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Ge isotope variations constrain the origin of volatile element depletions among meteorites

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The concentrations of moderately volatile elements (MVE) in meteorites vary by several orders of magnitude. These depletions may reflect heating processes in the protoplanetary disk which led to MVE removal from a parent body's precursor material [1]. For instance, variable MVE depletions among carbonaceous chondrites may reflect different proportions of volatile-rich matrix and volatile-depleted chondrules/chondrule precursors [2,3]. Among the differentiated meteorites, some of which exhibit much larger MVE depletions than the chondrites, MVE loss may also result from magma degassing or vaporization during planetesimal formation [4,5]. To distinguish between these different processes of MVE loss, and to assess as to whether MVE loss in chondrites and differentiated meteorites was governed by the same or different processes, we investigated the nature and extent of mass-dependent isotope variations of the MVE Ge in meteorites. The sample set of this study includes all major groups of carbonaceous chondrites as well as samples from all groups of magmatic iron meteorites, including strongly Ge-depleted irons. All isotope measurements were conducted using a ThermoScientific Neoma MC-ICP-MS at the Max Planck Institute for Solar System Research using a ^{70}Ge-^{73}Ge double-spike. The carbonaceous chondrites display systematic inter-group Ge isotope variations towards lighter isotopic compositions for stronger MVE-depleted samples and are correlated with the mass fraction of matrix in each sample. Thus, like for other MVEs [1,3], these variations can be accounted for by mixing between MVE-depleted and isotopically light chondrules and MVE-rich and isotopically heavy CI chondrite-like matrix. Compared to the chondrites, the iron meteorites of this study show much larger Ge depletions, but exhibit a similar range in Ge isotope compositions. The strong MVE-depletions observed for some irons, therefore, do not appear to have been associated with significant additional Ge isotope fractionations compared to their precursor material as represented by chondrites.

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