THE EFFECT OF X-RAY MICROTOMOGRAPHY IMAGING ON AMINO ACIDS AND THERMOLUMINESCENCE IN CHONDRITES.

J. M. Friedrich[1,2], D. W. G. Sears[3], D. P. Glavin[4], D. S. Ebel[2], M. L. Rivers[5], H. L. McLain[4,6], A. Sehlke[7], J. P. Dworkin[4], H. Sears[3]. [1]Department of Chemistry, Fordham University, 441 East Fordham Road, Bronx, New York 10458, USA e-mail: friedrich@fordham.edu, [2]Department of Earth and Planetary Sciences, American Museum of Natural History, 79th Street at Central Park West, New York City, New York 10024, USA, [3]NASA Ames Research Center/BAER Institute, Mountain View, California 95035, USA, [4]Solar System Exploration Division, NASA Goddard Space Flight Center, Greenbelt, Maryland 20771, USA, [5]Center for Advanced Radiation Sources, University of Chicago, Argonne, Illinois 60439, USA, [6]Catholic University of America, Washington, District of Columbia 20064, USA, [7]NASA Ames Research Center/USRA, Mountain View, California 95035, USA.

Introduction: X-ray computed microtomography (μCT) and synchrotron μCT are a useful means of characterizing cosmochemical samples such as meteorites or robotically returned samples. Interesting mineralogies, lithologies, or petrographic structures can be identified in 3D prior to cutting the sample, resulting in critical material conservation and preservation [1]. Petrography and physical properties can be investigated without the making of traditional petrographic thin sections, whose study can complicate interpretation of complex 3D structures [e.g. 2-4]. With respect to chondrites, μCT is generally considered a nondestructive technique since the chemical structures of silicate and metallic minerals are generally unaffected by x-ray exposure at the intensities and wavelengths used for μCT imaging. However, there are concerns that the use of μCT may be detrimental to other components or aspects of chondritic samples. In a series of experiments described and reported in [5,6], we examined if exposure to μCT causes detectable changes in the soluble organic compound (amino acid) content of a carbonaceous chondrite. We have also reported [7,8] on the effects of exposure to x-rays during μCT imaging on the natural radiation record of chondrites, in the form of thermoluminescence (TL).

Samples and Methods: For experiments examining amino acids in chondrites, we used powdered aliquots of the Murchison CM chondrite, a sample for which the natural abundances of amino acids has been established [9,5,6]. For TL experiments we used powdered aliquots of the Bruderheim (L6) chondrite heated to 500°C to remove the natural TL before imaging experiments were carried out [7,8]. Synchrotron μCT imaging was done at the 13-BM-D bending magnet beamline at the of the GeoSoilEnviroCARS (GSECARS) facility at the Advanced Photon Source (APS), Argonne National Laboratory. The synchrotron beamline setup exposed the samples to monochromatic x-rays at energies between 25 and 47 keV [5,8]. "Benchtop" or laboratory μCT imaging [10] was performed with a GE phoenix v|tome|x s240 μCT system of the AMNH, which generates characteristic and bremsstrahlung X-rays from an inclined tungsten target [6,7]. In each experiment, we irradiated our samples (imaged using common to harsher than typical duration and intensity) but also kept appropriate unexposed control samples. Most x-ray exposed samples experienced between ~300 to 1500 Gy [see 5-8 for details]. Amino acid abundance and enantiomeric ratio quantification [9,5,6] and TL analysis [7,8] were done with established methods.

Results and Discussion:

Amino acids. We found that the abundances and enantiomeric ratios of amino acids extracted from the irradiated Murchison samples were within analytical errors of the measurements made on the control Murchison sample [1,2].

Thermoluminescence. Samples of the Bruderheim chondrite imaged by μCT were shown to absorb a radiation dose comparable to that observed by meteorites from cosmic rays, during their 10 to 100 million year exposure, and from internal radioactivities during their lifetime.

Conclusions: We conclude that a synchrotron μCT and polychromatic μCT experiments do not alter the abundances of amino acids or their enantiomeric ratios to a degree greater than how well those abundances or ratios are measured with our techniques and therefore any damage to amino acids is minimal. However, more detailed experiments on organic compound exposure should be considered before concluding absolutely no damage is done to small organic compounds. We also conclude that typical x-ray radiation dosages imparted into a chondrite with μCT eradicates the natural radiation history of the sample, as measured by TL.

References: [1] Ebel D.S. and Rivers M.L. 2007. *Meteoritics & Planetary Science* 42:1627–1646. [2] Friedrich J. M. et al. 2008. *Planetary and Space Science* 56:895–900. [3] Friedrich J. M., et al. 2013. *Geochimica et Cosmochimica Acta* 116:71–83. [4] Friedrich J. M. et al. 2014. *Earth and Planetary Science Letters* 394:13–19. [5] Friedrich J. M. et al. 2016. *Meteoritics & Planetary Science* 51:429-437. [6] Friedrich J. M. et al. 2019. *Meteoritics & Planetary Science* 54:220-228. [7] Sears D. W. G. 2016. *Meteoritics & Planetary Science* 51:833-838. [8] Sears D. W. G. 2018. *Meteoritics & Planetary Science* 53:2624-2631. [9] Glavin D. P. et al. 2010. *Meteoritics & Planetary Science* 45:1948-1972. [10] Ebel D. S. and Friedrich J. M. this workshop.