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Early differentiation and evolution of magmatic iron meteorite parent bodies inferred from Mn-Cr chronometry.

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Members of magmatic iron meteorite groups are thought to sample the cores of distinct parent bodies that experienced large-scale chemical fractionation, most notably metal-silicate separation. The timing of metal core formation in the magmatic iron meteorite parent bodies provides a key time marker for the evolution of early formed planetesimals. The timing and duration of such early solar system processes, including accretion, differentiation and subsequent cooling, can be investigated using the short-lived ^{53}Mn-^{53}Cr ($t_{1/2}$≈3.7 Ma) chronometer.

Chromite and daubréelite are the two main carrier phases of Cr in magmatic iron meteorites. Both minerals have low Mn/Cr ratios (≈0.01) and thus, preserve the Cr isotope composition of their growth environment at the time of isotopic closure, while the in-growth of radiogenic ^{53}Cr from in-situ decay of ^{53}Mn is negligible. The Cr isotope ratios do not need any correction for cosmic ray exposure due to the low Fe/Cr of the samples. Model ages for chromite and daubréelite in magmatic iron meteorites can be obtained by comparing their Cr-isotope composition with the Cr-isotope evolution of the chondritic reservoir, using the known[1] abundances of ^{53}Mn and ^{53}Cr at the beginning of the solar system or any point in time thereafter and an estimate[1] for the Mn/Cr in the relevant reservoir.

The mean Mn-Cr core formation age for IIAB, IIIAB and IVA meteorites is ~1 Myr younger than their mean Hf-W core formation age[2]. A better fit can be obtained by adjusting the model parameters for Mn-Cr model age determination. Uncertainties on the ^{53}Mn decay constant and initial solar system ^{53}Mn/^{55}Mn result in only minor uncertainties in the model ages of generally <0.02 Myrs and hence can be ignored. However, determining the model ages using solar system initial ε^{53}Cr = -0.29, which is within its reported uncertainty (ε^{53}Cr = -0.23±0.09)[1] results in a perfect fit with the mean ^{182}Hf-^{182}W model ages for magmatic iron meteorite groups. Consequently, ε^{53}Cr = -0.29 ± 0.04 is proposed as a better estimate of the solar system initial ε^{53}Cr.

REFERENCES

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