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Inclusion Foliation in Murchison as Revealed by High-Resolution X-ray CT

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Several classes of chondritic meteorites have been found to contain flattened chondrules which exhibit a preferred orientation. However, one of the most extensively studied carbonaceous chondrites, the CM2 Murchison chondrite, has thus far not been reported to have any organized 3D fabric or foliation apart from a microscopic matrix foliation defined by the alignment of the basal plane of serpentine. One study did analyze Murchison chondrule shapes in situ but reported that the chondrules had a low mean aspect ratio (1.17) with no evidence of a preferred orientation. We have acquired preliminary volumetric data of a Murchison sample using high-resolution X-ray computed tomography (HRXCT), which has revealed the apparent alignment of elongated inclusions. HRXCT is well suited to the study of macroscopic 3D textures in meteorites as it can be used to non-destructively image the interior and produce a highresolution 3D digital dataset that can be analyzed to quantify such fabrics. The purpose of our study is to quantify and fully characterize the 3D texture evident in Murchison using HRXCT and identify and describe the components that define it.

Murchison sample USNM 5487 (~44 g) was scanned on the ultra-high-resolution ACTIS subsystem at the University of Texas High-Resolution X-ray CT Facility. Two separate populations of inclusions were identified in the HRXCT data based on their shape and differential X-ray attenuation. The first component is a set of inclusions that are brighter (more attenuating) than the matrix and appear to have a wide variety of shapes, some quite irregular and angular. The second component is a group of inclusions that are darker (less attenuating) than the matrix and are commonly spherical or elliptical in cross-section. We segmented and extracted 3D spatial information for both the bright and dark inclusions using Blob3D and fit a 3D ellipsoid to each extracted inclusion. Shape analysis was done by plotting the best-fit ellipsoids for each component on Sneed and Folk ternary diagrams using the TRI-PLOT software.

Our analysis suggests that the dark inclusions display a preferred orientation consistent with flattening while the bright inclusions do not. Because the dark inclusions are the least dense phase in the meteorite and can also be quite large (> 2 mm diameter) it is unlikely that they represent true, unaltered chondrules (reported to be rare in Murchison). Based on their elliptical cross section, low apparent density, and occasional evidence of bright, denser cores, we interpret the dark inclusions to be altered chondrules and the bright inclusions to be unaltered chondrules and anhydrous mineral fragments. Petrographic work will be done to verify this interpretation.

Keywords: meteorite, carbonaceous chondrite, chondrules, asteroid secondary processes, textural analysis, X-ray computed tomography, X-ray CT