SUBSAMPLING OF THE HAMBURG METEORITE: A STUDY IN COLD CURATION TECHNIQUES. J. L. Mitchell[1], M. D. Fries[1], C. D. K. Herd[2], A. D. Harrington[1], A. B. Regberg[1], F. M. McCubbin [1], P. J. A. Hill [2], and L. D. Tunney[2] [1] NASA Johnson Space Center, Houston, TX (Julie.L.Mitchell@nasa.gov), [2]University of Alberta, Edmonton, Alberta, Canada

Introduction: The Hamburg meteorite is an H4 chondrite which was collected from the surface of a frozen lake in Michigan shortly after its observed fall on 16 Jan 2018 [1]. During and after collection, the meteorite was stored under clean, cold conditions, thereby minimizing any alteration to the sample. The meteorite was transported to the Johnson Space Center (JSC) where it was stored in a freezer until it was subsampled at the University of Alberta's Sub-zero Facility for the Curation of Astromaterials (**Fig. 1**) [2]. Subsampling divided the meteorite into predefined target masses for preliminary examination and display purposes. This abstract summarizes the transport and subsampling process, which occurred in October 2019.

Figure 1. Hamburg meteorite before subsampling at the University of Alberta.

Background. The Hamburg meteorite was subsampled to allow for a full suite of preliminary examination analyses to be conducted at JSC. These analyses will include FTIR, evolved gas analysis, and numerous others using the mass allocations shown in **Table 1**. Preliminary examination will include both cold and warm analyses to determine whether any compositional alteration takes place during or after the thawing process. In addition, a procedural blank (quartz beads) and a positive control (ALH77294, an H4 chondrite) were subsampled to assess sources of contamination and procedural consistency. Throughout the transport and subsampling process, the temperature was monitored, and biological swab samples collected for bacterial, archaeal, and fungal characterization of the tools and meteorites.

Table 1. Subsampling mass allocations.

Min. Mass (mg)	Actual Mass (mg)	Purpose
~8000	7938	Full Sample
10	14	Pyro-GC-MS
100	226	GC-based organics, 1
100	514	GC-based organics, 2
500	1.833	Fusion crust for FTIR
200	435	EGA
4000	4365	Display clast(s)

The University of Alberta's Sub-zero Facility for the Curation of Astromaterials includes a sample preparation area, walk-in freezer (-15°C), and an argon-purged, positive-pressure glovebox. This facility has previously been used to study organic-bearing meteorites (Tagish Lake, Aguas Zarcas) and was used for subsampling the Hamburg meteorite. Hamburg was transported to the University of Alberta for subsampling under cold conditions and the subsamples (and associated monitoring samples) returned to JSC.

Timeline. The Hamburg meteorite, procedural blanks, positive control, and all of the ancillary processing hardware (curatorial hammers, chisels, tweezers, clean aluminum foil, etc. – **Fig. 2**) were transported in three layers of bags with an inner Teflon bag, within insulated, frozen shipping containers. The samples were hand-carried via checked baggage by JSC curators through commercial air transport.

Once at the University of Alberta, the procedural blank was subsampled to determine background contamination during the subsampling process. Biological swab samples of all processing hardware and the sample were collected prior to subsampling. After the procedural blank was processed, all tools, foil, and samples were removed from the glovebox prior to processing the meteorites.

The Hamburg meteorite was processed after the procedural blank. First, it was photographed and weighed. Second, it was swabbed to characterize any bacterial or fungal populations. Finally, it was split into subsamples based on the mass allocations in Table 1. Witness coupons were exposed for each sample processing routine. The meteorite subsamples were placed in sealed, clean containers and bagged for transport. This process was repeated, with separate tools/foil/etc., for the positive control. The subsamples and swabs were returned to JSC in the cold shipping containers used to transport the materials to Canada, with temperature monitoring throughout. The swabs were assessed for type and quantity of bacteria and fungus immediately after return to JSC [3]. The preliminary examination subsamples were placed in cold storage while the display subsample was thawed and delivered to JSC sample processors for sectioning and mounting.

Figure 2. A subset of curatorial tools used to process the Hamburg meteorite.

Results. The meteorites and biological swabs were successfully maintained at below-freezing temperatures throughout transport and subsampling (**Fig. 3**). The biological sampling results are shown in **Table 2** and demonstrate the general cleanliness of the sampling environment and tools.

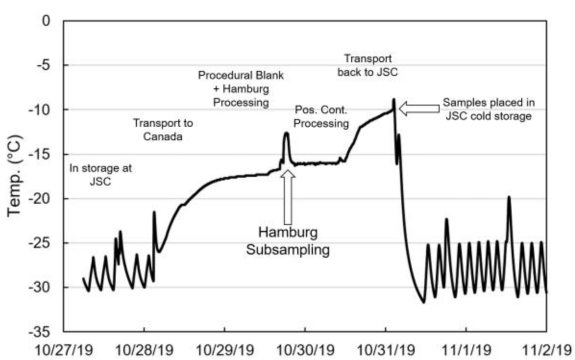

Figure 3. Temperatures during transport and subsampling.

Target	CFU	Species
External bag Pre-XCT	1	*Staphylococcus epidermidis*
Al foil, Hamburg	1 1	*Staphylococcus capitis* *Micrococcus luteus*
Chipping bowl, PC	1	*Staphylococcus hominis*
Al foil, PC	58	*Staphylococcus capitis*
Shipping container	1 1 1	*Staphylococcus capitis* *Staphylococcus hominis* *Bacillus sp.*

Table 2. Bioswab results for surfaces where detections were non-zero. PB = procedural blank, PC = positive control.

Conclusions. The successful collection, storage, transport, and subsampling of a continuously cold, fresh-fallen meteorite have been demonstrated. This activity was the first of its kind, showing that international collaboration can be levied to maximize the preservation and scientific return of astromaterials samples. In addition, we have demonstrated the effectiveness of biological sampling and temperature monitoring throughout transport and processing, paving the way for future cold astromaterials sampling, curation, and scientific study. An additional benefit of the study is the baseline biological characterization of the Subzero Facility, which had not previously been carried out.

Going Forward: We will continue our efforts in understanding contamination pathways during preliminary examination as we continue to process and characterize the Hamburg meteorite. In particular, we aim to streamline the order of operations for preliminary examination and identify/quantify biological, organic, and inorganic contamination levels and sources at each of the various steps in the sample processing procedure. This information will improve sample processing procedures for future preliminary examination efforts on returned astromaterials samples, which is a primary goal of advanced curation studies [4].

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