50th Lunar and Planetary Science Conference 2019 (LPI Contrib. No. 2132)

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SPECTRAL INVESTIGATION OF ANOMALOUS METAL-RICH CHONDRITE NORTHWEST AFRICA (NWA) 12273: IMPLICATIONS FOR ASTEROID (16) PSYCHE.

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Introduction: Northwest Africa (NWA) 12273 is a unique anomalous chondrite that is made up of 64% Ni-Fe metal and ~30% chondrules [1]. The meteorite was purchased by Jay Piatek from a Moroccan meteorite dealer on October 25, 2018. The main mass is a single 280 grams stone with a smooth, slightly oxidized surface, with subtle regmaglypts. A saw cut surface revealed small, shiny metal grains and scattered small, dark gray chondrules. [1] did SEM mapping and found modal abundances by area: kamacite 40%, taenite 17%, oxidized iron 8%, troilite 2.5%, silicate (primarily chondrules, only minor matrix) 30%. Olivine values in NWA 12273 are consistent with L3 or LL3 and low-Ca pyroxene values are consistent with H4 and the oxygen isotope values fall within the LL chondrite field [1]. They concluded that NWA 12273 is different from other known metal-rich meteorites including CB and G chondrites.

Motivation: Asteroid (16) Psyche is the largest metal-rich M-type asteroid in the main asteroid belt with a diameter of 233 km [2]. From radar and spectroscopic observations, Psyche's surface has been interpreted to be dominated by metal, silicate (low-Fe pyroxene) and exogenic carbonaceous chondrite impactor material [2,3,4,5]. In 2026, the NASA Discovery-class spacecraft Psyche is expected to arrive at the asteroid to study its topography and composition. Several meteorite analogs have been proposed based on Psyche's observed spectral reflectance. These include metal-rich CB chondrites, irons, pallasites and enstatite chondrites. Of all the proposed meteorite analogs, CB chondrites contain the two spectrally significant components on Psyche's surface. CB chondrites have the abundant metal and silicates (low-Fe pyroxene) similar to Psyche. The availability of NWA 12273 opened up the intriguing possibility of Psyche's surface resembling an anomalous metal-rich chondrite. Complementary to [1], we conducted visible-near infrared reflectance spectroscopy to directly compare with telescopic spectra of Psyche.

Sample Preparation: The main mass of NWA 12273 was obtained as a loan from the owner to perform non-destructive analysis. This meant we could not crush a small fraction of the sample for our analysis to mimic the metal-rich regolith on Psyche. We restricted ourselves to spectra of different spots on the surface of the meteorite. In addition to slab spectra of NWA 12273,

we created a mixture of metal and ordinary chondrite in the form of powders to better mimic asteroid regolith. We used the approximate ratios of metal to chondrite in NWA 12273 as a baseline. Our metal sample came in the form of metal shavings left over from slicing of a large Sikhote-Alin meteorite (IIAB iron). These shavings were contaminated with oil that was used during the cutting process. To remove the oil, we placed them on a 45 micron sieve and dosed with acetone until dried. Once free of acetone and oil, we then used multiple sieves to isolate the grain size of the shavings to between 106 and 212 microns. Our ordinary chondrite powder was obtained by crushing a fragment of Aba Panu using a mortar and pestle. Aba Panu is an L3 ordinary chondrite fall from Nigeria. We chose L chondrite over H due to availability of fresh L3 chondrite material. The OC material was then sieved to less than 45 microns grain size.

Experimental Setup: Visible and near-infrared reflectance spectra (0.35-2.5 μm) of our samples was taken using an ASD FieldSpec Pro HR spectrometer at i = 30 and e = 0, relative to a calibrated Spectralon standard, with a collimated 100W quartz-tungsten-halogen light source. Our spectrometer has a spectral resolution of 5-10 nm and capable of acquiring a spot size as small as 5 mm.

Results: Figure 1 shows the visible-near infrared reflectance spectrum of NWA 12273 slab. The spectrum has a distinctive red spectral slope due to metal and two absorption features at ~1.0 and 2 μm due to the minerals olivine and pyroxene in the silicates (chondrules). The noise in the data are due to some specular reflections from the bare metal surface and oxidation on the metal. Figure 2 shows the spectrum of Sikhote-Alin (65%) and silicate from L3 ordinary chondrite (35%) mixture. This spectrum shows similar spectral characteristics as NWA 12273 including red spectral slope, absorption features at 1.0 and 2.0 μm due to the minerals olivine and pyroxene. The spectrum is less noisy than NWA 12273 because it comprises of powder mixtures rather than bare slab.

Implications for Psyche: [4] used the near-IR spectrum of Psyche (Fig. 3) to constrain the metal and silicate abundance. Psyche's spectrum shows an overall red spectral slope and a weak (<2% depth) absorption feature at 0.90-μm due to low-Fe pyroxene. There is no feature at 2.0 μm. The metal abundance is estimated

to be 95% with 5% pyroxene. The detection of OH on the surface [5] and the mismatch between the shape model derived lightcurve and the observed lightcurve [2] suggested the presence of exogenic carbonaceous impactors. The presence of carbonaceous impactor material would subdue the absorption band depth and flatten the red spectral slope due to metal. Comparison of NWA 12273 spectrum (Fig. 1) or our metal + OC mixture (Fig. 2) with that of Psyche shows an obvious mismatch in spectral slope and silicate band depth. We suggest three reasons for this: 1) The lack of carbonaceous component on NWA 12273 or our metal + OC mixture to diminish the absorption features, 2) the ratio of metal to silicate might be lower in our samples than on Psyche, and 3) the presence of olivine in the L chondrite rather than just pyroxene on Psyche. Our next step would be to create a three component mixture with metal, silicate and carbonaceous chondrite materials as pioneered by [6].

References: [1] Agee C. B. et al. (2019) *LPSC* 50. [2] Shepard M. K. et al. (2017) *Icarus, 281,* 388-403. [3] Hardersen et al. (2005) *Icarus, 175,* 141. [4] Sanchez et al. (2017) *The Astronomical Journal*, *153,* 29. [5] Takir et al. (2018) *LPS XLIX,* Abstract #2624. [6] Cantillo D. C. et al. (2019) *LPSC 50.*

Figure 2. Mixture of metal from Sikhote-Alin (65%) and silicate from L3 ordinary chondrite (35%) showing similar spectral characteristics as NWA 12273. These include red spectral slope, absorption features at 1.0 and 2.0 µm due to the minerals olivine and pyroxene. The spectrum is less noisy than NWA 12273 because it comprises of powder mixtures rather than bare slab.

Figure 3. Near-IR spectrum of asteroid (16) Psyche from [4] showing red spectral slope and weak (<2% depth) absorption band at 0.9 microns.
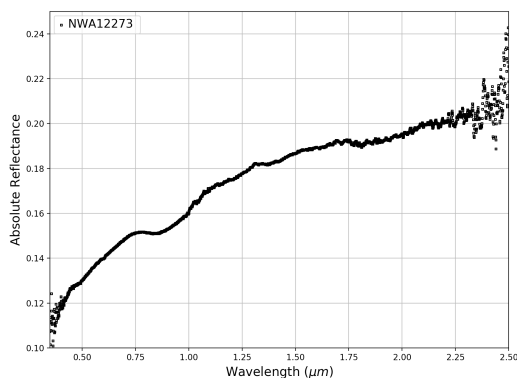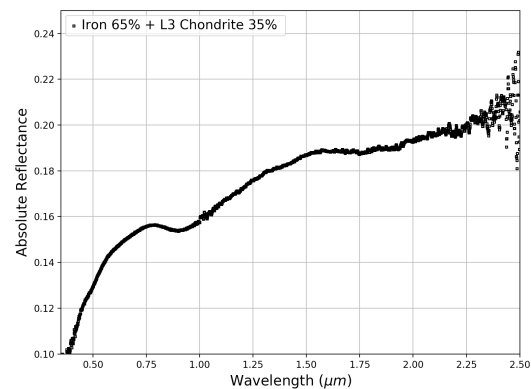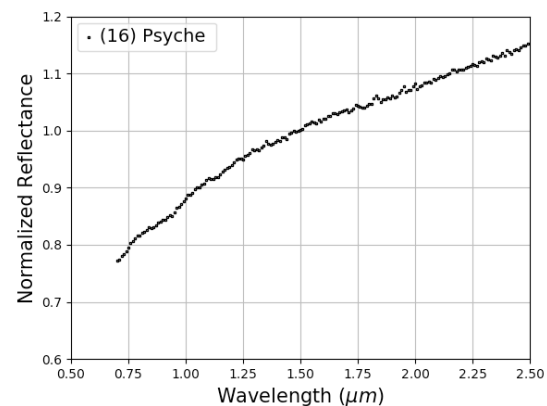

Figure 1. Visible-near infrared reflectance spectrum of NWA 12273 slab. The spectrum has a distinctive red spectral slope due to metal and two absorption features at ~1.0 and 2 µm due to the minerals olivine and pyroxene in the silicates (chondrules). The noise in the data are due to some specular reflections from the bare metal surface and oxidation on the metal.