Cross-Over (4-8 μm) Infrared Spectroscopy as a Tool to Identify Olivine and Determine Mg# on Mercury's Surface

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BROWN

Pure Olivine

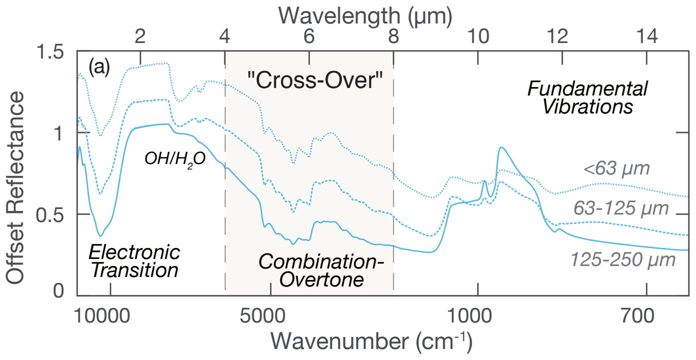

Fig. 1. "Cross-over" Overview. Visible to mid-infrared spectra of San Carlos olivine of varying particle sizes. Physical origins of bands in the different wavelength ranges are noted.

1. "Cross-Over" Range Overview

"Cross-over" is the region where volume-scattering in minerals in VNIR transitions to surface scattering in MIR. Emitted and reflected radiance both significant

•Combination-overtones of vibration bands dominate

•Olivine and other minerals exhibit strong, distinctive bands in the "cross-over" range

•Lab work currently assessing potential for remote sensing. Instrument in development for Moon

2. Olivine Mg#

•Strong, unique olivine bands at 5.6 and 6.0 μm

•Bands are strong in Fe-free olivine

•Olivine Mg# and positions of 5.6 and 6.0 μm bands in laboratory have strong linear relationship

•See Kremer et al. 2020, GRL for more on olivine Mg#

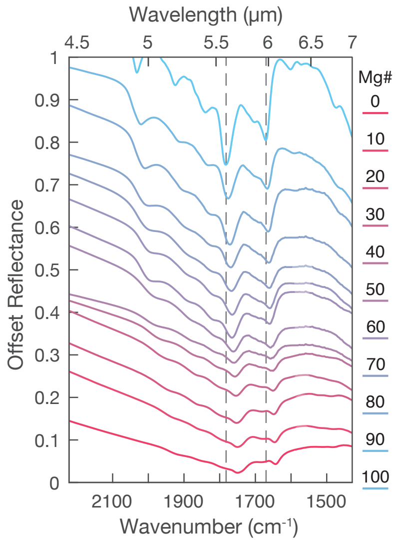

Fig. 2. Olivine Band Trends Reflectance spectra of synthetic olivine in the "cross-over" infrared region. (a) Olivine from the SUNY suite of synthetic olivine (see Dyar et al., 2009). Dashed lines show positions of bands in sample with Mg# =100.

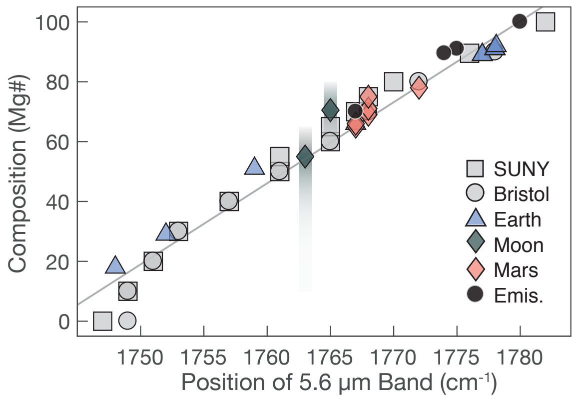

Fig. 3. Olivine Band Trends. Positions of 5.6 μm band in natural and synthetic olivine. Band positions from emissivity spectra are shown with black circles. See Kremer et al (2020) for 6.0 μm band trend and best fit equations.

Other Materials

3. Ongoing "Cross-Over" Work

•Ongoing work focuses on (1) particulate mixtures of forsterite and anorthite and (2) experimental laser irradiation of olivine and other minerals to simulate space weathering

•Olivine signatures at 5.6 and 6.0 μm are strong in mixtures with anorthite

•Space weathering does not appear to affect 5.6 and 6.0 μm olivine bands

•Future lab work on mixtures and SpWe planned

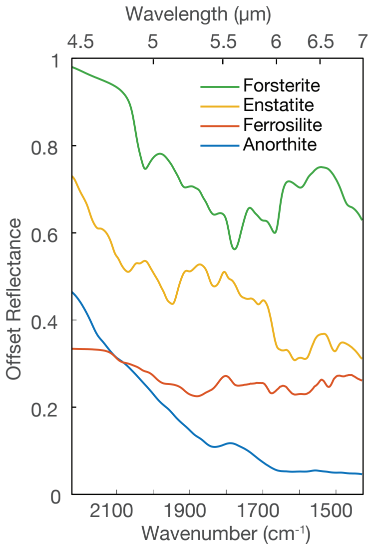

Fig 4. Other Common Minerals. Reflectance spectra of San Carlos forsterite, Miyake-Jima anorthite, ferrosilite, and enstatite.

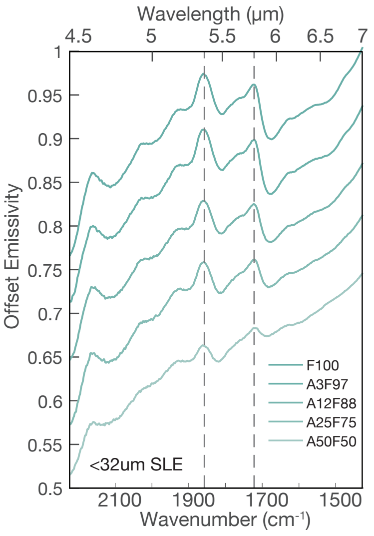

Fig 5. Anorthite and Olivine Mixtures. Emissivity spectra of mixtures of San Carlos forsterite (F) and Miyake-jima anorthite (A) in simulated lunar environment. See Greenhagen et al. (2020) and Kremer et al. (2021a) for details.

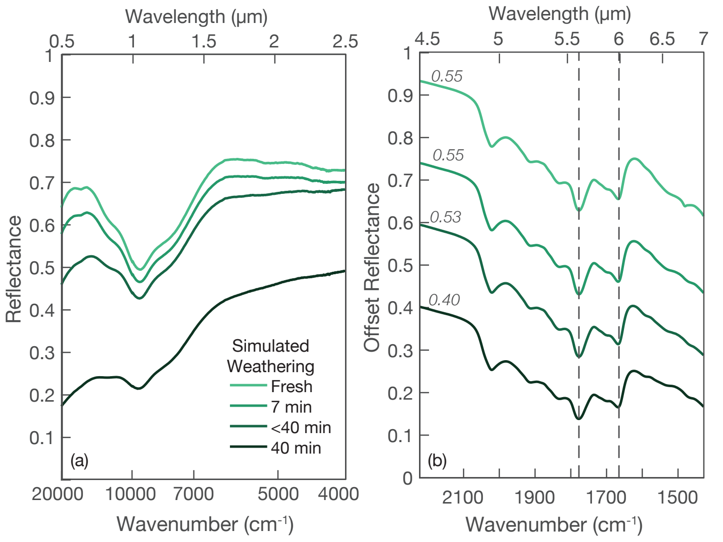

Fig 6. Space Weathering. (a) VNIR and (b)"cross-over" spectra of laser-weathered San Carlos olivine. Absolute reflectance at 4.5 μm of offset spectra given in italics. See Gillis-Davis et al. (2017) for methods and Kremer et al. (2021b) for measurements.

4. Key Points for Mercury

•Olivine detection with unique spectral signature in 4-8 μm range

•Robust, direct Mg# determination with 5.6 and 6.0 μm bands

•Space weathering has modest effect

Collaborators and Data Sources: *Darby Dyar (Mt. Holyoke) measured the synthetic SUNY olivine suite, Ben Greenhagen (APL) prepared and measured the forsterite-anorthite mixtures, Jeff Gillis-Davis (WUSTL) laser-weathered the olivine samples, and Kerri Donaldson Hanna (UCF) made emissivity measurements. Reflectance spectra were measured in the Reflectance Exerpiment Laboratory (RELAB) at Brown University (spectra available at http://www.planetary.brown.edu/relab/). Reflectance spectra also sourced from the USGS (https://crustal.usgs.gov/speclab/QueryAll07a.php) Emissivity measurements were made at the Johns Hopkins University Applied Physics Laboratory and at the University of Oxford.*

Selected Bibliography

Kremer et al. (2021a), LPSC, abs 2191 - Olivine-anorthite mixtures
Kremer et al. (2021b), LPSC, abs 2200 - Space weathering of olivine
Kremer et al. (2020), GRL 47 - Olivine Mg# trends in 4-8 μm range

Dyar et al. (2009), Am. Min. 94 - Synthetic olivine data and background
Gillis-Davis (2017), Icarus 286 - Space weathering technique
Greenhagen et al. (2020), Euro. Lun. Symp. - Oliv.-anorth. mixtures data