DETECTION AND IMAGING OF ORGANIC MATTER IN QUEEN ALEXANDRA RANGE 97008 VIA MICRO-RAMAN TOMOGRAPHY.

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Introduction: In addition to inorganic molecules, various organic molecules such as aliphatics and aromatics have been identified in meteorites [e.g., 1, 2, 3]. While carbonaceous chondrites have the highest abundance of organic species, some ordinary chondrites also contain substantial amounts of organic matter [4]. Primitive unequilibrated ordinary chondrites are meteorites that have been minimally altered/processed, and therefore (i) their organic and inorganic content as well as spatial distribution may provide clues for their formation pathways and regions, (ii) they may shed light on their parent body secondary histories such as thermal metamorphism and aqueous alteration. Queen Alexandra Range 97008 (QUE 97008) is a type L3.05 chondrite. Recently, an effort has been made to detect and map distribution of organic molecules and determine the composition in QUE 97008 via synchrotron-based micro-FTIR imaging in the mid-infrared region [4]. Here, we report the identification and spatial distribution of organic matter (i.e., aliphatic and aromatics) in QUE 97008 via three-dimensional (3D) micro-Raman spectroscopic imaging.

Samples and Technical Details: A thin section of QUE 97008 was loaned from NASA’s Antarctic Meteorite Collection. QUE 97008 has a very low weathering grade (A), indicating only minimal terrestrial weathering may have affected this meteorite. We conducted our Micro-Raman experiments at the Vibrational Spectroscopy Laboratory at Stony Brook University using a WiTec alpha300R confocal Raman imaging system equipped with a Nd:YAG laser (532 nm) and a 50X objective (NA = 0.8). The laser power on the sample surface was 0.8 mW. After locating a region of interest under the microscope, two dimensional Raman intensity maps were collected from the 100 μm X 100 μm area with ~1 μm lateral spatial resolution, and a full Raman spectrum was collected at every pixel within the measured area with 0.03 s integration time. Similar intensity maps from a total of 40 focal planes with 0.5 μm depth spatial resolution were collected, and the resultant maps for each molecular functional group were reconstructed and visualized using ImageJ and Avizo software packages.

Results: Our micro-Raman imaging experiments show that QUE 97008 contains chondrules that are dominated by anhydrous silicates, which are rimmed by both carbonaceous and metallic phases. The matrix of QUE 97008 also appears to contain abundant carbon, evident from the first and second order carbon bands in the Raman spectra.

The D and G carbon peak parameters extracted from the Raman spectra are usually used to determine and study the thermal metamorphism trends in meteorites [e.g., 5], however thin-section preparation may alter the carbonaceous matter and its structure such that Raman peaks of carbon may yield to a different/ altered peak parameters. Our 3D Raman measurements reveal that the Raman spectra extracted from z = 5 μm yield to results that are different than the results based on the carbon peak parameters extracted from the surface (z = 0 μm).

Our 3D Raman tomography results also show the presence of organic matter (aliphatics and aromatics) near z = 18 μm underneath a large olivine grain, showing that QUE 97008 is rich in organic matter such as aliphatics and aromatics. Namely, Raman spectra present a number of prominent peaks between 2800-3000 cm⁻¹ (due to C-H stretching vibrations in aliphatics), and a sharp single peak at 3065 cm⁻¹ (due to aromatics), consistent with previous work [4]. Additional Raman peaks appear near 1400-1470 cm⁻¹ (due to C-H deformation vibrations).

Our future work will map the spatial distribution of organic matter in QUE 97008 and their identification for larger areas via both micro-FTIR and micro-Raman spectroscopy in order to understand their distribution and spatial relations with inorganic materials, which will potentially provide clues for the formation and evolution histories of chemical constituents present in this extraordinary unequilibrated ordinary chondrite.