JUPITER TROJAN ASTEROID SIMULANT MIR SPECTRUM

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Introduction: Determining the composition of Jupiter Trojan asteroids is one of the objectives of the NASA Lucy mission which will fly by at least 6 Trojan asteroids over the next 12 years. We are developing Trojan simulants based on spectral features. The simulants consist of common minerals in meteorites, and the elemental abundance is roughly solar. Previous lab work included Jupiter Trojan simulant endmember selection [1] and simulant preparation [2]. Our Trojan simulants consist of olivine, iron sulfide and less mature coal. Spectrally, Trojan asteroids have no significant features except for red slope in the visible to near infrared (VNIR) while Trojans show a prominent 10µm feature in the mid infrared (MIR), which has been attributed to fine particulate, porous olivine [3,4]. The spectra of our initial simulant shown here doesn't exhibit this feature, even though the spectra in the 9 – 16.5µm wavelength range is dominated by olivine. The initial simulants had olivine particle size D<100µm. As the 10µm plateau is dependent both on particle size, porosity and composition [4–6], the feature may show up with decreasing particle size, increasing porosity or changing mixture composition. In this experiment particle size of all the endmembers was decreased to D<25µm. Samples were measured across the VNIR to MIR spectral range using a FTIR spectrometer.

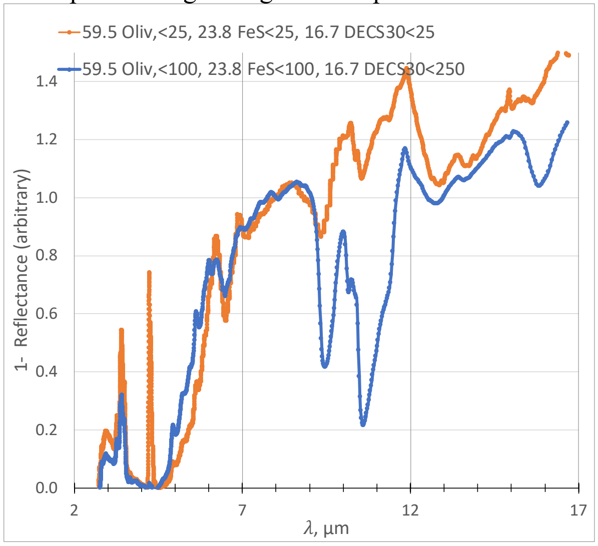

Figure 1. 1-Reflectance spectra of Trojan simulant mixture with 59.5% Olivine, 23.8% FeS and 16.7% medium volatility bituminous coal DECS30. Blue line is larger particle size at D<100µm and orange line is D<25µm.

Sample preparation: Initial samples were created in IPAG, Grenoble, France in June 2022 [2]. Trojan simulants consist of olivine, FeS and coals. Olivine is 92% forsterite and 8% fayalite D<100µm. FeS is 55 vol.% troilite and 45 vol. % pyrrhotite at two particle sizes D<100µm and D<1µm (hyperfine). Three types of coal are used: medium volatility bituminous DECS30 D<250µm, subbituminous coal DECS27 D<250µm, lignite PSOC1532 in two particle sizes D<250 and D<1µm (hyperfine). Samples were shipped to University of Central Florida, where the next experiments were performed. Whole samples were manually ground in a mortar and pestle to D<25µm. This particular particle size was chosen so that samples would be possible to sieve using dry sieving.

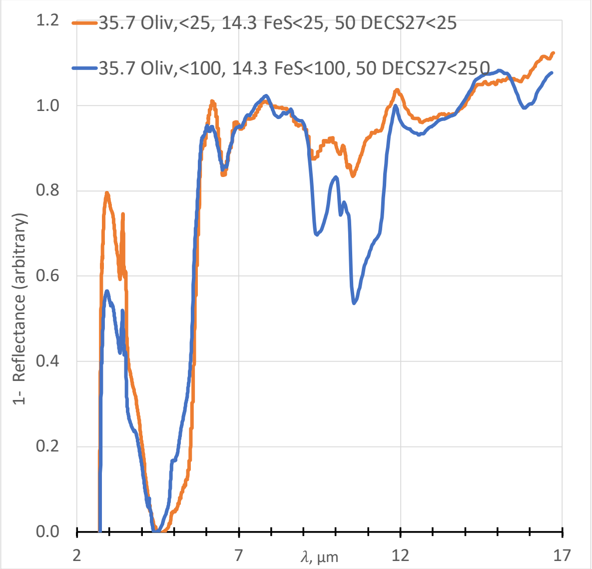

Figure 2. 1-Reflectance spectra of Trojan simulant mixture with 35.7% Olivine, 14.3% FeS and 50% subbituminous coal DECS27. Blue line is larger particle size at D<100µm and orange line is D<25µm.

Measurements and Results: Reflectance spectra of samples at D<25µm were taken with a Nicolet iS50 FTIR spectrometer across the 2.5-25µm spectral range, at the UCF, Orlando, Florida. Previous samples with larger particle size D<100µm were measured with Brucker Vertex 70V FTIR spectrometer across the 1.25-16.5µm range in IPAG, Grenoble, France. Hence here spectra are compared at 2.5-16.5µm range Samples were not heated to release absorbed and surface bound water. Samples have been exposed to the laboratory environment and show obvious oxidation. The hyperfine FeS samples were affected more strongly. Oxidation, water and OH^- absorption shouldn't have significant effects on MIR spectra, especially in the 10µm region of interest. Effective emission spectra were calculated using Kirchhoff's law (E=1-R) and plotted in Figures 1-3. Emission spectra can be compared to actual Trojan emission spectra [7], and spectra from other lab work [4,6].

All sample spectra show similar trends. With decreasing particle size, reflectance decreased from 7 to 12µm. Negative slope appeared in reflectance from 7 to 9µm, stronger for samples with hyperfine FeS and/or coal. Contrast for Christensen feature decreased for samples with regular FeS and coal particle size but increased in mixtures for hyperfine FeS and/or coal. Different coal types don't seem to have an impact on the 10µm region. While all samples show significantly increased emission brightness in the 10µm region, however mixtures with 50% coal have less prominent features than mixtures with less coal. Comparing to various particle size and porosity olivine features at this wavelength with [4] reveals similarities with olivine at 50-70% porosity, but doesn't show a 10µm plateau, that we wished to detect.

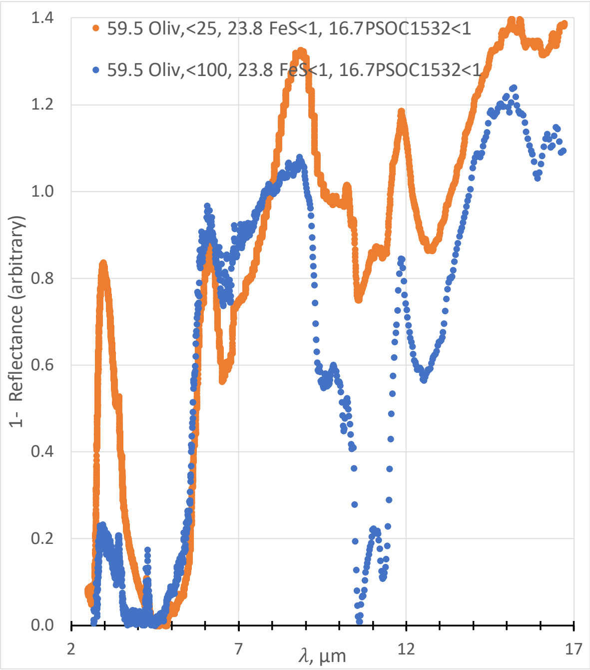

Figure 3. 1-Reflectance spectra of Trojan simulant mixture with 59.5% Olivine, 23.8% FeS and 16.7% lignite coal PSOC1532. Blue line is larger particle size for olivine at D<100µm and orange line is D<25µm, while FeS and coal are at hyperfine particle size D<1µm.

Conclusions and Future Work: In this experiment we decreased particle size of the Trojan simulant mixtures and observed emission increase in the 10µm region. This emission increase was not large enough to achieve a 10µm plateau, that we observe in Trojan asteroids. We likely need to reduce particle size further as well as looking at increasing the porosity. Further experiments with different particle sizes, endmember compositions could be performed to see the transformation of the spectra. Samples could be reheated to release absorbed and surface bound water to test if this has any effect. Smaller particle size can only be achieved with wet sieving, but we were concerned, that this would degrade the coal endmember. Amorphous olivine equivalent could be used in addition to crystalline mineral, this should have effect on 10µm plateau as discussed in [4].

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References: [1] Šļumba, K. et al. (2022). LPSC2022 Abstr. 2014. [2] Šļumba, K. et al. (2022).DPS54, 520.01. [3] Emery, J.P. et al. (2003). Icarus, 164, 104–121. [4] Martin, A.C. et al. (2022). Icarus, 378, 114921. [5] Lowry, V.C. et al. (2022). Planet. Sci. J., 3, 181. [6] Beck, P. et al. (2022).LPSC2022, 1427. [7] Emery, J.P. et al. (2006). Icarus, 182, 496–512.