SYNCHORTRON X-RAY COMPUTED MICROTOMOGRAPHY AND THE RADIATION HISTORY OF METEORITES.

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Introduction: X-ray computed tomography (CT) has become a popular option for examining the internal three-dimensional structure of a varietyof objects, including meteorites. However, we recently showed, using thermoluminescence (TL) methods, that the technique involves exposing the sample to a considerable dose (kGy range) of ionizing radiation and this completely compromises the sample's natural radiation record [1]. Our previous study utilized the GE Phoenix VtomeX S240 computed microCT (μCT) instrument in the American Museum of Natural History, which uses polychonmatic x-rays generated with an x-ray tube. We are now investigating whether the same effect exists μCT experiments performed with monochromatic x-ray beams.

Procedures: Non-magnetic material (ground to ~250 μm) from a chip of the Bruderheim L6 chondrite provided by Chris Herd of the University of Alberta, was heated to 500°C to remove the natural thermoluminescence (TL). This was then divided into ten 25 mg aliquots and sent to the Advanced Photon Source (APS) at Argonne National Laboratory. Five vials were used as controls, since the use of security X-ray machines cannot be excluded in the transfer of these samples, and five were placed, under a variety of X-ray energies (25-45 keV monochromatic in four experiments, and polychromatic "pink-beam" x-rays centered at ~40 keV for another experiment) and times (5-40 min.) typical of μCT applications [2]. The instrumentation used for imaging was beamline 13-BM-D at the GeoSoilEnviro Center for Advanced Radiation Sources (GSE-CARS). The samples were then returned to Mountain View and their radiation exposure determined by the measurement of their TL using a customized version of the Daybreak Nuclear and Medical TL apparatus commonly used for meteorite research [3]. The identity of the controls and samples placed in the μCT is unknown to the NASA group at the present time.

Results: Preliminary measurements for the TL signal registered by the samples are indicated in the table below. Based on amount of noise on the curves and typical reproducibility for Bruderheim, the data have one sigma uncertainties of about 10%.

Vial Label	TL counts/second	Vial Label	TL counts/second
Vial AA	80	Vial FF	>800,000
Vial BB	80	Vial GG	>74,000
Vial CC	80	Vial HH	>28,000
Vial DD	60	Vial II	>10,800
Vial EE	14	Vial JJ	>11,600

The background reading for the apparatus under the present conditions is ~80 cps or less, so clearly we were not detecting any absorbed dose for the first five vials. These must be five of the control vials. No radiation exposure occurred during transit. Vials FF-JJ all showed evidence for considerable exposure to radiation, but therange was considerable and vial FF is distinguished by the high levels of dose absorbed. FF-JJ were were clearly placed in the μCT apparatus. Future work will enable values to replace limits for the bright samples. For reference, 60,000 cps usually translates to about 100 krad (1 Gy).

Discussion/Conclusions: It seems that the radiation exposure for the samples is probably greater for the μCT method than the laboratory CT method. This makes it imperative that irreplaceable samples not be used for CT by any method without a knowledge of the changes in the samples and a conviction that the science gain from the measurements is worthwhile in view of the information lost. We note that many kinds of sample are being examined, or have the potential to be examined, by the CT technique; returned samples from missions to Mars, the Moon and asteroids for example, as well as archeological samples. The TL technique is probably the most sensitive to radiation exposure, this is why it is the standard radiation dosimetry technique in common use today. However, there are other techniques that would be affected (such as ESR and cosmogenic isotope studies), especially if neutron-CT studies were used instead of, or in conjunction with, x-ray CT.

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