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Evidence from achondrites for a temporal change in Nd nucleosynthetic anomalies within the first 1.5 million years of the inner solar system formation

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Heterogeneity in isotopic compositions within the protoplanetary disc has been demonstrated for a number of elements measured in extra-terrestrial materials, mostly based on chondrite meteorite analyses. However, precise ^{182}Hf-^{182}W and ^{26}Al-^{26}Mg ages of iron meteorites, achondrites, and chondrules show that chondrites accreted later than achondrites and therefore do not strictly represent the early (<2 Ma) solar system composition [e.g.1,2].

We obtained Nd mass-independent stable isotopic compositions measured by thermal-ionization mass spectrometry of a suite of diverse achondrites to better constrain the Nd isotope evolution of the early solar system. Carbonaceous (C) achondrites are indistinguishable from their chondritic counterpart. However, early formed planetesimals as sampled by silicate-rich non-carbonaceous (NC) achondrite meteorites have high $\mu^{145}Nd$ and $\mu^{148}Nd$ (deviation/JNdi-1 $\times 10^6$) compared to NC chondrites as observed recently by [3] with angrite and eucrite achondrites. Moreover, the Nd nucleosynthetic composition of a silicate inclusion from the non-magmatic IIE iron meteorite Miles and compiled data for martian and lunar samples suggest that planetary bodies and IIE irons all present a systematic deficit in $\mu^{145}Nd$ and $\mu^{148}Nd$ compared to early-formed NC achondrites.

Unlike chondrites, the Nd isotopic anomalies in achondrites are not correlated to the heliocentric distance of accretion of their respective parent bodies as inferred from redox conditions. Chronological constraints on planetesimal accretion suggest that Nd nucleosynthetic isotope compositions of the inner protoplanetary disc significantly changed around 1.5 Ma after Solar System due to thermal processing of dust in the disc. This relatively late event coincides with the beginning of chondrule formation or at least their preservation [2]. Terrestrial planets formed subsequently by a complex accretion regime during several million years. Therefore, two scenarios are envisioned considering the reported Nd isotope composition of early planetesimals: 1) Terrestrial planets accreted mostly chondritic material similar in composition to enstatite chondrites, or 2) early planetesimals constitute substantial parts of terrestrial planets building blocks mixed with highly thermally processed material enriched in *s*-process, still unknown so far.

[1] Kruijer et al. (2014), Science 344, 1150-1154; [2] Pape et al. (2019), GCA 244, 416-436; [3] Render and Brennecka (2021), EPSL 555, 116705; [4] Kruijer and Kleine (2019), GCA 262, 92-103.