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Dating metal segregation in asteroids using short-lived ^{60}Fe

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The ^{182}Hf-^{182}W systematics of magmatic iron meteorites showed that core accretion took place early in their parent bodies, from ≈ 0.7 to ≈ 2.9 Myr after the start of the solar system as defined by the Ca-, Al-rich inclusions (CAIs), implying that these bodies started to accrete as early as ≈ 0.3 Myr after CAIs [Kruijer et al., 2014]. Another short-lived nuclide, ^{60}Fe decaying to ^{60}Ni with a half-life of 2.62 Myr, can be used to date metal segregation in the parent bodies of differentiated achondrites [Tang and Dauphas, 2012]. However, its use requires a demonstration of its homogeneous distribution in the accretion disk and a precise definition of its initial abundance. We used Erg Chech 002, the oldest known fragment of the igneous crust of a differentiated planetesimal [Barrat et al., 2021], to better constrain the initial abundance of ^{60}Fe in the early solar system. With the help of a high-precision Ni isotope analysis method on MC-ICP-MS, we defined the most precise Fe-Ni isochron to date which returns a ^{60}Fe/^{56}Fe ratio at the time of EC 002 crystallisation of (5.02 ± 0.11) ×10^{-9}. Combining the Pb-Pb absolute crystallisation age of EC 002 (4565.68 ± 0.21 Ma, [Connelly et al., 2023; Krestianinov et al., 2023]) the solar system initial ^{60}Fe/^{56}Fe is defined to be (7.71 ± 0.47) ×10^{-9}, which is 5 times more precise than previous estimates and is recommended to be the reference value for further studies. The ^{60}Fe-^{60}Ni systematics indicates that metal-silicate differentiation in the source of EC 002 took place 0.82(+0.61/-0.52) Myr after CAIs and ≈ 0.8 Myr before the crystallization of the EC 002 parent melt. This constrains a thermal structure and an accretion history for the EC 002 parent body consistent with the EC 002 parental melt being derived from ≈ 25% partial melting of a chondritic source stabilized on a magma ocean [Barrat et al., 2021; Sturtz et al., 2024]. Similar early ages of 0.95(+0.95/-0.76) Myr and 2.26(+1.97/-1.28) Myr after CAIs are found with ^{60}Fe for the core segregation in Vesta and in the parent body of angrites.