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Origin of the volatile element depletion in CR and CV carbonaceous chondrites and their components

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The origin of the volatile element depletion shown by different groups of carbonaceous chondrites (CC) relative to CI chondrites is debated. Explanations included incomplete condensation from nebular gas [e.g., 1] or variable mixing of volatile-rich and volatile-poor components [e.g., 2].

In CC bulk rocks, the moderately volatile element Zn displays a scattered correlation of its abundances with mass-dependent $\delta^{66/64}$Zn [3, 4] which is difficult to explain by kinetically-controlled evaporation processes. Previous studies have shown that isotopic compositions on separated components of CV chondrites display even larger ranges compared to bulk rocks: Chondrules and refractory inclusions are characterized by variable Zn depletion and lighter isotopic compositions whereas matrix is isotopically similar or slightly heavier than the bulk rock [e.g., 3-5]. However, the origin of the variations among bulk rocks still remains uncertain.

Here, we investigate these processes in the CR2 chondrite MIL15328 in comparison to new and previous data on CV chondrites [4, 5]. As for CV chondrites, MIL15328 displays strong internal heterogeneity of Zn abundances and $\delta^{66/64}$Zn. A matrix-rich aliquot from MIL15328 has a slightly lighter $\delta^{66/64}$Zn (0.20±0.04‰) compared to the respective bulk rock (0.38±0.06‰). Three single chondrules from MIL15328 display a large $\delta^{66/64}$Zn range from -3.17±0.17‰ to 0.28±0.06‰. These values correlate linearly with Zn mass fraction (12 to 36 µg/g) and chondrule size, respectively. The data suggest that the Zn budget of small chondrules predominantly records the interaction with strongly isotopically fractionated cooling gas. In larger chondrules, Zn may be a mixture between isotopically heavy Zn hosted by metal and sulfide inside chondrule rims [5] and metal- and sulfide-poor chondrule interiors which are more strongly affected by isotopically light gas. The differences in the behavior of mass-dependent Zn isotopes in chondrules compared to less volatile elements such as Si reflects the different volatility, diffusivity and partitioning behavior of these elements during cooling of the chondrules.

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