SUTTER'S MILL: USING COMPUTED TOMOGRAPHY TO CURATE SCIENTIFICALLY IMPORTANT METEORITES.
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Introduction: Meteorites in scientific collections are an important resource to the research community. Getting the most science return out of a collection requires both maximizing research return from each sample and effectively communicating the nature of available samples to prospective researchers. Previous studies have discussed X-ray Computed Tomography (CT) as a screening or curation tool for extraterrestrial samples [1-4]. Flynn et al. [2] suggested the use of synchrotron CT to screen returned mission samples prior to targeting specific areas for laboratory study, but did not discuss curation. Tsuchiyama et al. [3] used a commercial CT system to inform sectioning of the Kobe (CK4) meteorite fall of 1999 for dissemination. Both these systems have drawbacks in the context of curation of museum collections. Synchrotron CT requires abundant and rapidly available beam time, and is most appropriate for small samples [4]. Older commercial CT systems lack sufficient power and resolution for high-quality imaging. Current advances in X-ray Computed Tomography have allowed institutions such as museums to acquire smaller footprint, higher powered CT machines that do not require extensive staffing or intensive maintenance. This advancement allows for museums to nondestructively analyze specimens before destructive analysis, to guide destructive sampling (e.g., sectioning) using 3D images, and to make data available for public outreach, both to peer researchers and to the public at large.

Sutter's Mill: While some scientifically important meteorites have total known weights (TKW) in the tons, e.g. Allende [5], the Sutter's Mill (SM) carbonaceous chondrite (CM) breccia has a current TKW of less than 1 kg [6]. Additionally, the SM sample suite is known to contain breccias, as well as relatively homogenous samples [7,8]. Further supplementary CT data on SM is archived at [9]. This scarcity of material combined with the inhomogeneous nature of SM makes proper sampling and targeting of specific lithologies and clasts of SM a priority. Traditional methods involve sectioning such samples using rock splitters, or small kerf saws, while using surficial characteristics to determine where to cut. These methods are random in nature. They can lead to excessive cutting that misses important targets of research (e.g., intact metal grains, large clasts). Here, we report efforts to use CT imaging prior to cutting or splitting of AMNH sample SM54S, to maximize science return.

Methods: Data for this study was collected on the smaller of the two parts of SM 54, SM54S, at the American Museum of Natural History's Microscopy and Imaging Facility on a GE Phoenix VtomeX S240 scanner. The sample was mounted on a custom built sample holder and held in place with low density foam. Two side-by-side images (4 total frames) were collected in 1000ms exposures using a 0.1 mm Cu filter at 110 kV and 120 nA. Stacks of 2-D density maps were reconstructed via Volume Graphics software and exported as 1746 slices of 16 bit (very high contrast) TIF files. The TIFs were processed as stacked images using ImageJ and converted to AVI movies for quick visual analysis. Sample resolution was 12.175 μm/voxel edge[4]. This data is publicly available as the AVI movie file SM54S_12B_fused_inc3.avi at [9], and http://www.youtube.com/watch?v=j4dMnAPZu70. Movie formats, however, compress data and reduce it to 8-bit contrast resolution. Full resolution data (6.94 GB) can be obtained from the authors.

Sample Description: Several lithologies, up to four [9], are present in the SM samples as a whole and have been characterized as dark and light domains, when compared to matrix [7]. SM54S contains both of these, as well as other features (Fig 1A). Metal or metal sulfide grains are pervasive, appearing as bright white areas in the CT images (Fig 1B). Large mottled lighter clasts are present through the sample, visible on the center left of Fig 1B and Fig 1C. Small rounded dark clasts are present throughout the sample. Several angular clasts greater than 1000 μm are present (Fig 1). These clasts are all extensively internally fractured. One clearly layered object is also identifiable in the data (Fig 1D). Chondrule abundance in general is consistent with CM chondrite lithology.

Other features include fractures and some terrestrial red clay contamination in depressions in the fusion crust [9]. Some fractures follow the morphology of the fusion crusted surface (right side of Fig. 3).

Curation using CT data: Each virtual slice from SM54S contains potential targets for research, and could be targeted for polished thick or thin sections. Since the data is publicly available [9], it is possible for researchers to determine what slice would be best suited for a particular study.

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Figure 1. A) Slice Z_1136 of SM 54. This slice contain abundant matrix with one large internally fractured clast present. This fractured clast is a potential target for further study. B) Slice Z_750 of SM 54. The mottled lithology on the left is one of several large brecciated clasts. The bright spot, either a metal or metal sulfide grain, is approximately 250um across. The fractures on the right go through the sample. C) Slice Z_581 of SM 54. Fractures present here and the mottle clast are continuations visible from B. In this slice, an additional internally fractured grain is evident. A polished sample from this slice could be useful for a variety of research projects. D) Slice Z_1386 of SM 54. Multiple dark clasts are present in this slice compared to other slices. A potential rimmed chondrule exists in the bottom left corner.