THREE DIMENSIONAL CHARACTERIZATION OF THE MUNDRABILLA METEORITE,

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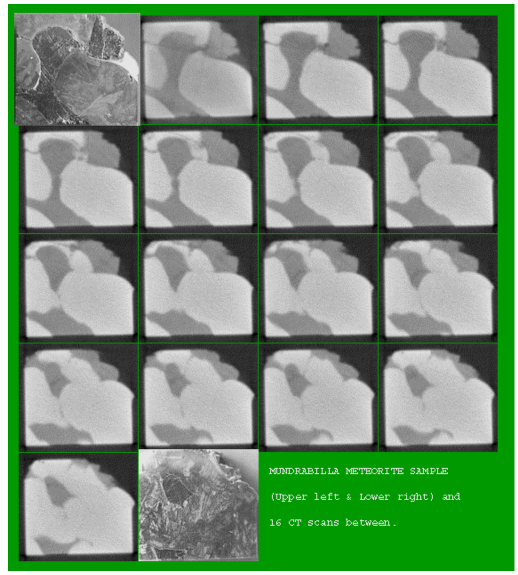
The differentiated meteorite, Mundrabilla, exhibits a rare structure of primary kamacite/taenite, and at least 25 volume % of sulfide (troilite and daubreelite). The structure has been investigated in three dimensions using the technique of gamma-ray computed tomography (CT) with a radioactive ^{60}Co isotope as the source of the flux. Using CT, a 50 kg slab with dimensions 12.6 x 8.2 x ~70 cm has been sectioned at 1 mm intervals over 50 cm length, and the three dimensional structure is at present being evaluated. These data revealed, in addition to the metallic and troilite-rich phases, the presence and distribution of graphite-rich cones (up to 5 cm long), and small (1-2 mm), low density particles. The graphite cones are readily visible on the surfaces of many of the sections of Mundrabilla, while the smaller phases have a density (determined from CT) of approximately 2.9 g/cc, and are assumed to be silicate inclusions. CT spatial resolution is not adequate to elucidate the shapes of these particles. One can only state that they show no directionality and are equiaxed.

A smaller piece, 3.6 x 3.2 x 0.9 cm, was also available, and was polished and etched on both sides. CT scanning of this piece at 0.5 mm intervals is shown in the accompanying figure. Macrographs are shown at each end of the specimen. CT reveals clearly the nature of the two primary phases, recognizably distinctive from their densities, with the lighter shading corresponding to the denser metallic phase. Neither graphite nor silicate was observed in this sample. The progressive change in the shape of the primary metallic phase can readily be seen in these photographs.

In the larger sample, the graphite is visible in CT as intermediate density triangles passing through several cm of depth, while the silicate inclusions, show up as black dots. Of specific interest here is the ability to visualize in three dimensions the shape of the iron and sulfide phases with respect to their curvature. Mean interfacial curvature is a driving factor in the coarsening of dendritic structures. Recent work has determined a method for quantifying three dimensional interfaces using measurements of curvatures derived from serial sectioning and microscopy of metal samples.[1] CT data are ideal for these computations and are being reduced to show the extent of maturity of coarsening present in the sample. In Mundrabilla an initial supposition is that the iron-nickel is the primary phase of a directionally solidified eutectic. Should this be the case, then the structure would exhibit the characteristics of dendritic solidification, and the long duration at high temperature would result in much coarsening of the structure.



Computed Tomography sections through the Mundrabilla meteorite

Another use for the CT data is as the data set for fabricating models of the structure using the technique of free-form fabrication or rapid prototyping.[2] A low melting point material such as a solder or plastic is layer-by-layer injected onto a plate to build up a three dimensional representation of a component. A computer file controls the two-dimensional movement of the feed, in this case derived from the CT data for one of the phases. The contiguity of both the metal and sulfide phases can be established by this technique.

References [1] Alkemper J., Mendoza R. and P. W. Voorhees, (2001) TMS Fall Meeting, Indianapolis, Nov. 2001. [2] Cooper, Kenneth G., (2001) "Rapid Prototyping Technology: Selection and Application," pub. Marcel Dekker.