

GERMANIUM ISOTOPES REVEAL DISTINCT PROCESSES OF MODERATELY VOLATILE ELEMENT DEPLETION AMONG PLANETESIMALS

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The depletion of moderately volatile elements (MVEs) is a key characteristic of a planetary body's chemical composition, but the origins of these depletions are unclear. The MVE depletions may result from heating of dust in the solar nebula or devolatilization during planetesimal formation and differentiation. To investigate the relative importance of these processes for a given object, we studied the mass-dependent isotopic composition of the MVE Ge in a comprehensive set of chondrites and iron meteorites. The chondrites exhibit Ge isotope fractionations which correlate with matrix mass fraction and degree of Ge depletion. As for other MVEs [e.g., 1,2], this indicates mixing between volatile-rich, isotopically heavy matrix and a volatile-poor, isotopically light chondrule component. Despite much larger Ge depletions, the iron meteorites exhibit a similar range of Ge isotope fractionations as the chondrites. Specifically, the strongly depleted IVA and IVB irons have lighter Ge isotope compositions than the CI chondrites, while there rarely are iron groups with heavier compositions. These observations indicate that the MVE depletions among the irons cannot simply result from degassing of CI-like starting materials. Instead, these systematics are best understood as reflecting two stages of MVE depletion. The first stage took place in the solar nebula and, like for the chondrites, involved mixing of volatile-rich and volatile-poor precursor components. This process resulted in MVE-depleted and isotopically light compositions for the iron parent bodies. The second stage occurred on the iron parent bodies and likely involved degassing from molten iron cores, after collisional disruption of the parent bodies. While for most irons the elemental depletion in Ge mostly occurred during this second stage, these losses do not appear to have induced large Ge isotope fractionations. As such, an iron parent bodies' Ge isotopic composition largely reflects that of its precursor material, which in turn was set by volatile fractionation in the solar nebula. Thus, both primordial nebular and secondary planetary volatile loss shaped the MVE budgets of differentiated planetesimals.

References: [1] Pringle et al. (2017), *Earth Planet. Sci. Lett.* 468, 62–71. [2] Hellmann et al. (2020), *Earth Planet. Sci. Lett.* 549, 116508.