3D TOMOGRAPHIC MEASUREMENTS ON ALLENDE VOLUMES – CONSTRAINTS ON THE FORMATION AND ACCRETION OF CHONDRULES AND MATRIX.

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Introduction: Did chondrules and matrix material in carbonaceous chondrites form and accrete in closed, local chemical systems of solar composition [e.g.-2]; or where chondrules formed in one place, then transported to combine with matrix in some other region of the protoplanetary disk [e.g.-1]? This is a central issue in deducing the early history of the solar system.

Chondrules and matrix in some carbonaceous chondrites were shown by [2], using thin-section analysis, to be complementary in terms of their bulk chemical composition. Critical measurements include: (1) bulk chemical compositions of the meteorite and individual components; and (2) volume proportions of component chondrules, CAIs, dark inclusions and matrix. To address item (2), we used x-ray computer-aided microtomography (XR-CMT) to determine the exact volumetric proportions of chondrules and matrix in Allende (CV3). Despite its altered nature, Allende is well-suited for study because chondrules and matrix are chemically different and easy to distinguish in tomographic datasets.

Method: Tomographic images of two ~6x6x12mm equally sized Allende samples were collected using 40-42 KeV x-rays on the GEOCARS beamline of the Advanced Photon Source (APS) at Argonne National Laboratory in Illinois [3]. Image analysis programs were used to separate volume elements (voxels) within the images by their average x-ray attenuation. Repeated measurements of the whole section and smaller subsections showed that the resulting chondrule/matrix ratio can be determined with accuracy better than 5%. Chondrule and matrix compositions were also obtained by broad beam microprobe analysis of thin sections cut from the volumes.

Results: Both samples are expected to have the same bulk chemistry, and the matrix of both samples is found to be isochemical. However, the chondrule/matrix ratios differ by nearly a factor of two. Chondrule chemical compositions must, therefore, differ in the two samples.

Discussion: The close, complementary relationship between chondrule chemistry and matrix chemistry supports a highly localized, isochemical scenario for both the chondrule-forming and the chondrite accretion processes. Hypotheses [e.g.-1] which form chondrules in one region of the solar nebula, then mix them with matrix elsewhare, can be firmly excluded.

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