SOURCES OF RECYCLED PLANETESIMAL DEBRIS DURING THE ERA OF CHONDRULE FORMATION

I. S. Sanders, Department of Geology, Trinity College, Dublin, Ireland. E-mail: isanders@tcd.ie

Collision and recycling in the young disk: It seems likely that most chondrules were made some 2 Myr after the parent bodies of magmatic iron meteorites [1] and were therefore forged in a disk already populated with planetesimals. Since the latter were undergoing collisional accretion, then chondrules were presumably made from the resulting collision debris. This conclusion is strongly supported by fragments of sintered (hence planetesimal-derived) olivine-rock inside chondrules [2].

Volatile-poor early planetesimals: Noting that magmatic irons are highly depleted in volatile elements, and were formed perhaps at 1 AU, Bland and Ciesla [3] propose that they accreted early in a partially condensed hot inner nebula. Their disruption and recycling into the disk would then perhaps have carried the volatile element depletion signature inherited by the younger chondrites. Scott and Sanders [4] infer a similar break-up of an early generation of refractory planetesimals to account for the Mn-Cr whole-rock isochron for carbonaceous chondrites.

FeO-poor early planetesimals: Fedkin and Grossman [5] puzzle over the presence of FeO-bearing olivine and pyroxene in chondrules when FeO-free silicates and iron metal are thermodynamically stable in a hot nebula of solar composition. They speculate on a local oxidizing environment for chondrule formation, namely an impact-generated vapour plume where the colliding bodies carried water ice. In this context one can ask if 'oxidising' water may explain the correlation of the FeO/(FeO+MgO) and the Δ^{17}O values of E, O and R chondrites.

Molten planetesimals: The uniformly high level of heat-producing ^{26}Al in nebular dust [6] means that many planetesimals that accreted in the first 1.5 Myr, like the iron meteorite parent bodies, melted and remained molten for about the first 3 Myr [7]. Their disruption would have launched into the disk cascades of molten droplets (chondrules) as well as fragments of sintered rock from their outer unmelted regions. Some if not all chondrules must have formed in this way, as proposed by [8]. Their age range is perfect. Depending on their time and place of accretion, the molten bodies would have been volatile-depleted and reduced to varying degrees. Molten reduced planetesimalsIs may have splashed to yield type-I (FeO-poor) chondrules.

Chondrules display some features perhaps unique to an origin in an expanding cloud splashed from a large body of melt. Some are > 1 cm across. Some contain mm-sized megacrysts, too large to have grown during the few hours of chondrule cooling. Some were molten when they impinged on their neighbours, making clustered sticky chondrule aggregates [Hewins, pers. comm.]. Perhaps most importantly, Na in chondrule olivines [9] implies such close proximity of droplets during initial cooling that, if they were not moving apart, they would have fallen together under gravity, accreted hot, and lost their low temperature matrix.

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