QUANTITATIVE COMPOSITIONAL DETERMINATION OF EXTRATERRESTRIAL ROCKS IN THE 4-8 MICRON INTERMEDIATE INFRARED (IMIR) RANGE. C. H. Kremer[1,2], T. D. Glotch[1], and C. M. Pieters[2], [1]Department of Geosciences, Stony Brook University, Stony Brook, NY. [2]Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI (christopher_kremer@brown.edu).

Introduction: Pure mineral samples of olivine and pyroxene exhibit a strong relationship between solid solution composition and the positions of spectral bands in the intermediate infrared (IMIR) range (4-8 µm). These relationships enable quantitative determination of Mg-Fe composition in olivine and pyroxene, as well as qualitative assessment of Ca-content in pyroxene, using band position alone [1,2].

In particulate mixtures with olivine or pyroxene abundances greater than ~50 wt% [3], IMIR spectral bands enable quantification of Mg# with the same accuracy as pure minerals: ±~10 mol% (olivine, low-Ca pyroxene) ±~20 mol% (diopside-hedenbergite), and ±~30 mol% (augite).

Compared with artificial mixtures, a natural rock sample may host a wider range of olivine and pyroxene compositions as well as numerous minor phases. Therefore, applying IMIR spectroscopy to the remote sensing of planetary surfaces requires evaluation of its effectiveness for determination of mineral Mg-Fe composition in well-documented, natural rock samples. As instruments are in development for IMIR measurements on the Moon [4]**,** studying the capabilities of IMIR spectroscopy in lunar-like rocks is necessary. We examine laboratory spectra of: 1) mafic-rich extraterrestrial (including lunar) rock samples and 2) olivine and pyroxene separated from these rocks.

Background: Olivine has major Mg#-diagnostic bands at 5.6 and 6.0 µm, which shift systematically to longer wavelengths with increasing Fe content [1]. The 5.1 and 5.3 µm bands of high-Ca pyroxene and 5.2 µm band of low-Ca pyroxene also shift to longer wavelengths with increasing Fe content [2]. Spectral bands of silicates in the IMIR range are hypothesized to arise as overtones and combinations of fundamental vibrations at longer wavelengths [5].

Materials: We study bulk rock samples and olivine and pyroxene separates derived from **14** extraterrestrial rocks, comprising **9** Mars meteorites, **2** lunar samples, **2** cumulate eucrites, and **1** unclassified achondrite. Mars meteorites include Allan Hills A77005 [6], Allan Hills 84001 [7], Chassigny [8], Lewis Cliff 88516 [9], Miller Range 03346 [10], Nakhla [11], Northwest Africa 2737 [12], Yamato 984028 [13], and Zagami [14]. Lunar samples include returned sample 15058 [15] and meteorite Miller Range 05035 [16]. Cumulate eucrites include Yamato 980433 [17] and Moore County [18]. The final sample is unclassified achondrite Northwest Africa 6693 [19].

Spectra of the sample compilation appear in Fig. 1 and are organized by the most abundant mineral in each sample. The proportions of the most abundant minerals are also noted in parentheses. Rock types in this diverse sample set include dunite, pyroxenite, lherzolite, and cumulate basalt. Samples are particulate and have particle sizes of <25, <45, <50, or <63 µm. We also include data for 7 enstatite chondrite and 5 diogenite samples, which are whole rock samples with particle sizes of <45 µm. See [2] for details.

Methods: Spectra were compiled from the PDS Geosciences Node Spectral Library. Spectra were measured at the NASA Reflectance Experiment Laboratory

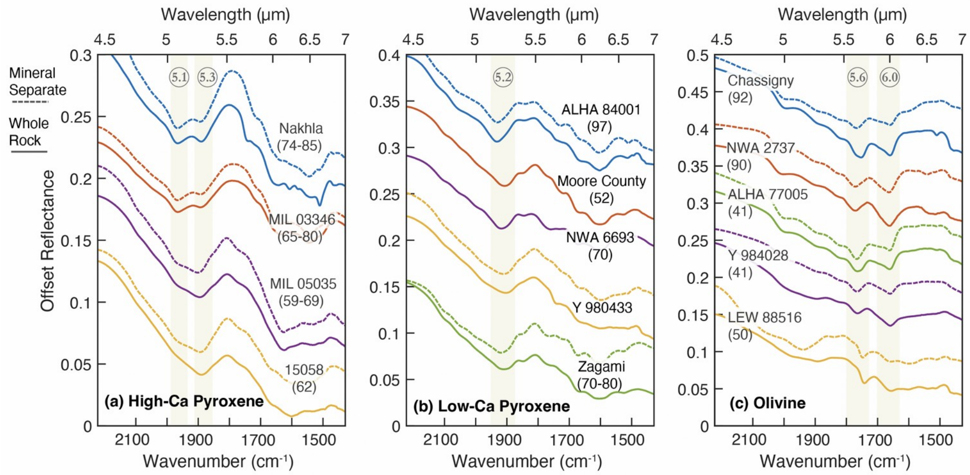

Fig. 1. IMIR spectra of whole rock (solid line) and mineral separate (dashed line) samples derived from extraterrestrial rocks organized by the dominant mafic mineral: (a) High-Ca pyroxene, (b) Low-Ca pyroxene, and (c) olivine. Vol % of dominant mineral in parentheses. Mineral separate corresponds with dominant mafic mineral, excluding LEW 88516, whose separate contains pyroxene.

(RELAB) at Brown University with a Pike diffuse reflectance accessory attached to a Thermo-Nicolet Nexus 870 FTIR.

For each extraterrestrial rock, we use the positions of the IMIR band minima to calculate olivine and pyroxene Mg# using the methods and equations of [1,2]. We do not perform continuum removal on spectra. We then compare Mg# estimates of both the bulk rock and mineral separate to published chemical measurements of the rock's olivine and pyroxene compositions.

For samples with a reported range in solid solution composition for olivine and/or pyroxene, we compare our spectral estimates of Mg# to reported median Mg# or mid-range values of reported Mg#.

Results: The spectra of the bulk rock samples and mineral separates are shown in Fig. 1 and the relationships between Mg# and IMIR band positions are summarized in Fig. 2. For most samples, spectra of the mineral separates of olivine and/or pyroxene strongly resemble those of the bulk rock spectra.

Mg# estimated from IMIR bands in both bulk rock and mineral separates agree with reported chemical measurements, with Mg# errors of 1-22 mol% (high-Ca pyroxene), 1-10 mol% (low-Ca pyroxene), and 0-11 mol% (olivine), well within the errors for IMIR-based Mg# estimates of pure mineral samples. The relationship between Mg# and band position for our samples is shown in Fig. 2.

We also find that the IMIR bands of whole rock samples tend to yield slightly lower calculated Mg# compositions than the mineral separates. This trend resembles that seen in particulate mixtures, where the spectral bands of a given mineral shift to longer wavelengths with decreasing proportions of that mineral, leading to lower modeled Mg# [3].

Conclusions: Our results indicate that IMIR bands provide accurate Mg# estimates in extraterrestrial rocks samples with mafic to ultramafic composition. The mineralogies surveyed here have been previously identified in lunar rock samples or inferred from remote measurements, indicating that IMIR is a powerful tool for remote Mg# determination in lunar rocks.

Acknowledgments: Spectra from RELAB are archived on the PDS Geosciences Node Spectral Library and are available at https://pds-speclib.rsl.wustl.edu/. This work was funded by an NPP to C.H.K.

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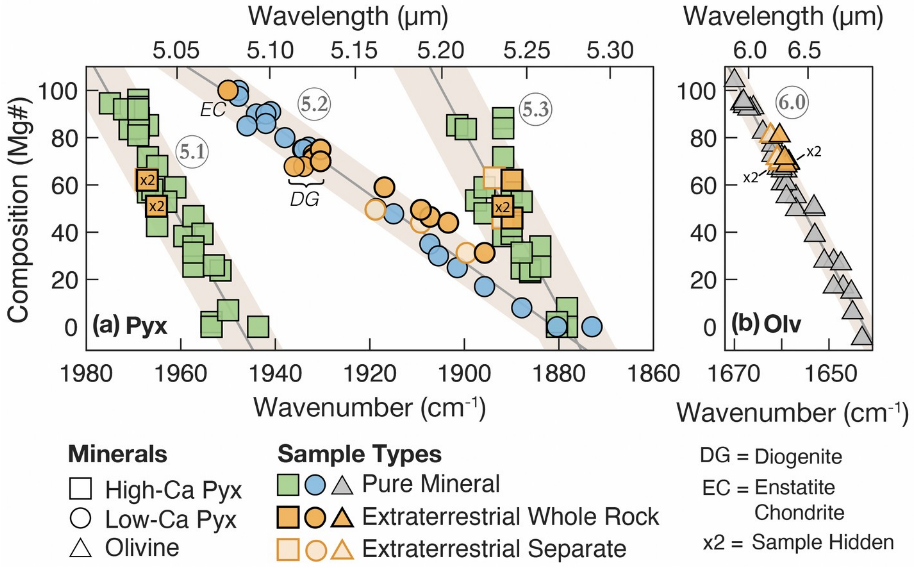

Fig. 2. Summary of the relationship between Mg# and positions of (a) the 5.1 and 5.3 μm bands in high-Ca pyro-xene, the 5.2 μm band in low-Ca pyroxene, and (b) the 6.0 μm band in olivine. Mineral separates and whole rock samples from extraterrestrial rock samples in orange. Diogenite and enstatite chondrite samples discussed in [2] also in orange. Fit lines and 95% confidence intervals (beige) to pure minerals described in [1,2].