2-D Major, Minor and Trace Element Characterization of Astromaterials via Coordinated Limited-Destructive *in-situ* Geochemical Analyses.

Jacob B. Setera*[1], Justin I. Simon[2], Jhanis Gonzalez[3], Jennifer S. Gorce[4], Timmons M. Erickson[4]

[1]CASSMAR, University of Texas at El Paso – Amentum JETS II Contract, NASA Johnson Space Center, Houston TX, USA.

[2]Center for Isotope Cosmochemistry and Geochronology, NASA Johnson Space Center, Houston TX, USA.

[3]Applied Spectra, Inc. West Sacramento CA, USA.

[4]Amentum JETS II Contract, NASA Johnson Space Center, Houston TX, USA.

*Corresponding author: Jacob.b.setera@nasa.gov

Compositional mapping of geologic materials provides powerful constraints for a wide variety of petrologic processes, and with continued technologic advancements, the detection limits and spatial resolutions that these measurements can be made continues to improve. With sample limited materials, such as astromaterials, this 2-D characterization has largely been focused on non-destructive techniques (e.g., Scanning Electron Microscope [SEM], and Electron Probe Microanalysis [EPMA]), though there has been recent advancement in using destructive Laser Ablation ICPMS techniques. Here, we present a workflow that can provide quantitative 2-D characterization analysis, with limited sample destruction, of a large suite of major to trace elements via a coordinated analytical approach utilizing multiple measurement techniques and instruments housed in the Astromaterials Research and Exploration Science Division at NASA JSC. The instrumentation and facilities are available to the community through the NASA Facility for Astromaterials Research (NESF) program.

Initial sample characterization is conducted via optical petrography, and qualitative major element maps are generated via SEM. This provides mineralogical and textural context needed for quantitative EPMA maps of minor elements (>1 wt. %). Minimally destructive LA-ICPMS analyses are performed next, as well as concurrent analyses of select volatile elements, spectroscopy for various polymorphs and molecular species, and/or isotopic systems.

Central to this analysis pathway is the Applied Spectra iX-fs-Tandem LA-LIBS instrument, which can be coupled simultaneously to both the Nu SP1700 MC-ICPMS and the Thermo-Scientific ElementXR ICPMS at NASA JSC. The synergistic integration of fs-LA-LIBS offers high spatial resolution elemental mapping, enabling the identification of microscale variations within samples. During the LA experiments (controlled to 1-2 µm depth), trace elements are collected via ICPMS (e.g., REEs), while two spectrometers can be setup to collect additional trace elements and/or select volatile elements (e.g., F, H_2O) via Laser Induced Breakdown Spectroscopy (LIBS). Concurrently, the MC-ICPMS can collect isotopic analyses, with the final integration of all the 2-D quantitative datasets yielding a wealth of geochemical information for a given sample that can be used both for geologic interpretations, but also for targeting future analyses (e.g., conventional LA analyses, SIMS, and micro milling for ICPMS/TIMS).