WHY DO CHONDRULES WITH VOLUMETRIC METAL/SILICATE RATIOS OF 1 TO 37% AGGREGATE TO SOLAR FE/SI IN THE RENAZZO CR CHONDRITE?

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Introduction: A first order observation is that the CR and most other chondrites have nearly identical, solar Si:Fe:Mg abundance ratios, despite very different chondrule sizes and textures, and different chondrule/matrix ratios [1]. Why are chondrules and matrix (and CAIs) complementary in always summing to near-chondritic proportions of major elements [2-5]?

The answer bears on the location and mechanism of chondrule formation in the protoplanetary disk. This 'complementarity'[1] suggests that chondrule precursors and matrix originally constituted batches of material with solar Si, Fe, Mg (and Ca, Al, etc.) relative abundances, from which chondrules formed in varying amounts, and accreted with local matrix material to make chondritic meteorites. It seems unlikely that this chondritic composition could be preserved by remote formation of chondrules (e.g., near the sun), transport, and combination with matrix (e.g., at 3-5 AU). Indeed, why would the chondrules in different chondrite types have the distinctly different characteristics observed?

Results: We have measured the actual volumetric abundances of metal and total silicate in 8 chondrules representative of >100 chondrules in a 1 cm^3 piece of Renazzo, using synchrotron tomography (17 micron/pixel) and image analysis [6]. Metal/silicate ratios vary widely from 1 to 37%. Modal reconstructions yield highly variable Mg/Si ratios in bulk silicates.

Discussion: The aggregate of chondrules is complementary, in the same sense as matrix and chondrules [1-5]. That is, despite their very high variability in both metal/silicate (measured in 3D) and Mg/Si (from 2D data) the chondrules in Renazzo have, in aggregate, just the correct abundances to combine with matrix into a chondritic whole. The chondrules are complementary individually to each other, and complementary in aggregate to the matrix. This is further evidence that local heating occurred in batches of chondritic precursor mineral dust, forming chondrules in various chondrule/matrix proportions, highly variable individual chondrule compositions, and chondrules with distinctive textures in each local region. Chondrules and local, unprocessed dust (matrix) accreted with little mixing, into parent bodies that preserve the bulk chondritic abundances present in the original local regions. This requires a widespread mechanism to heat dust aggregates in highly localized volumes out in the disk without destroying nearby presolar grains that remain in matrix [7]. Two plausible ideas consistent with accretion theory are [8, 9].

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