VNIR SPECTRAL MASKING EFFECTS OF HEMATITE ON MAFIC MARS ANALOGS. K. E. Lapo*[1] and M. S. Rice[1], A. Eng[1], S. A. Curtis[2], [1]Western Washington University, Geology Department, 516 High Street, Bellingham, WA 98225 *lapok@wwu.edu, [2]Million Concepts, LLC.

Introduction: Iron oxides are near-ubiquitous on Mars in global fine dust and as a major component in many rock coatings [1]. Hematite, in particular, has been an important indicator of diagenetic alteration at Gale and Jezero craters. However, the spectral masking effects of hematite on Martian lithologies have not been well quantified. Understanding the influence of small concentrations of hematite on the spectra of rocks is key for characterizing the mafic mineralogy of many outcrops on Mars.

The Mastcam-Z instrument on NASA's Mars2020 Perseverance rover has characterized widespread Fe-oxides in the floor units of Jezero Crater [e.g., 2]. Mastcam-Z has documented spectra consistent with hematite associated with basaltic outcrop in the Máaz formation, and with ultramafic outcrop in the Séítah formation. Curtis et al. [1] looked at the NIR properties of natural Mars analog surfaces and identified spectral progressions from unweathered to weathered material consistent with increasing hematite (and other Fe-oxides) that masks the underlying lithology. Here, we build upon this work by quantifying the concentrations of hematite required to mask the absorption mafic iron features centered ~900-1000 nm that characterize the visible to near-infrared (VNIR) spectra of basalts and ultramafic lithologies. We make first order recommendations for the interpretation of Mastcam-Z spectra based on our study of how mafic signatures are masked by ferric dust and/or coatings.

Methods: We studied two-phase mixtures of hematite with mafic and ultramafic rocks. We used Mars analog basalts collected at Dry Falls in the Columbia River Basalts of Eastern WA [3], and dunites from Twin Sisters Mountain in Northwestern WA [1]. We ground unaltered interiors of each lithology and sieved to < 125 um. We ground crystalline hematite with a mortar and pestle until red, approximately < 5 um. We combined a series dunite- and basalt-hematite mixtures from 5 to 20 wt. % hematite. Spectra of endmembers and mixtures were collected using a standard contact probe (i = 12, e = 35, az= 0) attachment with a Malvern Panalytical ASD FieldSpec 4 Hi-Res Spectrometer. Spectra were measured as absolute reflectance using a calibrated Spectralon® white reference. Spectra were convolved to Mastcam-Z bandpasses following the method adapted from [3].

Results: Mastcam-Z convolved data is generally consistent with full-resolution data and will be the focus of this analysis unless otherwise noted.

Ultramafic and mafic endmember spectra have negative NIR slopes (figs. 1 and 2), and local maxima at 677 nm for dunite and 800 nm for basalt in full-resolution spectra (figs. 1 and 3). Dunite has a broad olivine absorption centered at 1058 nm in full-resolution data that results in a steep negative slope with a left shoulder at 677 nm. Basalt has a broad pyroxene absorption centered at 1022 nm with a shoulder at 820 nm. The pure hematite spectrum has a positive NIR slope and local maximum at 754 nm (figs. 2 and 3) and the characteristic ferric absorptions at ~530 nm and 860 nm.

With the addition of just 5% hematite, the dunite NIR slope flattens to nearly zero, and becomes positive between 7.5 and 10% hematite, then asymptotically approaches the positive NIR slope for pure hematite (fig. 2a). The basalt NIR slopes, with the addition of hematite, linearly progress towards a flat slope, and 15% hematite with basalt yields a near-zero slope (fig. 2b).

Local maxima change significantly with small additions of hematite (e.g., 5%) to pure dunite and basalt (fig. 3). In Mastcam-Z convolved data, just 5% hematite shifts the local maxima to match that of hematite. There is slightly more subtlety in the full-resolution spectra, but even 5% of hematite is enough to dramatically shift band maxima from 684 nm to 729 nm.

Discussion: We find that small amounts (< 5 wt. %) of hematite in mixture with dunite and basalt can partially or fully mask mafic spectral signatures in data convolved to Mastcam-Z bandpasses. Based on our laboratory analyses, the negative NIR slope due to the olivine in dunite rocks is fully masked by 10% hematite, which yields a positive NIR slope and a local maximum consistent with hematite. Similarly, the mafic absorptions in basalt are fully masked by just over 15% hematite.

These preliminary experiments best simulate mafic and ultramafic grains in Martian soil mixed with fine-grained hematite, and the spectral mixing effects will differ when these phases are intimately mixed in outcrop and/or are layered as in rock coatings. However, these simple mixtures provide initial constraints of the masking effects of hematite on

Mastcam-Z spectra of outcrops in Jezero crater. We suggest Mastcam-Z spectra with flat NIR slope and local maxima near 754 nm are candidates for mafic lithologies partially obscured by hematite.

To expand on this preliminary study, we plan to reproduce this experiment using nanohematite and/or JSC-Mars-1 dust, to simulate contributions from Mars global dust. We will also expand our analysis to include andesite and olivine as a more felsic and a pure ultramafic endmember compositions. Comparison of nanohematite particulates with basaltic sand will be compared to [4]. Ongoing work by [5] at WWU includes the study of the spectral effects of nanohematite coatings on dunite slabs.

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References: [1] Curtis, S. A. et al., (2002) *LPS LIII*, Abstract #2401. [2] Rice, M. S. et al., (2022) *LPSC*, Abstract #2559. [3] Hoza, K. (2019) *Western CEDAR*. [4] Lapo, K. (2021) *Western CEDAR*. [5] Gabbert, M. et al. (2023) *LPSC, this meeting*.

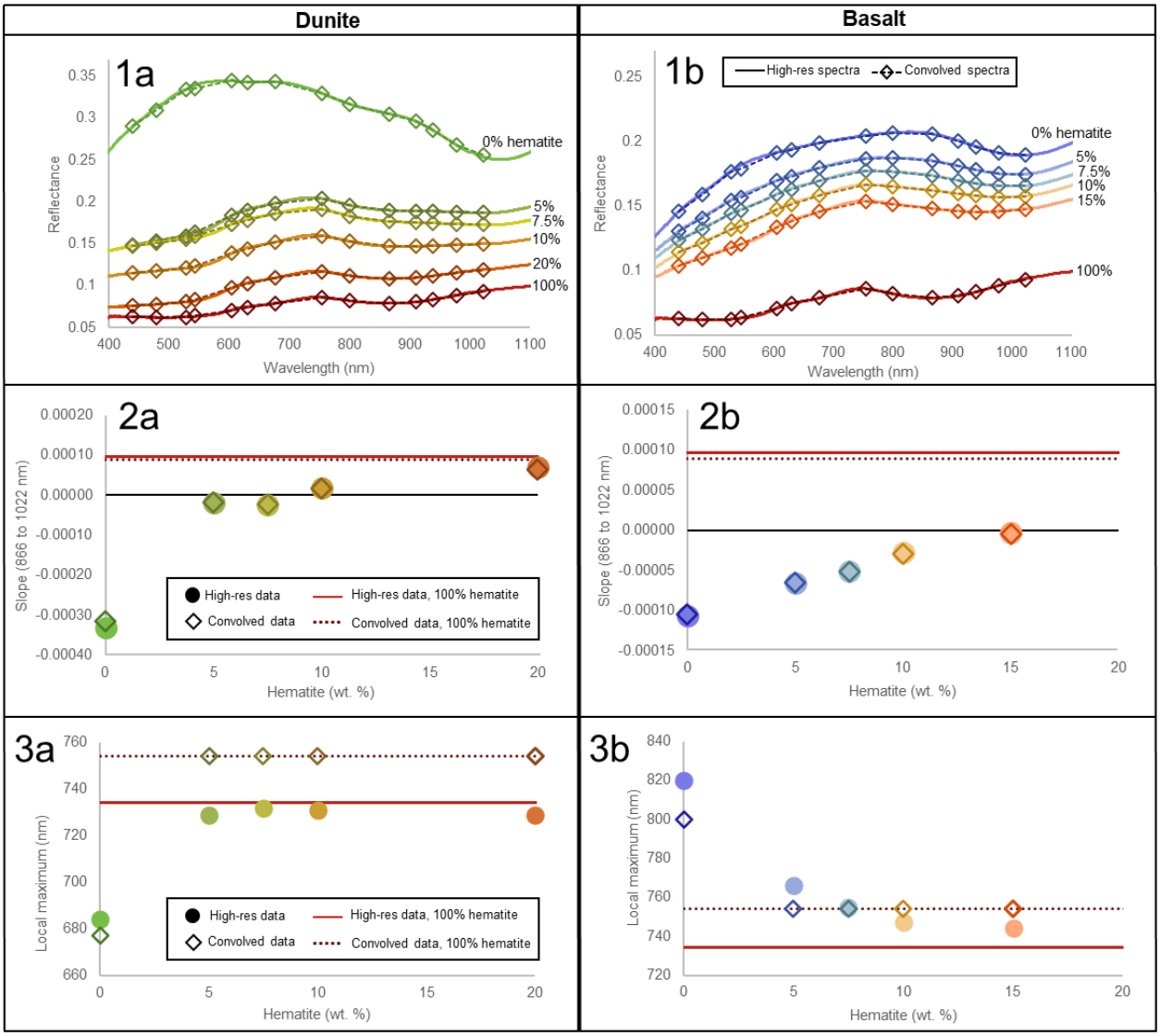

Figure 1: Full-resolution and Mastcam-Z convolved spectra of endmembers **(a)** dunite and **(b)** basalt in mixture with 5 to 20 wt. % crushed hematite, and crushed crystalline hematite. **Figure 2:** Spectral slope between 866 and 1022 nm versus wt. % hematite for **(a)** dunite and **(b)** basalt for full-resolution and Mastcam-Z convolved data. Slope values for 100% hematite are displayed as a horizontal asymptote. **Figure 3**: Local maximum versus wt. % hematite for **(a)** dunite (shoulders at ~550 to 1050 nm, lab; 528 and 1022 nm, convolved) and **(b)** basalt (shoulders at ~590 to 990 nm, lab; 528 and 1022 nm, convolved) for lab and Mastcam-Z convolved data. Maxima values for 100% hematite are displayed as a horizontal asymptote.