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LETTER

A simple inorganic process for formation of carbonates, magnetite, and sulfides in Martian meteorite ALH84001

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ABSTRACT

We show experimental evidence that the zoned Mg-Fe-Ca carbonates, magnetite, and Fe sulfides in Martian meteorite ALH84001 may have formed by simple, inorganic processes. Chemically zoned carbonate globules and Fe sulfides were rapidly precipitated under low-temperature (150 °C), hydrothermal, and non-equilibrium conditions from multiple fluxes of Ca-Mg-Fe-CO_2-S-H_2O solutions that have different compositions. Chemically pure, single-domain, defect-free magnetite crystals were formed by subsequent decomposition of previously precipitated Fe-rich carbonates by brief heating to 470 °C. The sequence of hydrothermal precipitation of carbonates from flowing CO_2-rich waters followed by a transient thermal event provides an inorganic explanation for the formation of the carbonate globules, magnetite, and Fe sulfides in ALH84001. In separate experiments, kinetically controlled ^{13}C enrichment was observed in synthetic carbonates that is similar in magnitude to the ^{13}C enrichment in ALH84001 carbonates.