MSR Curation Technology Development – Developing Protocols for Pre-Basic Characterization Measurements. V. Tu[1], A. D. Harrington[2], A. Hutzler[3], F. Thiessen[3], A. Zemeny[3], C. Orgel[3], S. Gerdts[4], J.-M. Dudley[1], [1]Jacobs JETS II at NASA-Johnson Space Center, 2101 E. NASA Pkwy, Houston, TX 77058 (valerie.m.tu@nasa.gov), [2]NASA-Johnson Space Center, 2101 E. NASA Pkwy, Houston, TX 77058, [3]ESA ESTEC, [4]Jet Propulsion Laboratory.

Introduction: The joint NASA/ESA Mars Sample Return (MSR) campaign could deliver to Earth the first pristine Martian rock and regolith samples, collected by the Mars2020 science mission, *Perseverance*. In preparation for their arrival, the NASA/ESA Joint Curation Office (JCO) within the Sample Receiving Project (SRP) is developing curation technology needed to perform initial characterization of the samples while isolating samples from the Earth's biosphere and protecting the samples from terrestrial contamination. (RSTA; Fig. 1). The MSR Science Planning Group 2 (MSPG2) identified methods for achieving an array of potential science objectives for MSR outlined by the International MSR Objectives and Samples Team (iMOST) [1]. One category of methods, called Pre-Basic Characterization, recommends potential analyses that would happen before the Returnable Sample Tube Assemblies (RSTA; Figure 1) are opened: 1) Magnetometer & Magnetic Susceptibility; 2) X-ray Computed Tomography (XCT) Scanner [2]. To be in compliance with planetary protection requirements, and to limit the amount of time sample tubes are outside of an isolated contamination controlled environment, secondary containment is necessary. A Sample Tube Isolation Container (STIC) and Secondary Outer Containment Case (SOCC) is currently being developed at NASA JPL under the direction of the SRP JCO.

Background: One of the main science priorities of this mission is to constrain the origin of the magnetic field on Mars. Magnetometry measures the magnetic forces and magnetic susceptibility of how materials become magnetized in an applied magnetic field [3, 4, 5]. Magnetometry for this study could derive an estimation of the ancient Martian field strength that magnetized the samples, and the potential magnetic alteration of samples. Additionally, magnetometry can be used for a baseline to monitor magnetic contamination of samples in storage (magnetic fields < 0.5 mT from collection through Earth) [4]. The current notional plan, based on MSPG2 findings, is that the MSR samples would be measured prior to sample extraction from RSTAs, to limit additional disturbance to the paleomagnetic orientation once they arrive within the magnetic field on Earth [2].

XCT can provide a means to look inside the RSTAs, at the samples, without having to open the tubes and expose them to Earth contamination. XCT is a largely non-destructive technique that could be a method of analyzing extraterrestrial samples [6]. The MSPG2 identified compelling reasons to perform penetrative 3D high resolution XCT prior to opening the samples, to record the orientation of the samples, grains and determine relationships of the layers to each other, porosity and density measurements, and documents veins, fluid inclusions, or other special geometric attributes [2]. Due to the array of geospatial information the XCT can provide, this type of measurement could be critical for informing MSR Curation processing, subsampling, and allocating of the returned samples, as well as opening the tubes for solid sample extraction.

Samples: Perseverance has collected and deposited on the surface of Mars, igneous and sedimentary rock cores, regolith, in addition to atmospheric samples. Following recommendations from the MSR Rock Team, analog samples have been identified to form the SRP Analogue Sample Library. Terrestrial rocks and regolith analog samples have been obtained across the world by the MSR Rock Team, and two (2) of these analog rock and regolith samples will be used in the pre-basic characterization XCT & Magnetometry feasibility study, with the possibility of adding two (2) more later in the study, depending on availability of the analog rocks.

Analytical Methods (XCT): XCT will be conducted on "test pieces" (cylindrical tubes made from each potential STIC material (Titanium Grade 1, Aluminum Grade 6061, Polytetrafluoroethylene) at the University of Austin, Texas (UT) (NASA led) and in Europe (ESA led). The NASA led component of the XCT study is utilizing UT's XCT North Star Imaging (NSI) scanner, capable of multiple specialized imaging modalities (SubpiX, MosaiX, helical), to assess potential impacts on sample imaging resolution from the STIC, SOCC, and RSTA. Helical scanning protocol shall be used to capture the sample height and the sample height + top-to-bottom of the STIC/SOCC. The field of view would be set at ~2cm, which would yield ~10-micron voxel resolution, resulting in ~11500 CT slice (approximate at this time). Without having prior knowledge of the X-ray attenuation of these materials, adjustments to the scanning parameters and/or instrument configuration may be necessary. The ESA led component of the XCT study will utilize an array of XCT instruments (tbd) to assess the potential customization of an instrument to meet comparable image resolution outputs while decreasing required infrastructures requirements (e.g., footprint) within the Sample Receiving Facility (SRF). It will also assess deposited dose on the samples, and facilitate an subsequent XCT effect study.

Analytical Methods (Magnetometry):

Small coupons of the STIC materials have been sent for magnetometry pre-characterization, to MIT, and the results will help inform the magnetometry parameters needed for analyses to be conducted on the STIC "test pieces" (NASA led). This data will be utilized for magnetometry and magnetic susceptibility analyses to assess the full "test pieces" and RSTAs for magnetic interference (ESA led). The ESA led component will also gather input on a potential design for bespoke instrumentation within the SRF.

Discussion: Currently, magnetometry pre-characterization on coupons of the materials is being conducted. Results and findings from this will be used to predict any potential challenges and hurdles faced with the magnetometry analyses on the "test pieces". Currently, we do not know how X-rays attenuating the components, materials, and samples could interfere with results and interpretations, so analyses of these materials are key.

At the conclusion of the feasibility study, results from XCT and Magnetometry analyses will be utilized to assess: 1) Optimal STIC and SOCC materials and design for XCT and Magnetometry, 2) if the same STIC material and configuration can be utilized for both XCT and magnetometry measurements, 3) if a smaller, less infrastructurally demanding custom XCT instrument can be developed that meets curation and science requirements (relative to the NSI XCT), 4) design and programmatic elements of bespoke instrumentation for magnetic measurement and 5) inform the concept of operations within the SRF.

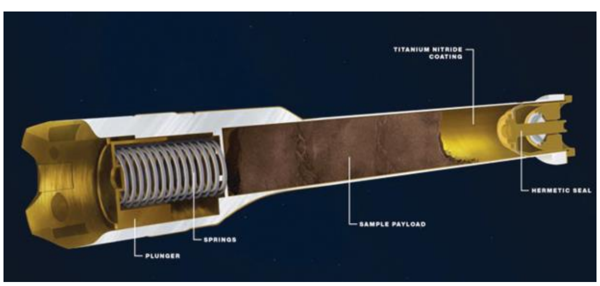

Fig 1. RSTA, Credit: NASA/JPL-Caltech

Acknowledgements: JPL Engineering team, Rock team, MSR Science team, MSR Curation team, Scott Eckley, Eduardo Andrade Lima, Benjamin Weiss, Romy Hanna, Dave Edey, Matthew Colbert, Jessica Maisano.

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