INVESTIGATING PLANETARY VOLATILE DEPLETION PROCESSES BY GERMANIUM ISOTOPES IN MAGMATIC IRON METEORITES. E. Wölfér*, C. Burkhardt, and T. Kleine, Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany. *Corresponding author. Email: woelfer@mps.mpg.de

**Introduction:** The concentrations of Ge and other moderately volatile elements (MVE) in magmatic iron meteorites vary by several orders of magnitude (Fig. 1), a feature that has been fundamental for defining the major magmatic iron meteorite groups [1]. These depletions may reflect heating processes in the protoplanetary disk which led to MVE removal from a parent body’s precursor material [e.g., 2]. For instance, mass-dependent isotopic variations of MVEs among carbonaceous chondrites may reflect variable proportions of volatile-rich matrix and volatile-depleted chondrules/chondrule precursors [3]. Alternatively, the MVE depletions in the iron meteorites may also result from magma degassing and/or vaporization during planetesimal formation [e.g., 4-6]. For example, the extreme MVE depletions of group IVA irons have been proposed to reflect evaporative losses from exposed molten iron cores after collisional stripping of their silicate mantles [5,6]. Such degassing is expected to result in mass-dependent isotope fractionation, but until now no clear evidence for such isotope fractionation has been found among those iron meteorites that sample protoplanetary cores.

To provide new constraints on the origin and processes of MVE depletion and Ge isotope fractionation among the different magmatic iron meteorite parent bodies, we measured the Ge elemental and isotopic compositions of a comprehensive set of magmatic iron meteorites to search for mass-dependent isotope variations among variably MVE-depleted iron meteorite parent bodies, spanning the entire range of observed Ge depletions (Fig. 1).

**Samples and Methods:** Six IC, eight IIAB, two IIG, eleven IIIAB, one IIIE, two IVA, one IIF, one IIC, five IID, two IIIF, and one IVB iron meteorite samples, as well as three samples of the South Byron Trio (SBT), two samples of the Butler Duo (BD), and two ungrouped carbonaceous iron meteorites were investigated for their Ge elemental and isotopic compositions. All samples were digested in HNO3, followed by chemical separation and purification of Ge by ion-exchange chromatography [7], which has been adapted to the large sample amounts required for analyses of the Ge-poor IIIF, IVA, and IVB irons. Germanium isotopic compositions and concentrations were measured on a Neoma MC-ICP-MS at the Max Planck Institute for Solar System Research in Göttingen using a 70Ge-74Ge double-spike. The Ge isotopic data are reported in $\delta^{74/70}$Ge values as permil deviations from the NIST SRM 3120a Ge standard.

**Fig. 1.** Logarithmic plot of Ge against Ni showing the major magmatic iron meteorite groups. Within each group Ge concentrations are relatively constant, whereas they vary by four orders of magnitude from ~34 ppb for the IBV iron Dumont to ~240 ppm for the IC irons. The two samples of the BD show elevated Ge concentrations of >2000 ppm, but these irons are probably non-magmatic and, thus, do not sample a protoplanetary core [8].

**Results:** The Ge concentrations of the iron meteorites as determined by isotope dilution are consistent with literature data [1] and range by four orders of magnitude from ~34 ppb for the IBV iron Dumont to ~240 ppm for the IC irons. The two samples of the BD show even higher Ge concentrations of >2000 ppm, but these irons are probably non-magmatic and, thus, do not sample a protoplanetary core [8].

The magmatic non-carbonaceous (NC) iron meteorites of this study have relatively uniform Ge isotope compositions with $\delta^{74/70}$Ge values of ~1 (Fig. 2). These results agree well with prior results for IIAB and IIIAB irons [7] and show that these irons together with other magmatic NC irons such as the IC, IIG, and IIIE irons (for which no Ge isotopic data have been reported previously) all have very similar Ge isotopic composition. The only exception are the IVA iron meteorites, which are characterized by a very distinct $\delta^{74/70}$Ge value of −0.5 (Fig. 2).
Contrary to the largely uniform Ge isotopic composition of the magmatic NC iron meteorites, the new data of magmatic CC iron meteorites show more variable $\delta^{74/70}$Ge. Whereas the IIC and IID iron meteorites have $\delta^{74/70}$Ge values of $\sim 1$ (i.e., close to those of most NC iron meteorites), the SBT displays intermediate $\delta^{74/70}$Ge values, and the IIIF IVA parent body lost its entire volatile budget (including Ge) during a catastrophic impact collision [5,6], and subsequently accreted some small fraction of re-condensed and isotopically light Ge. This interpretation, however, is not easily reconciled with the observation that the IVB iron meteorites (CC), which exhibit even stronger volatile element depletion than the IVA iron meteorites, are isotopically heavier (Fig. 2).

Ge isotopic variations among CC iron meteorites. Compared to the NC iron meteorites, the CC iron meteorites exhibit more variable Ge isotopic compositions, but despite the large differences in volatile element depletions their $\delta^{74/70}$Ge values do not correlate with Ge/Ni. For instance, the most volatile-depleted group IVB and the most volatile-rich IIF iron meteorites exhibit the same $\delta^{74/70}$Ge, whereas the relatively volatile-rich groups IIC, IID, and IIIF show quite variable $\delta^{74/70}$Ge. Nevertheless, excluding the IIF iron meteorites, there might be a correlation of decreasing volatile content with decreasing $\delta^{74/70}$Ge, but this trend would, as for the NC iron meteorites, again be opposite of what would be expected from volatile loss by degassing from a melt. Overall, the observed Ge isotopic systematics among magmatic iron meteorites are not easily reconciled with MVE depletion by simple magma degassing and/or vaporization during planetesimal formation. More complex processes, such as partial re-condensation after near complete volatile loss, may be required to explain some of the observed systematics, in particular for the most strongly volatile-depleted iron meteorites. However, it remains to be tested in further studies as to whether the Ge isotopic variations (at least among the CC iron meteorites) simply reflect different mixing proportions of isotopically distinct volatile-rich and volatile-depleted precursor materials, analogously to what is observed for CC chondrites [3].