IMPACT PLUME ORIGIN OF FERROAN CHONDRULES IN CH CARBONACEOUS CHONDRITES.

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Origin of chondrules is one of the fundamental, but unsolved problems in cosmochemistry. Among the recently proposed mechanisms of chondrule formation are shock waves [1,2], collisions between partially molten planetesimals [3], collisions between undifferiantiated planetesimals [4], and current sheets [5]. Our goal is to identify characteristic features of chondrules produced by a possible chondrule-forming mechanism.

There is a general consensus that most chondrules in CB chondrites and significant fraction of chondrules in CH chondrites formed in an impact generated plume of gas and melt ~5 Myr after formation of CV CAIs [6–9]. In contrast to type I and II porphyritic chondrules dominated in most chondrite groups, the impact produced chondrules in CHs and CBs show a number of unique characteristics: almost exclusively non-porphyritic textures [skeletal olivine-pyroxene (SOP) and cryptocrystalline (CC)], Mg-rich compositions ($Fa/Fs_{\sim2–3}$), large depletion in moderately volatile elements (Mn, Na), narrow range of O-isotope compositions [10], and mass-dependent fractionation effects in Fe and Mg [11,12]. We have previously suggested that magnesian CC chondrules (Mg-CC) formed as gas-melt condensates, whereas Ca,Al-rich SOP chondrules resulted from complete melting and partial evaporation of solid precursors in the plume [6,10]. Here we report on the mineralogy and O-isotope compositions of ferroan CC chondrules (Fe-CCs) in CHs studied by SEM, EPMA, FIB+STEM, and SIMS.

The Fe-CCs are generally small, ~20–30 μm in apparent diameter, and very rare compared to Mg-CCs. They are highly depleted in CaO and Al_2O_3 (typically <0.04 wt%), contain higher abundance of MnO (0.1–0.9 wt%) and Na_2O (up to 0.5 wt%) than Mg-CCs, and have pyroxene-normative compositions ($Fs_{8–44}$). Most Fe-CCs contain compositionally uniform euhedral inclusions of Ni-rich (10–18 wt%) metal [12]. Some Fe-CCs are surrounded by thin rims (3–5 μm) of ferroan olivine ($Fa_{44–62}$) with tiny inclusions of metal, chromite, and ±sulfides. The rim olivines have acicular morphology and display triple juncions. The rimmed chondrules show enrichment in FeO towards the olivine rims, suggesting Fe-Mg interdiffusion after rim formation. Fe-CCs show a range of O-isotope compositions ($\Delta^{17}O$ ~ –2‰ to ~2±1.5‰, 2σ), and are slightly ^{16}O-depleted relative to Mg-CC chondrules ($\Delta^{17}O$ = –2.2±0.8‰) [10]. We propose the following impact plume scenario for the origin Fe-CCs: (*i*) condensation of magnesian silicate melt around Fe,Ni-metal melt droplets, (*ii*) partial dissolution of Fe,Ni-metal oxidized by the surrounding ^{16}O-depleted gas in the silicate melt, and volatilization of some FeO from silicate melt, (*iii*) crystallization of euhedral metal grains from supercooled silicate melt followed by its solidification, (*iv*) condensation of ferroan olivine rims, and (*v*) high-temperature annealing in the plume.

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