Nondestructive Analysis of Astromaterials by Micro-CT and Micro-XRF Analysis for PET Examination.

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Introduction: An integral part of any sample return mission is the initial description and classification of returned samples by the preliminary examination team (PET). The goal of the PET is to characterize and classify returned samples and make this information available to the larger research community who then conduct more in-depth studies on the samples. The PET tries to minimize the impact their work has on the sample suite, which has in the past limited the PET work to largely visual, non-quantitative measurements (e.g., optical microscopy). More modern techniques can also be utilized by a PET to nondestructively characterize astromaterials in much more rigorous way. Here we discuss our recent investigations into the applications of micro-CT and micro-XRF analyses with Apollo samples and ANSMET meteorites and assess the usefulness of these techniques in future PET.

Results: The application of micro computerized tomography (micro-CT) to astromaterials is not a new concept [1-2]. The technique involves scanning samples with high-energy x-rays and constructing 3-dimensional images of the density of materials within the sample. The technique can routinely measure large samples (up to ~2700 cm^3) with a small individual voxel size (~30 μm^3), and has the sensitivity to distinguish the major rock forming minerals and identify clast populations within brecciated samples. We have recently run a test sample of a terrestrial breccia with a carbonate matrix and multiple igneous clast lithologies. The test results are promising and we will soon analyze a ~600 g piece of Apollo sample 14321 to map out the clast population within the sample.

Benchtop micro x-ray fluorescence (micro-XRF) instruments can rapidly scan large areas (~100 cm^2) with a small pixel size (~25 um) and measure the (semi) quantitative composition of largely unprepared surfaces for all elements between Be and U, often with sensitivity on the order of a ~100 ppm. Our recent testing of meteorite and Apollo samples on micro-XRF instruments has shown that they can easily detect small zircons and phosphates (~10 μm), distinguish different clast lithologies within breccias, and identify different lithologies within small rock fragments (2-4 mm soil Apollo soil fragments).

Discussion: Micro-CT and micro-XRF scanning will likely become a standard part of future PET studies of astromaterials. The analyses have virtually no impact on the samples, can be done through shielding materials (e.g., Teflon) so the samples can be kept pristine, and provide significant compositional information about the samples that will allow for more efficient distribution and use of samples. These techniques can also be retroactively applied to existing astromaterial collections to enhance the scientific return of these collections, particularly the Apollo and ANSMET meteorite sample suites. For example, new clasts of important lunar lithologies (e.g., granites, KREEP basalts, etc.) can be identified within Apollo breccias, providing "new" samples that can be used to address a variety of important scientific questions about the origin and evolution of the Moon.

References: [1] Towner M. C. et al. 2010. *LPS* **41**: #1758. [2] McCausland P. J. et al. 2010. *LPS* **41**: #2584.