

Mg isotope evidence that magnesite in Martian meteorite ALH84001 precipitated as hydromagnesite

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We report the first magnesium ($^{26}\text{Mg}/^{24}\text{Mg}$) isotopic compositions of magnesium carbonate concretions in martian meteorite ALH84001 (an ancient orthopyroxenite) based on *in-situ* ion microprobe measurements. Mg-rich carbonate minerals (magnesite and magnesio-siderite) are present in ALH84001 as compositionally zoned concretions. These 3.94 Ga carbonates, which are important products of the Noachian water and rock cycles, formed at 18 ± 4 °C by evaporation of CO_2 -rich aqueous fluid from a subsurface reservoir on Mars [1]. Mg isotopic compositions discriminate among Mg sources (dissolution of clays, serpentinization, igneous rock weathering, etc.) and constrain aspects of the authigenic carbonates' paragenetic history such as the identity of the originally precipitated phase (hydrous or anhydrous).

The magnesite rims are enriched in ^{26}Mg ($\delta^{26}\text{Mg}_{\text{DSM-3}} = +0.6$ to $+0.9$ ‰) compared to bulk solar system. This indicates that the original precipitate was hydromagnesite which, unlike anhydrous magnesite, preferentially incorporates ^{26}Mg from Mg dissolved in aqueous fluid. The hydromagnesite must have subsequently dehydrated to magnesite.

Hydromagnesite forms on Earth by evaporation. Similar mechanisms of hydrous Mg carbonate formation operated on Noachian Mars. Calculated $\delta^{26}\text{Mg}_{\text{DSM-3}}$ of bulk fluid Mg in isotopic equilibrium with the hydromagnesite ($+0.2$ to $+0.5$ ‰) are higher than primary igneous silicate minerals (olivines and pyroxenes; -0.3 ‰) in martian meteorites including ALH84001, indicating that the Mg for hydromagnesite growth was derived from the dissolution of secondary silicate phases, which are also enriched in ^{26}Mg .

These results are evidence of vigorous low temperature aqueous weathering on early Mars.

[1] Halevy, Fischer & Eiler (2011), *Proc. Natl. Acad. Sci.* 108(41), 16895-16899.