POTENTIAL ALTERTION PRODUCTS OF ORGANIC MATERIALS BY X-RAY COMPUTED TOMOGRAPHY OF MARS RETURNED SAMPLES

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Introduction: The Mars 2020 rover mission will collect and cache samples from the martian surface for possible retrieval and subsequent return to Earth. Mars Returned Samples may provide definitive information about the presence of organic compounds that could shed light on the existence of past or present life on Mars. Post-mission analyses will depend on the development of a set of reliable sample handling and analysis procedures that cover the full range of materials which may or may not contain evidence of past or present martian life [1].

MSR Curation Protocol- Preliminary Examination by XCT: As part of planning for the initial characterization and subsequent distribution to the scientific community, samples would be analyzed while still sealed in their containers using non-destructive, non-invasive techniques. Studies [1,2] suggest that X-ray Computed Tomography (XCT) may minimally alter samples for most subsequent techniques including organic analyses. Both [1,2] also point out that the effects of increased radiation on the organics in samples would need to be evaluated, especially for what is expected to be a small native organic signal [3] that would be difficult to detect.

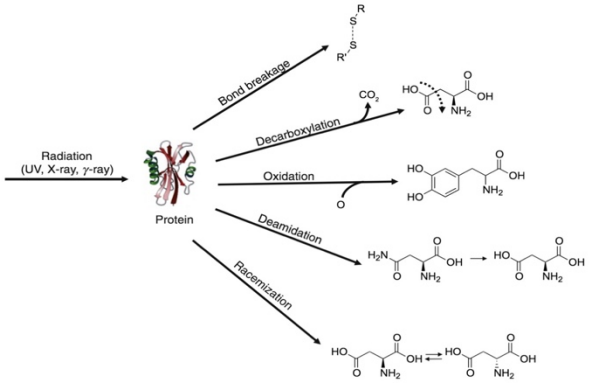

Figure 1: Examples of the types of alteration that organic compounds may experience as a result of primary and secondary effects following X-ray exposure. Image from [6]

Evidence for alteration of organics from XCT. Several studies show no alteration of organics (in meteorites) following exposure to monochromatic synchrotron radiation [4,5]. Others [5,6] show that work is needed to quantify the effects of polychromatic laboratory laboratory XCT radiation, especially at fluences and energies that will allow in situ examination through the Mars 2020 cache tube. X-rays, transmitted to samples through X-ray tomography, X-ray diffraction, and/or X-ray fluorescence interact with sample materials, potentially producing ionizing radiation. Bertrand et al. [6] suggest that organic rich materials experience a wide range of alteration by both primary and secondary radiation effects from photon energies that approach the carbon absorption edge (Fig. 1). Other additional indirect effects may include the creation of chemically reactive by-products, which can react with the original atoms or molecules (e.g. formation of OH radicals or the production of free radicals from macromolecular carbon (MMC) [5]). This combination of effects is the principal mechanism of concern for X-ray alteration of organic-bearing returned samples.

Types and products of organic alteration. An example set of the Tier I analytes selected for this work [7]; were mixed with simulant and loaded into two analogue Mars 2020 cache tubes. One tube served as a control and was not exposed while the other was imaged for 545 minutes at 180 kV and 150 μA using a 1 mm Cu filter to test the instrument's ability to adequately penetrate the cache analogue tube (Fig. 2). Taking into account the variety of potential alteration effects for the given suite of organic analytes we will provide a list of the potential by-products produced during XCT exposure to be tested in individual exposure experiments and analyzed by GCMS. Preliminary examination of the supernatant fluid extracted from the XCT exposed sample suggests that some type of visually identifiable change occurred in the simulant material.

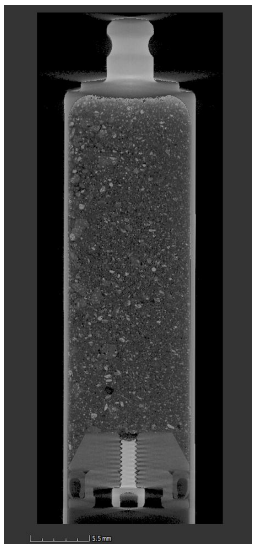

Figure 2: XCT image of a Mars 2020 analogue cache tube, with Mars simulant (<1mm to 4mm fragments) and organic compounds inside.

References: [1] Kminek, G. et al. (2014) Report of the workshop for life detection in samples from Mars *Life Sciences in Space Research* 2: p. 1-5. [2] Hanna, R. et al. (2017) *Chemie de Erde* 77, #4, p. 547-572 [3] Summons R. E., et al. (2014) *Astrobiology* 14.12 : p. 969-1027. [4] Glavin, D.P. et al. (2017) *LPSC XLVIII* abstract #1070 [5] Friedrich, J. M. et al. (2016) *Meteoritics & Planetary Science* **51**: p. 429-437 [6] Bertrand, L. et al., (2015) *Trends in Analytical Chemistry* 66: p. 128-145. [7] Welzenbach, L. C. et al., (2017). *80th METSOC*, Abstract #6253.