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# XRF Characterization of MMOD Impact Damage

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## ABSTRACT

### Introduction

The Hypervelocity Impact Technology (HVIT) Group at the NASA Johnson Space Center (JSC) has performed over 150 post flight MMOD inspections on returned space-exposed hardware and collected over 1,600 samples. Determination of the impactor source typically requires an analysis of the projectile residue in the damage feature. At this time, about 20% of the samples have been processed.

### Types of Samples

Samples in the HVIT group collection can be classified into two types. Indirect (non-destructive) samples are produced when a pliable material (e.g., adhesive tape or dental mold) is inserted into an impact feature. With this type of sampling technique, crater material and (hopefully) projectile residue material is embedded in the sample media and can detected using further chemical characterizing techniques. Direct (destructive) sampling involves the intact extraction of material from the spacecraft and is done in a manner that the entire impact feature can be excised intact. This technique provides the greatest chance of successfully determining impactor source due to the entirety of the projectile remnants being present within the collected sample.

### Updated Projectile Residue Detection Techniques

Previous assessments of projectile provenance have involved the use of samples that are first mounted in epoxy, sectioned to expose the crater interior, imaged with a scanning electron microscope (SEM), then any observed impactor residue was then analyzed using an energy dispersive spectrometer (EDS). This technique, while proven, may be supplemented with other types of elemental analysis techniques that can observe major element chemistry, in order to improve throughput of sample analysis.

The Astromaterials Research and Exploration Science (ARES) Division at JSC, for example, operates a Bruker M4 Tornado micro-X-Ray fluorescence (XRF) spectrometer, capable of creating elemental maps of areas around these small impact features in a couple of hours, with a spot size <20 μm. The potential advantage with this technique lies in sample preparation, as no polishing or conductive coatings are needed. Early trials attempted to determine impactor composition by collecting spectra from intact samples by aiming the X-Rays directly into the impact feature, but the signal:noise ratio was too low for confident material identification. Sample preparation for XRF then relies on sectioning the samples parallel to the impactor trajectory in order to expose the largest area of subsurface damage possible, thus maximizing the signal from any small impactor remnants. Complementary to the use of XRF for sample analysis, ARES also houses a Nikon XTH 320 micro-X-Ray computed tomography (XCT). This instrument can be used to create 3D visualizations of impact damage for the determination of crater volumes and dimensions, as well as for the determination of the best place to section each sample for the subsequent XRF analysis.