INVESTIGATING THE IMPACT OF X-RAY COMPUTED TOMOGRAPHY IMAGING ON ORGANIC MATTER IN THE MURCHISON METEORITE: IMPLICATIONS FOR BENNU SAMPLE ANALYSES.

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Introduction: X-ray computed tomography (XCT) measurements are increasingly being used for 3D reconnaissance imaging of meteorites and returned samples to identify interesting lithologies or petrographic structures prior to sample processing and detailed mineralogical and chemical analyses [1]. At the intensities and wavelengths typically used, XCT does not affect silicate and metallic minerals in chondrites. However, X-ray exposures during XCT can obscure the natural radiation history of chondrites as measured by thermoluminescence [2]. There is also concern that XCT imaging could alter the organic chemistry of the samples. Previous experiments have shown that XCT imaging up to a total dose of ~3 kGy did not alter the amino acid abundances or their enantiomeric ratios in the Murchison meteorite [3,4]. However, the impact of XCT on bulk organic chemistry, other soluble organic matter (SOM) compounds, and insoluble organic matter (IOM) in carbonaceous meteorites is unknown.

XCT is being considered for initial characterization of samples from asteroid Bennu by the Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer (OSIRIS-REx) mission [5]. To inform planning for OSIRIS-REx sample analyses, we irradiated one split of a crushed sample of the Murchison meteorite up to the maximum X-ray dose (~180 Gy) that a Bennu sample would experience during XCT imaging and compared its bulk hydrogen, carbon, and nitrogen abundances and isotopic compositions, SOM abundances and distributions, and IOM residue compositions [6] to a control split from the same sample that was not imaged by XCT.

Results and Conclusions: After XCT, we extracted organic compounds from the X-ray–exposed Murchison sample and the control. We conducted non-targeted soluble organic analyses to compare the chemical distributions of C-, H-, O-, N-, and S-bearing species using Fourier transform ion cyclotron resonance mass spectrometry. We performed targeted measurements using gas and liquid chromatography mass spectrometry to quantify the abundances of protein amino acids, amines, carboxylic acids, hydroxy acids, carbonyl compounds, polycyclic aromatic hydrocarbons, alcohols, sugars, and N-heterocycles in the meteorite extracts. We also made C, N, and H abundance and isotopic measurements using an elemental analyzer–isotope ratio mass spectrometer and 1H and 13C solid-state nuclear magnetic resonance analyses of IOM residues isolated by acid dissolution of the bulk meteorite samples. We found that XCT imaging of the Murchison meteorite had no measurable impact on the average molecular and isotopic composition of IOM, or relative distributions of most of the soluble organic compounds targeted in this study. Elevated abundances of several SOM compound classes were observed in the XCT-scanned Murchison sample relative to the control, which is likely related to the particle size heterogeneity observed by XCT and the measured specific surface area differences between the sample aliquots, rather than a result of the X-ray exposure. These data provide additional confidence that XCT will not significantly alter the organic composition of samples returned by OSIRIS-REx.


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