PREPARING FOR ANALYSIS OF RETURNED MARS SAMPLES THROUGH COLLABORATIVE ANALYSIS OF HIGH FIDELITY ANALOGS. N. Randazzo[1], J.I. Simon[2], M. Tuite[3], D. Flannery[3,4], C.D.K. Herd[1], T. Fornaro[5], S. Benaroya[1], D.G. Froese[1], S. Eckley[6], J. Harvey[1], F.M. McCubbin[2], J. Pumple[1], E.W. O'Neal[6], A. B. Regberg[2], R.A. Zeigler[2], [1]Dept. of Earth and Atmospheric Sciences, University of Alberta, Edmonton Alberta, T6G 2E3 (randazzo@ualberta.ca), [2]Astromaterials Division, NASA JSC, Houston, TX 77058, USA, [3]Jet Propulsion Laboratory, Pasadena, CA, 91109, USA. [4]Queensland University of Technology, Brisbane, Australia, [5]INAF-Astrophysical Observatory of Arcetri, 50125 Florence, Italy, [6]Jacobs Technology, JSC, Houston, TX 77058, USA.

Introduction: The Mars 2020 Perseverance Rover landed in Jezero Crater, Mars on February 18, 2021. A primary objective of the rover's mission is the collection of rock core and regolith samples for eventual return to Earth in the early 2030s [1]. The Mars Analog Returned Sample Network (MARSnet) is a collaborative effort to maximize the scientific yield of the anticipated ~30 precious samples (roughly 15 g each) using Earth samples analogous to samples that have been or likely will be collected on Mars. MARSnet is intended to work within the iMOST objectives [2] and designed to supplement current Mars Sample Return (MSR) efforts such as the Mars Sample Return Planning Group 2 (MSPG2) [e.g., 3-6] which outline detailed plans, collaborative efforts, and considerations for the safe handling, curation, biocontainment, and analyses of martian samples within Sample Receiving Facility (SRF). The use of replaceable, terrestrial Mars analogue samples will essentially provide multiple "practice runs" to allow MSR researchers to streamline and modify the current handling and analysis protocols and be better prepared when the actual Mars samples arrive on Earth.

Among the challenges to be worked out over the next decade before the samples arrive on Earth are: preliminary examination protocols to identify subsample targets for high priority sample-specific science objectives; estimating the mass requirements and order of analyses; determining how specific analyses constrain downstream analyses; developing best practices for sample mass conservation and minimal sample contamination; creating mature data and information protocols to enable collaborative research; and, engaging the public and building excitement for the Mars Sample Return campaign [e.g., 3-6].

A suite of Archean-age samples was collected in the Pilbara region of Western Australia during the summer of 2022 by a JPL/QUT team using a rotary/percussion drill with a coring bit that captures a core with the similar dimensions as the Perseverance drill (Figure 1).

Figure 1: *Abraded surfaces and a drill borehole where a core was collected. Observations via proximity science instruments of abrasion sites provide a more comprehensive assessment of the sampled outcrop than analyses of just the weathered surface.*

Each drilling event was preceded by a surface abrasion that was subjected to analysis by handheld analogs for rover instruments. Solvent cleaned stainless steel coring bit liners (15 mm outside diameter with a 1 mm thick wall) were transported to and from the field within solvent cleaned Teflon tubes allowing minimal exposure to the environment. Four "witness" tubes were prepared before departure from JPL – three were filled with ashed (24hrs @ 550°C) sand and another with a well characterized organic-rich Jurassic mudstone.

Eleven samples, including two of the witness tubes, were sent from JPL to the University of Alberta (UAb) and an additional eleven samples were sent to NASA JSC to initiate collaborative analysis by visualizing the contents of the unopened core tubes. If appropriate, next generation DNA sequencing will be used to evaluate the amount and type of biological contamination introduced by sample handling. This is to both understand potential terrestrial and microbial contamination of samples as well as contribute to a series of analyses proposed to be conducted on martian samples by the Sample Safety Assessment Protocol Framework including the utilization of X-ray Computed Tomography (XCT) to identify potential targets within the cores for biological sampling [5].

Methods: Samples were imaged with a high resolution XCT scan of the entire tube (19-50 µm/voxel), followed by an 8-9 µm/voxel scan of specific areas of interest. The witness samples were handled with care to reduce the number of potential contaminants introduced to the samples from, e.g., direct hand contact, which can include the transfer of the organic compounds from the skin, to storage in plastics which can transfer phthalates to the samples [7].

XCT scanning allows for rapid, minimally-destructive, three-dimensional examination, classification, and analyses of mineral and lithic fragments as well as void spaces within the sample tubes, as well as identify any structural defects introduced to the tubes during transport that might complicate opening the tubes. The samples sent to the UAb were scanned using a Nikon XTH 225 ST capable of a minimum effective pixel size of 3 µm, fixed with a 225kV 450W rotating target head resulting in a 10 µm spot size up to 30 W, located in the Permafrost Archives Science Laboratory (PACS Lab). Samples sent to JSC were scanned using a Nikon XTH 320 with a 225 kV 225W reflection target head capable of a 3 µm spot size up to 7 W, located in the Astromaterials X-ray Fluorescence and Computed Tomography (X-FaCT) Laboratory. Reconstructed data were visualized with Dragonfly™ software v. 2022.22 (ORS) [8]. Four of the 11 UAb samples have been scanned thus far: a witness tube, regolith, laminated mudstone, and coarse sandstone. Two of the 11 JSC samples have been scanned thus far: a laminated mudstone and an igneous rock (diabase). Figures 2 and 3 detail preliminary XCT scans and illustrate features within the samples including the identification of void spaces. All images have a voxel resolution of 8-9µm.

Current and Future Work: Contamination analyses at the UAb are planned with a focus on comparing the XCT-scanned samples, which received more handling, with the samples that were not scanned. Coordinated organic, inorganic, and biological sample handling procedures will ultimately be tested and refined iteratively using the lithologically diverse set of Precambrian rock cores. Targeted subsampled materials will be subsequently studied by collaborative analytical observations using current state-of-the-art sample science analytical techniques, e.g., those employed in the Astromaterials Division at NASA JSC, in order to develop best practice and next generation sample analysis to maximize the science of samples collected by Perseverance [e.g., 9-12] for Mars Sample Return.

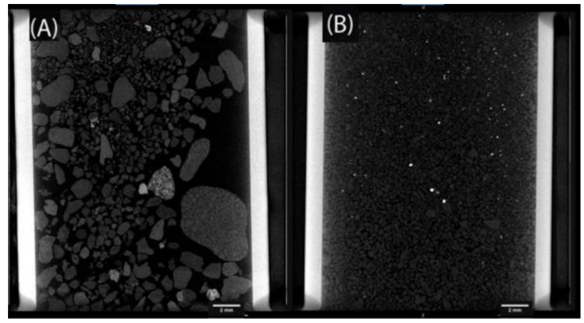

Figure 2:*Side cross section view of the XCT scan of (A) regolith, (B) ashed sand witness from the UAb XCT. Brighter colors represent material with higher-X-ray attenuation. Textures indicative of potential subsample targets can be observed among and within the samples. Scale at 2 mm.*

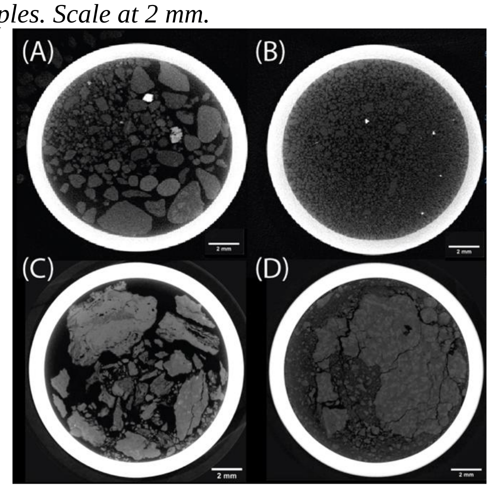

Figure 3: *Top cross section view of the XCT scan of (A) regolith and (B) ashed sand witness from the UAb XCT, and (C) mudstone and (D) diabase, from JSC. Scale at 2 mm.*

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