SPECTRAL CHARACTERIZATION OF THE ANCIENT SHERGOTTITES NORTHWEST AFRICA 7034 AND 8159.

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Introduction: Thermal infrared (TIR) spectroscopy is a powerful remote sensing tool used to unravel the surface compositions of a target body. This technique has been widely used in space missions, because of its ability to detect and determine modal mineralogy of the surface geology. It has been instrumental in developing our understanding of Mars, as the majority of missions sent to Mars have included an infrared spectrometer. These spectrometers can operate either in the visible (VIS) to near-infrared (NIR) or in the mid-infrared (MIR). The results presented here primarily cover 5-15 µm, which overlaps the THEMIS spectral range.

In the MIR, the bulk spectrum of the surface acquired from a satellite can be linearly deconvolved to reproduce the modal mineralogy [1]. Deconvolution relies on the use of spectral end-members to accurately deconstruct the acquired bulk spectrum. These end-members are derived in the laboratory from particulate samples of either bulk rocks and/or minerals. The majority of end-members used in the deconvolution are terrestrial. Though Martian meteorite bulk spectra have also been used in deconvolutions, they don’t provide a good match to the Martian surface geology [2], most likely because the spatial resolution of the instruments was too low. While the use of terrestrial end-members has significantly advanced our understanding of the geology of Mars, the use of Martian meteorite mineral end-members may be able to provide additional information and accuracy to mapping the surface geology.

Due to the rarity of Martian meteorites, the destructive technique of acquiring mineral spectra from a particulate is not feasible or desired. However, by analyzing thin-sections using non-destructive µ-FTIR (micro-Fourier Transform Infrared) spectroscopy, we can acquire spectra from specific Martian minerals using thin-sections. This however, introduces orientation effects on the spectra, which is avoided when using particulates, as they produce a randomly orientated spectra. These effects can be quantified and accounted for using Electron Back-Scattered Diffraction (EBSD).

Here we investigate MIR spectral characterization of the shergottites Northwest Africa (NWA) 7034, a polymict breccia, and NWA 8159, an augite basalt. NWA 7034 contains ancient Martian crust as old as 4.39 ± 0.04 Ga [3], while NWA 8159 crystallized 2.37 ± 0.25 Ga [4]. This makes them, and NWA 7635 (2.403 ± 0.14 Ga), the oldest confirmed shergottites recovered so far [5]. As the only shergottites of Early Amazonian to Noachian in age, they provide an invaluable opportunity to understanding Mars’ early history.

Methods: Both samples (~0.5g chips) were acquired from UNM and were made into epoxy mounts. NWA 8159 was analyzed with a Tescan Integrated Mineral Analyzer (TIMA) to determine modal mineral abundancies and produce high-resolution mineral maps. NWA 8159 was also analyzed using EBSD to characterize the crystallographic orientation of the grains. Data were collected at a step size of 1 µm and an accelerating voltage of 20 keV, using a Tescan Mir3 scanning electron microscope (SEM) and the Oxford Instrument Symmetry CMOS detector. NWA 7034 will also be analyzed using TIMA and EBSD. Both samples will be analyzed a Nicolet iN10MX Infrared Imaging Microscope. They will be analyzed using a nitrogen-cooled MCT/A (Mercury Cadmium Telluride) detector with a wavelength range of ~5-15 µm. Though a shorter wavelength range than the MCT/B or DTGS (Deuterated Triglycerine Sulfate) detector’s, the signal to noise ratio is significantly improved. This allows a much smaller spot size to be viably used. Increasing the spatial resolution of the analysis will allow smaller and more complicated grains to be accurately analyzed. A 100 µm spot/step size will be used to create large spectral maps of the sections, followed by a 25 µm spot/step size to analyze specific areas of interest at high resolution.

Results: Initial results indicate NWA 8159 is primarily composed of pyroxene and plagioclase, both ~43% (Fig. 1). The pyroxene is zoned, with high-Ca augite cores and low-Ca pigeonite rims. The plagioclase has not been fully shocked to form maskelynite. Magnelite and olivine are also present at ~6% and ~5%, respectively. Accessory phases include silica and apatite. Pyroxene and magnetite occur on the rims of the olivine grains, most likely due to a replacement reaction [4]. NWA 8159 is very fine grained at <200 µm though phenoctysts can be up to ~500 µm (Fig. 2). There is a varying texture across the sample, with areas of coarser grains (200-400 µm) and areas of much finer grains (<100 µm). A large shock melt vein (~600 µm wide) cuts through the sample. Maskelynite is present both within and in close-proximity to the vein. Micro-garnets are...
also present inside the vein. Ca-rich veins, possibly carbonate, occur through the sample, most likely due to terrestrial weathering [6].

Mineral orientation and spectral observations will be presented at the meeting.

**Discussion**: NWA 7034 and NWA 8159 represent unique samples of the Martian crust. NWA 7034 is a polymict breccia, the only sedimentary Martian meteorite (and its pairs) so far confirmed. The igneous clasts in NWA 7034 are composed of a wide variety of igneous lithologies, representing a broad compositional range of the Martian crust [7]. In addition, there are a number of sedimentary clasts, lithic fragments of previously lithified Martian regolith [7]. Both sets of clasts represent not previously sampled parts of the Martian crust and surface. NWA 8159, is classed as an ‘augite basalt’ due to the predominant clinopyroxene phase, augite, in the meteorite. This makes it unique, as the other shergottites usually have a higher abundance of low-Ca pigeonite than high-Ca augite. Furthermore, plagioclase that has not been fully converted into maskelynite is also present, providing a constraint on the impact shock history of this meteorite.

Both these meteorites provide an opportunity to expand the Martian spectral library into compositionally diverse and more ancient fragments of the Martian crust. While previous studies have spectrally analyzed these meteorites [4,8,14], there has been limited MIR spectral analysis of targeted regions inside these meteorites. Spectrally analyzing targeted areas, such as sedimentary clasts, will enable their use in the deconvolution process, thereby providing a new avenue in mapping the surface geology of Mars.

Further petrological and MIR characterization of these meteorites and their constituent components will be presented at the meeting.


**Figure 1. Modal mineralogy of NWA 8159 compared to previously reported mineralogy [4], and typical mineralogy of shergottites from different sub-groups: Diabasic – Los Angeles [9], Fine-Grained – Zagami [10], Poikilitic – RBT 04262 [11], Olivine-Phryic – Dhofar 019 [12], Gabbroic – NWA 7032 [13].

**Figure 2.** Mineral map of NWA 8159 showing the varying texture and the large shock-melt vein cutting through the section.