

## SIMULATION OF A COLD CURATION PRELIMINARY EXAMINATION USING A HAMBURG METEORITE

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**Introduction:** The Hamburg, Michigan (H4 chondrite) meteorite fall occurred at 01:08:33 UTC on 17 Jan 2018 (8:08:33 PM local time, 16 Jan). The fireball traveled west of Detroit, MI along an azimuth of approximately 288° according to 674 eyewitness accounts compiled by the American Meteor Society (AMS), which records the event as #168 for the year 2018. Shortly after the fall, meteorites were recovered from the frozen surface of small lakes near Hamburg. One ~5g stone was collected in a clean fashion, kept frozen, and delivered to the Astromaterials Acquisition and Curation Office at NASA Johnson Space Center without allowing it to thaw. This meteorite provides a unique opportunity to study a meteorite that has not thawed since its recovery. A plan to study this frozen sample of Hamburg meteorite is being executed as if it were a returned sample from a cold sample return mission. The purposes are to perform an end-to-end trial of a conceptual Curatorial Preliminary Examination process for a cold sample, and to identify procedural, technological, and analytical strengths and shortcomings in the PE process for cold astromaterials. Lessons learned will feed forward to actual cold sample return missions.

**Description:** Curatorial Preliminary Examination (PE) is the process whereby astromaterials from a sample return mission are first described and analyzed for the purpose of documenting their as-received condition. PE is the first step before addressing the science goals of a sample return mission. The PE Team (PET) performs a broad suite of analyses to characterize mineralogical, organic, isotopic, and other aspects of the material in accordance with the defined mission goals. This characterization is used to guide future analyses. To date, NASA has not performed a cold sample return spaceflight mission, but upcoming potential missions will do so (e.g. comet, lunar volatiles, and/or icy world sample return). The primary purpose of the Hamburg meteorite study is to test established PE procedures adapted for a cold sample, and to identify strengths and weaknesses in the protocol. The principal science product will be a thorough lessons-learned description and recommendations for cold curation of actual sample return materials which will feed forward to cold curation processing capabilities at NASA JSC.

The Hamburg meteorite was generously loaned for this purpose by the Sloan Museum and Longway Planetarium (Sloan\*Longway) in Flint, MI. The meteorite was delivered cold (-20°C) to NASA Curation and is maintained at -20°C. A metal-free, cold container was fashioned and used for XCT imaging as a first step in the analytical sequence. To characterize the background contamination environment, microbial swab samples were collected before and after XCT and the Opera (v.1) [1] instrument followed the meteorite through the XCT process, monitoring the particulate and organic contaminant background. XCT imagery was performed without removing Hamburg from its packaging, and it was returned to the freezer afterwards. The meteorite will be transported to the Subzero Facility for Curation of Astromaterials at the University of Alberta [2] for sub-sampling, using clean NASA Curation hardware in a cold (-20°C) glovebox environment. Next steps in the analytical sequence include thermal analysis to measure volatile content of the frozen meteorite, FT-IR before and after thaw to assess chemical changes incurred during thaw, pyrolysis-GC-MS to obtain bulk organic content, extraction-based GC analysis of the interior and exterior of the stone, C-XANES of minor carbon phases, petrography/mineralogy examination and description, and imaging Raman spectroscopy to provide spatial context for the mineralogical and carbonaceous components. Microbial swab and Opera measurements will be performed during transport and handling of the meteorite. Finally, the remaining meteorite mass will be cut and polished for public display at the Longway Planetarium. 3-D printed models of the meteorite will be produced from XCT data and referenced throughout the processing steps, and will be provided to Sloan\*Longway along with XCT imagery for science outreach purposes.

**Summary:** Cold sample return is a component of future NASA mission planning. Cold Curation is a significant but achievable technical challenge, and the Hamburg exercise provides NASA Curation with unique experience needed to prepare for upcoming missions.

**References:** [1] Fries, M.D., Fries, W.D., McCubbin, F.M. and Zeigler, R.A., 2018. 49th LPSC, Abstract #2276. [2] Herd C.D.K. et al. (2016) *MAPS*, 51, 499-519.