IDENTIFYING THE EFFECTS OF X-RAY COMPUTED TOMOGRAPHY ON MARS 2020 TIER I ORGANIC COMPOUNDS

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Introduction: Mars sample return presents unique challenges for the clean collection, containment, curation and processing of samples [1]. The related issues of life detection and Planetary Protection are of particular importance when developing successful strategies for the acquisition and handling of Mars returned samples. In order to achieve the Mars Sample Return (MSR) science goals, reliable analyses will depend on overcoming some challenging signal/noise-related issues, such that sparse Martian organic compounds will need to be reliably analyzed against the contamination background arising from the complicated MSR campaign. Reliable analyses will depend on clean acquisition, as well as robust documentation of all aspects of both the development and management of the cache [2]. There will also need to be a 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. Several reports [1-3] recommend that a carefully defined set of measurements should be made to effectively inform both science and Planetary Protection, applied in the context of the two hypotheses: 1) that there is no detectable life in any of the samples; or 2) that there is Martian life in the samples. Foremost is the concern that the initial steps must protect the pristine nature of the samples. A vital part of preserving pristine samples lies in identifying sources of contamination and methods of capturing Contamination Knowledge (CK), along with potential alteration products that might degrade recognition of non-terrestrial signals of life. Panels have been convened to set standards of organic contamination and CK for preparation of sample collection hardware and storage technologies. Following MSR, preliminary, non-invasive techniques such as computed X-ray tomography (XCT) have been suggested as the first method to interrogate and characterize the cached samples without altering the materials [1-3]. However, there have been some concerns about the potential effects of XCT radiation on organic compounds [4]. This study seeks to address those concerns by quantifying the effects of XCT radiation on Mars 2020 relevant organic compounds, such as those described by the 2014 Organic Contamination Panel (OCP) (see modified and abbreviated set of compounds in Table 1 below)[2].

Contaminant Class	Example	Quantifing Method	Justification
Nucleic acid	Adenine	GCMS	Universal signature of terrestrial life
Amino acid	Glycine	GCMS	Most abundant amino acid in nature;
Lipid	Palmitic acid	GCMS	Most common fatty acid in bacteria and eukarya
Hydrocarbon biomarker	Pristane	GCMS	Common component of petroluem
Polycyclic Aromatic Hydrocarbons (PAH's)	Napthaline	GCMS	Most abundant, readily detectable PAH; found in martian meteorites; should be monitored to avoid false positive measurements
Nitrogenous compound	Urea	GCMS	Important to pre-biotic chemistry
Hydroxy carboxylic acid	Pyruvic acid	GCMS	Metabolite of sugars and important metabolic intermediate
Linear hydrocarbon	Heptacosane	GCMS	Common industrial hydrocarbon contaminant

Table 1: Abbreviated list of Tier I compounds, modified from [2].

How Clean is Clean? Organic contamination, as defined by the 2014 OCP [2] is "any substance that significantly interferes with our ability to detect the presence of martian organic compounds, or prevents our confidently determining that an organic compound is of martian and not terrestrial origin." Of equal concern is the possibility that any preliminary examination may alter what is expected to be a small organic signal that would be difficult to detect at even more energy intensive investigations. To ensure that preliminary interrogations would not diminish detection of a martian indigenous signal, or alter any known contaminants, we will conduct a set of experiments on Tier I compounds (Table 1), which are compounds defined by the 2014 OCP as molecules that are potential contaminants, and likely to be most important to the science goals of the mission [2]. Understanding the degree of alteration of these compounds during exposure to X-ray radiation is critically necessary to allow differentiation of contaminant versus native signal. It is a vital part of the framework for understanding signals that may be the result of alteration, allowing a degree of confidence in our conclusions that is necessary to meet the mission requirements.

Experimental Approach: We will define an alteration function after exposing the following compounds to a range of X-ray energies and intensities in a phased approach that examines nine isotopically labelled compounds from the Tier I list: Adenine, Glycine, Glucose, Heptacosane, Napthalene, Palmitic acid, Pristane, Pyruvic acid, and Urea. Phased experiments will include pure analytes, analytes with known pure substrate in cache-like containers, and finally analytes with Mars analogue materials in cache-like containers.

References: [1] Rummel, J. D., et al. (2002) NASA/CP-2002-211842. [2] Summons R. E., et al. (2014) *Astrobiology* 14.12 : 969-1027. [3]Kminek, G. et al. (2014) *Life Sciences in Space Research* 2: 1-5. [4] Hanna, R., et al., (2017) Chemie de Erde (in press) 26pp.