

Lithium isotope constraints on surface processes on Mars

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Lithium contents and isotope compositions were determined for a suite of martian meteorites, including Tissint and breccia NWA 7034. The latter meteorite is considered representative of ancient, chemically distinct martian crust. The ranges in Li abundances and isotope ratios in most chassignites and shergottites are similar to terrestrial peridotites and basalts and provide further constraints on the $\delta^7\text{Li}$ homogeneity of inner Solar System planetary bodies. The estimated $\delta^7\text{Li}$ of the martian mantle is 4.2‰, indistinguishable from that of the Earth, Moon and Vesta. The absence of correlations with indices of magmatic fractionation (Mg#) and/or incompatible element depletion (La/Sm) indicates decoupling of Li from these parameters. The source of enriched shergottites probably underwent olivine segregation resulting in slightly elevated $\delta^7\text{Li}$ in the most primitive members (LAR 06319) relative to depleted/intermediate shergottites. Part of the $\delta^7\text{Li}$ variation may also be linked to AFC processes. The lack of heavy $\delta^7\text{Li}$ in nakhlites with abundant alteration products suggests ephemeral activity of low-T fluids on the martian surface. From coupled Li-Cl, systematic variations towards high [Li] and low $\delta^7\text{Li}$ in shallow-seated nakhlites imply active percolation of sub-surface hydrothermal Cl-rich fluids/brines after crystallization of augite, but the exact timing of fluid/brine percolation remains unknown. These findings are confirmed by an even lighter $\delta^7\text{Li}$ paralleled by elevated [Cl] in NWA 7034, although a chemically distinctive 'crustal' reservoir appears less permissible from radiogenic (Nd, Os) isotope constraints.

The differences in [Li] and $\delta^7\text{Li}$ between the martian crust and mantle are equal in magnitude to the Earth's continental crust and mantle and invoke similar partitioning behavior of Li in silicate Earth and Mars. The near-identical $\delta^7\text{Li}$ of the mantles of inner Solar System bodies (Earth, Mars, Moon, Vesta) invoke inability of enstatite chondrites to form the major building blocks of the terrestrial planets.