Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.34930

Moderately volatile element isotopes record distinct condensation regimes in CB and CH chondrites

VINCIANE DEBAILLE[1], GUILLAUME FLORIN[2], JÉRÔME ROLAND[1] AND STEVEN GODERIS[3]

[1]Université libre de Bruxelles
[2]Université Clermont Auvergne
[3]Vrije Universiteit Brussel

CB (Bencubbin-like) and CH (High-metal) carbonaceous chondrites are unusual meteorite groups with exceptionally high metal abundances, reaching ~70 vol% in CB and ~30 vol% in CH chondrites. Both are strongly depleted in volatile elements, implying formation under conditions unlike most other carbonaceous chondrites. Textures, isotopic zoning, and ^{207}Pb-^{206}Pb ages indicate that they did not form via standard nebular condensation but rather by condensation within an impact-generated vapor plume. In such environments, isotopic fractionation develops as condensation proceeds along gradients in temperature and cooling rate, producing localized signatures governed by plume dynamics. Bencubbin chondrites are subdivided into CBa and CBb groups mainly by texture and grain size. CBa chondrites are coarse-grained and dominated by centimeter-scale metal aggregates, with silicate clasts and fragmented chondrules. CBb chondrites are finer, with metal grains averaging ~200 μm and chondrules typically 50–200 μm in diameter. Related CH chondrites contain the finest textures, dominated by barred olivine chondrules ~80–150 μm across.

We measured bulk elemental abundances and isotopic compositions of Fe and moderately volatile elements (MVE: Cu, Zn and Ga) in CB and CH chondrites to constrain their formation histories. Fe, Cu, and Ga show coherent trends: CBb chondrites are enriched in lighter isotopes relative to CBa, while CH chondrites are intermediate. Zn shows the opposite behavior, with CBb and CH enriched in heavier isotopes compared to CBa.

Isheyevo, which contains both CBb- and CH-like lithologies, yields intermediate isotopic compositions, reinforcing a genetic link among these groups. The opposing behavior of Zn versus Ga-Cu-Fe likely reflects shifts in condensation regime during plume expansion and cooling. We propose that CBa records relatively slow cooling that permitted near-equilibrium condensation, followed by disequilibrium conditions due to rapid cooling before Zn condensation (697 K at 10^{-4} bar). On the contrary, CBb likely experienced rapid initial cooling followed by conditions favoring equilibrium condensation. CH chondrites record a mixture of these two endmember conditions.

Overall, combining multiple MVE isotope systems constrains the thermodynamic evolution of impact plumes and clarifies how transient, high-energy events shaped the chemical and isotopic diversity of early solar system materials.