feature in backscattering geometries than for uncoated basalt, and uncoated basalt spectra show a stronger absorption feature than coated basalt in forward scattering geometries. Between 700 and 1600 nm, coated basalt spectra exhibit greater reflectances than uncoated basalt spectra in forward scattering geometries, and uncoated basalt spectra show greater reflectances than coated basalt

spectra in backscattering geometries. Initial bandcenter analyses for the absorption feature near 990 nm in coated and uncoated basalt show a measurable but negligible 0-7nm shift shorter in coated basalts than in uncoated basalts.

**Discussion:** Ferric oxides adhere to sand surfaces through Si-O-Fe bonds [3], which provides an explanation for lower rates of hematite adhesion to basalt, where fewer bonding sites exist compared to silica sands. In this study, we observe an uneven distribution of hematite on all sands that differs from the uniform coatings seen in [3]. This may be due to differences in starting materials (type of sand, size of hematite) or the rotational agitation method used in this work. Though the mode of adhesion in this study is uneven, the presence of spheroidal hematite aggregates in basaltic terrains terrestrially and on Mars has been demonstrated by multiple studies (e.g., [5] and references therein), making our lab-coated sands a viable Mars analog.

Based on preliminary data, some metrics show that trends between backscattering and forward scattering geometries are inverse between coated and uncoated basalt grains. We hypothesize that these differences are the result of increased pathlengths through the hematite coating in extreme forward scattering geometries. The iron absorption feature in basalt (~990 nm) was expected to shift towards the hematite absorption feature at ~860 nm in coated basalt, but no such pattern was observed. This lack of shift suggests that bandcenter for the 990 nm iron absorption feature is a poor metric to detect the presence of a hematite coating on basalt. Analyses of spectra from higher angular resolution measurements may provide further insight.

**Future work:** In our ongoing study, we will acquire spectra at a full range of incidence and emission geometries, with high angular resolution, for coated and uncoated basalt and quartz. Additionally, we will extend this work to include spectrogoniometric measurements of silica-coated basalt sand.

**Acknowledgements:** We thank Ben Paulson for his support in the lab and the design of the lab rotary, Vincent Hill of the Western Machine shop for his help with the goniometer, and the Western Mars Lab member past and present for their support.

**References:** [1] Bishop J.L. et al. (2002) *JGR Planets*, 107, E11. [2] Johnson J.R. et al. (2004) *Icarus*, 171, 546-556. [3] Scheidegger A. et al. (1993) *Geoderma*, 58, 43-65. [4] Hoza K.M. and Rice M.S. (2019) *LPS L*, Abstract #2958 [5] Morris R.V. et al. (2005) *EPSL*, 240, 168-178.