Visible and Near-Infrared Spectral Effects of Porosity and Albedo on Asteroid and Lunar Analog Samples

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Introduction & Methods

Spectroscopy is a fundamental tool in the study of the surfaces of airless bodies like the Moon and asteroids. Often in these studies, regolith simulants are used to simulate known properties of asteroid and lunar regolith including composition, porosity, albedo, and particle size fraction where **Regolith Porosity** refers to the percent of empty spaces (or voids) within the regolith.

Here we present an examination of the **Visible and Near-Infrared (VNIR; 0.4 - 2.5 µm) reflectance** spectra of high regolith porosity, fine particulate olivine samples with three different albedos.

Methods and Spectral Analysis

- I produced and examined physical mixtures of San Carlos olivine, potassium bromide (KBr) and carbon black in two particle-size fractions: **45-125 µm and 0-45 µm.**
- Samples were ground, sieved, and mixed to ratios based on regolith porosity (reported as wt.% KBr): **0%**, **10%**, **50%**, and **90%.**
- Carbon black was then added to each sample until a specific albedo was achieved as measured at 0.7 µm: 0.15, 0.10, and 0.05 **±0.005**.
- I measured the VNIR spectra and albedo of each sample using a Thermo Nicolet iS50 Fourier Transform Infrared (FTIR) spectrometer using a PIKE Diffuse Reflectance Accessory from 8600-15000 cm^{-1} with a 2 cm^{-1} resolution (Figures 2-9). **45-125 µm s**amples were also measured at Brown University's Reflectance Experiment LABoratory (RELAB; Figures 2-5).

For analysis, I modified preexisting Python code to obtain the parameters of the 1-µm feature:

- To calculate a spectrum's continuum, we use the equation for slope $y = mx + b$ where y represents the output, m is the slope, x is the input and b is the y-intercept.
- Band center is the minimum value between 0.9-1.4 µm.
- Band depth is calculated by $D_H = \frac{R_C - R_B}{R_C}$ where R_C is the reflectance of the continuum and R_B is the reflectance at the band center.

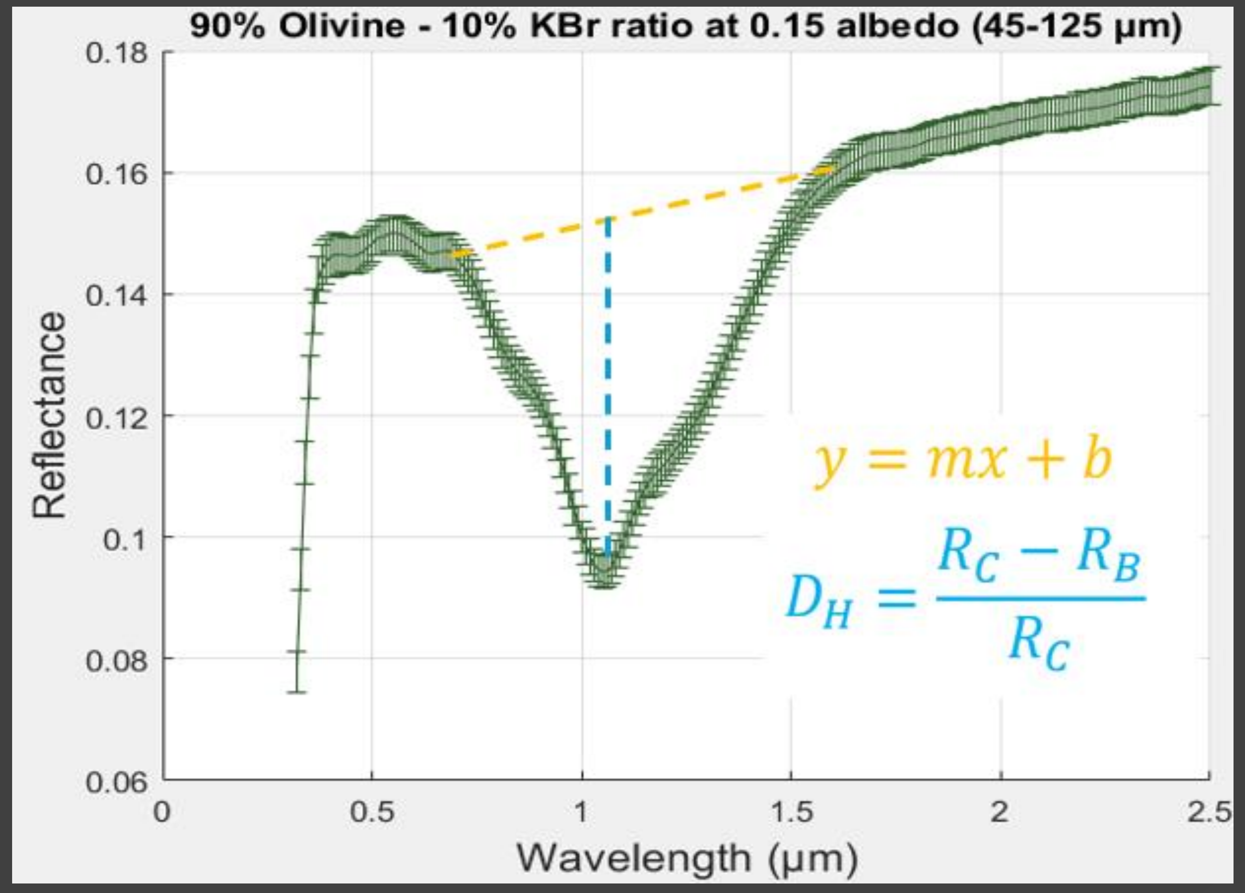


Figure 1: Spectra of olivine and potassium bromide mixture with 0.15 albedo. Included are the depth shown in blue and the continuum slope shown in orange.

Sample Measurements

Figure 2: 100% Olivine & 0% KBr (45-125 µm)

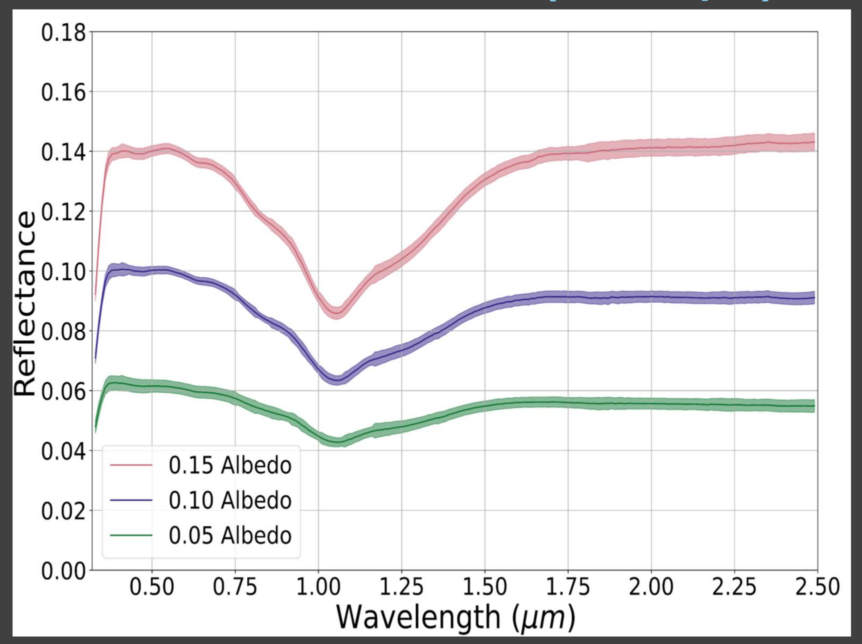


Figure 3: 90% Olivine & 10% KBr (45-125 µm)

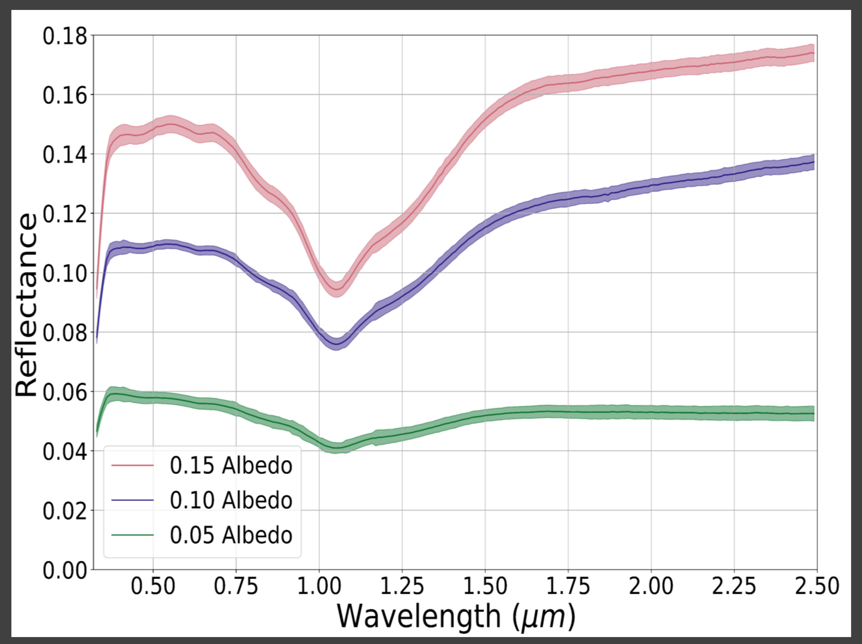


Figure 4: 50% Olivine & 50% KBr (45-125 µm)

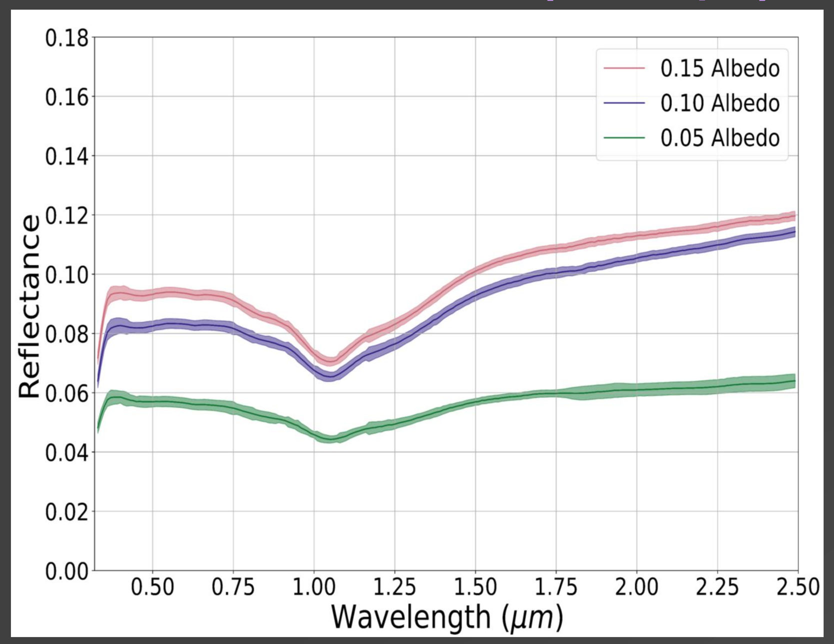


Figure 5: 10% Olivine & 90% KBr (45-125 µm)

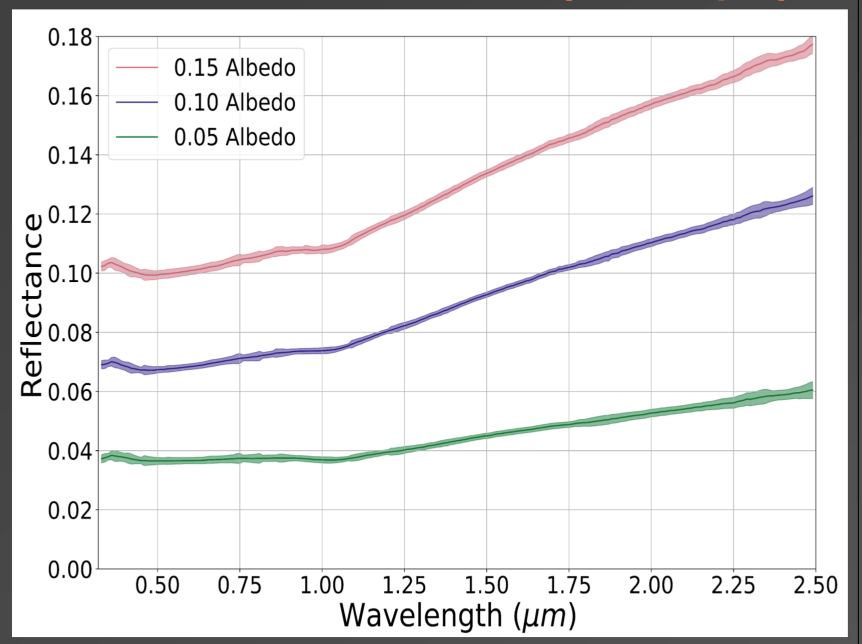


Figure 6: 100% Olivine & 0% KBr (0-45 µm)

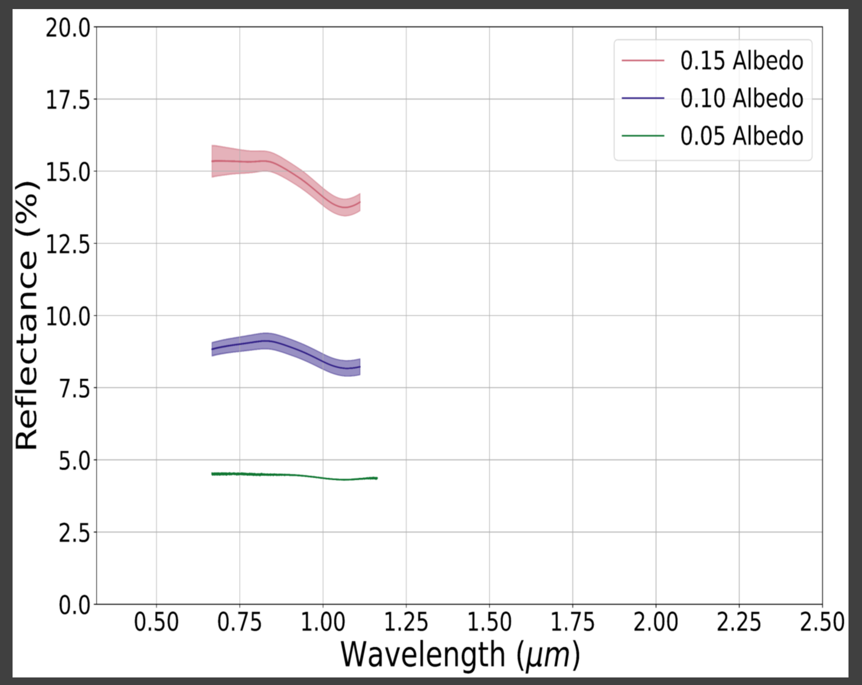


Figure 7: 90% Olivine & 10% KBr (0-45 µm)

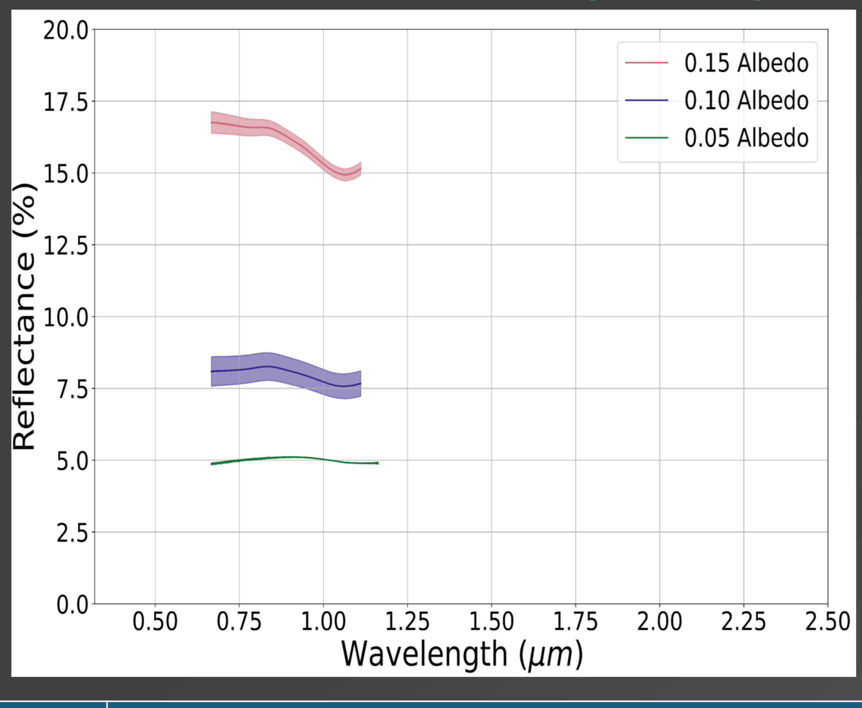


Figure 8: 50% Olivine & 50% KBr (0-45 µm)

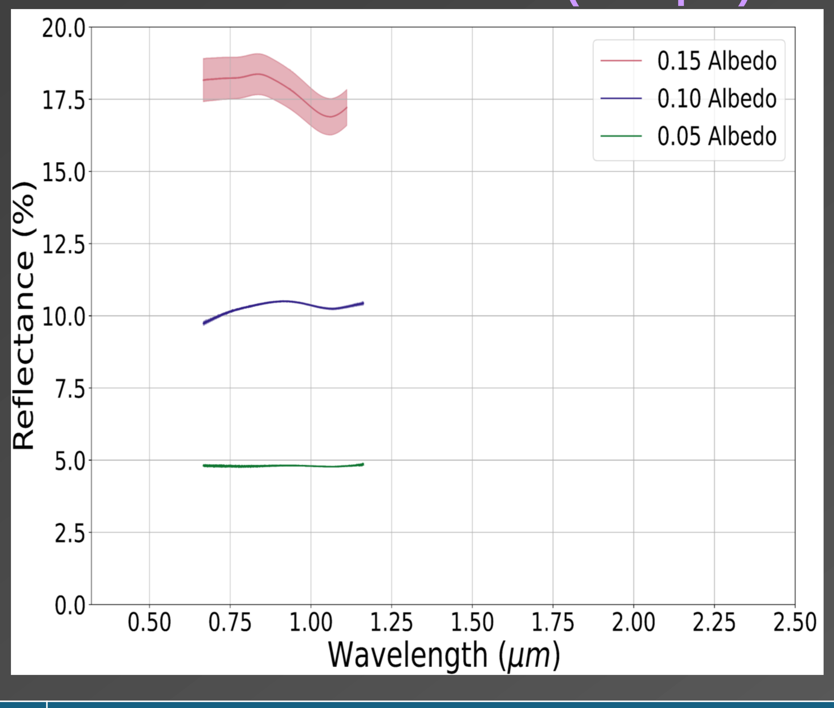
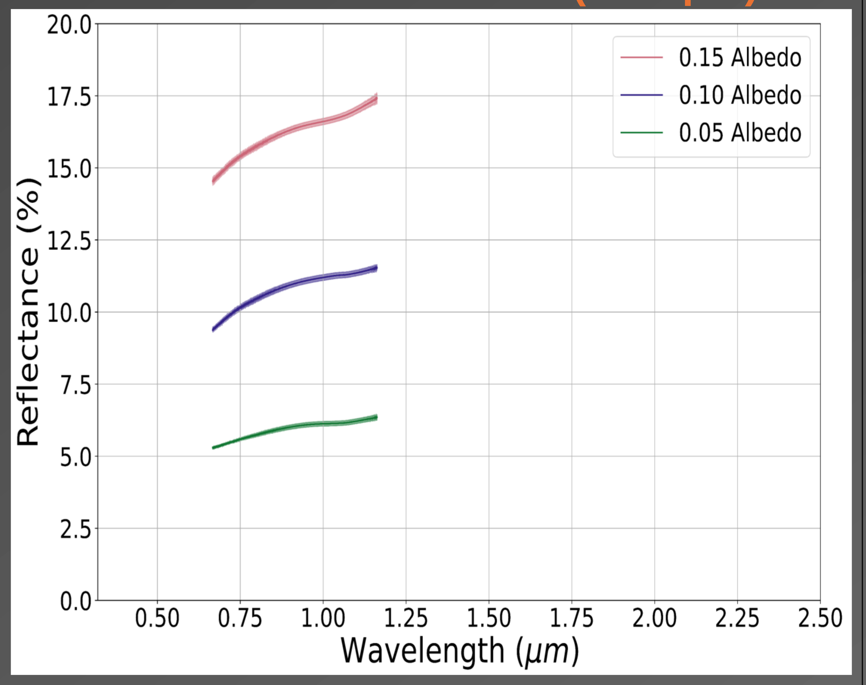


Figure 9: 10% Olivine & 90% KBr (0-45 µm)



100% Olivine & 0% KBr (45-125 µm)	90% Olivine & 10% KBr (45-125 µm)	50% Olivine & 50% KBr (45-125 µm)	10% Olivine & 90% KBr (45-125 µm)
Slope: 0.00552 ± 0.000166 Band center: 1.10 µm Band depth: 30.5%	Slope: 0.0144 ± 0.000137 Band center: 1.10 µm Band depth: 32.4%	Slope: 0.0148 ± 0.000137 Band center: 1.10 µm Band depth: 23.5%	Slope: 0.0419 ± 0.000190 Band center: 1.11 µm Band depth: 5.5%
Slope: -0.000148 ± 4.10e-05. Band center: 1.11 µm Band depth: 25.0%	Slope: 0.0177 ± 6.50e-05 Band center: 1.10 µm Band depth: 26.7%	Slope: 0.0194 ± 4.84e-05 Band center: 1.10 µm Band depth: 20.1%	Slope: 0.0327 ± 3.99e-05 Band center: 1.12 µm Band depth: 4.8%
Slope: -0.00138 ± 1.26e-05 Band center: 1.10 µm Band depth: 20.1%	Slope: -0.000923 ± 2.05e-05 Band center: 1.10 µm Band depth: 19.4%	Slope: 0.00488 ± 2.80e-05 Band center: 1.11 µm Band depth: 17.4%	Slope: 0.0152 ± 3.04e-05 Band center: 1.16 µm Band depth: 2.6%
100% Olivine & 0% KBr (0-45 µm)	**90% Olivine & 10% KBr (0-45 µm)**	**50% Olivine & 50% KBr (0-45 µm)**	**10% Olivine & 90% KBr (0-45 µm)**
Band center: 1.06 µm	Band center: 1.06 µm	Band center: 1.06 µm	Band center: 1.10 µm
Band center: 1.10 µm	Band center: 1.07 µm	Band center: 1.10 µm	Band center: 1.10 µm
Band center: 1.11 µm	Band center: 1.10 µm	Band center: 0.90 µm	Band center: 1.10 µm

Acknowledgments and Citations

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- Clark, R. N., and Roush, T. L. (1984). Reflectance spectroscopy: Quantitative analysis techniques for remote sensing applications. Journal of Geophysical Research, 89(B7), 6329–6340. doi:10.1029/JB089iB07p06329.

Results & Future Work

- As seen in other laboratory studies, as albedo is decreased the spectral contrast of the 1 µm feature decreases.
- Spectra containing 0% (Figure 2) and 10% (Figure 3) KBr exhibit similar absorption features, while the spectra for 90% (Figure 5) KBr have much steeper slopes and reduced spectral contrast.
- Spectra of the 0-45 µm samples with 0.05 albedo have weak 1 µm features.
- These laboratory analyses will contribute to the understanding of how factors, including regolith porosity and albedo, effect spectra. Such insights will be instrumental in interpreting telescopic observations of asteroid bodies, akin to those obtained from the James Webb Space Telescope (JWST).