COLD CURATION TECHNIQUES: X-RAY COMPUTED TOMOGRAPHY OF THE HAMBURG METEORITE

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Introduction: The Hamburg meteorite fell on 17 January 2018 near the town of Hamburg, outside Detroit, MI [1]. Meteorites were recovered from frozen lake surfaces almost immediately following the fall. One stone in particular was collected by the Sloan*Longway Museum and Planetarium for the purpose of a Cold Curation study (Fries et al, abstract this meeting). An early step in the cold curation analytical sequence is to conduct a non-destructive scan of the meteorite with X-Ray Computed tomography (XCT).

Cold XCT of planetary materials: XCT is a well-established non-destructive tool for curating planetary materials [2], but at the time of this writing has never been completed with cold astromaterials. XCT of cold samples has been accomplished in both the oil and gas exploration industry and the medical fields [3,4], with the latter likely providing the best applications of cryo-scanning using laboratory XCT instrumentation. As part of this Preliminary Examination process for a Cold Curation sample, we have fabricated a simple sample holder for cold measurement and to establish instrument parameters for generating high resolution 3D imagery of the meteorite. Key factors include maintaining low temperatures for the duration of a high resolution scan, and removing interferences caused by cold containment hardware.

Sample Handling Procedure: For this effort, the Nikon XT H 320 LC at NASA's Johnson Space Center was used to conduct the scan. Large cabinet instruments such as this are capable of handling large samples on a free standing sample stage that can rotate 360 degrees. The sample stage currently does not have cooling capability, so a stand alone sample container that can maintain cold temperatures would need to be created. The metal-free, commercially available thermally insulated container was obtained and modified to hold the sample, rated to maintain both hot and cold temperatures for up to 3 hours. To ensure the coldest temperatures could be maintained as rated and potentially for longer during a high resolution scan, dry ice would be used inside the sample container. The interior was modified to house a centrally situated separate sample holder that would stabilize the sample and isolate it from contact with the dry ice. One of the chief concerns beyond sample contamination was stability of the sample and container during the duration of the scan with specific regard to devolatilization of the dry ice. For this reason, the dry ice was pulverized and packed into the space between the central sample chamber and the interior walls of the thermal container.

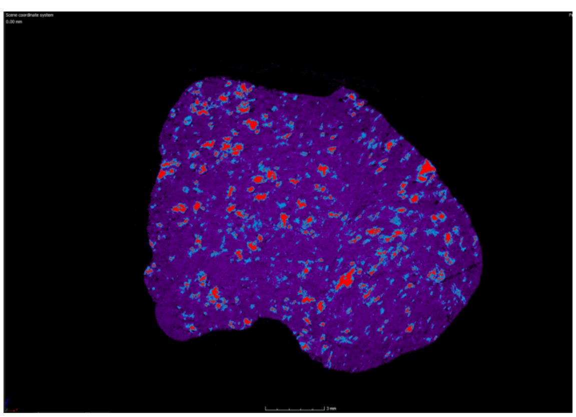

Figure 1- False color image slice of the Hamburg meteorite. Red and blue are metal and sulfide phases, purple undifferentiated silicate phases. Image by Z. Wilbur, NASA-JSC.

XCT of Hamburg: Parameters for scanning the Hamburg meteorite were established from a series of tests with three different proxy samples. Starting with a sample at room temperature, we identified the parameters needed for a scan of sufficient resolution, using the same sample materials that currently enclose the Hamburg meteorite. Follow up tests using dry ice provided information about the stability of dry ice during several subsequent scans before conducting a final scan with the Hamburg meteorite. While the proxy scans provided the best method of loading the sample and dry ice, the Hamburg sample enclosing materials may have shifted during the scan, leading to minor distortion of the scan. The scan parameters of 130 kV at 109 uA, 1250 frames at a resolution of 15 microns were sufficient to penetrate all materials and provide good contrast of silicates and metal phases. Total time from sample loading to its return to the freezer was 3.5 hours. The temperature of the interior sample chamber when the sample was loaded was below the detection limit of the laser thermometer (-40 degrees Celsius) and the final reading of the interior of the sample chamber was -30 degrees Celsius with half the dry ice remaining.

References: [1] Hanna, R.M et al. (2017) *Chemie de Erde* 77(4)pp. 547-572. [2] Kampschulte, M., et al. (2015) *Scanning*, 37(1), pp.63-72 [3] Vasilescu, D.M., (2016) *Journal of Applied Physiology*, 122(1), pp.161-169 [4] Greer, J. et al. (2019) *LPSC XV*, Abstract #1638.