The timing of early solar system reservoir separation

B. JACOBSEN[1], M. -C. LIU[2], A. T. HERTWIG[2], N. E. MARKS[1], K. D. MCKEEGAN[2], T.S. KRUIJER[1], L. E. BORG[1]

[1]Nuclear and Chemical Sciences Division, Lawrence Livermore National Laboratory (jacobsen5@llnl.gov)
[2]Earth, Planetary, and Space Sciences, University of California, Los Angeles

Chondrites fall into two main groups; non-carbonaceous and carbonaceous chondrites, according to distinct $\Delta^{17}O$ and $\varepsilon^{54}Cr$ isotope compositions with no apparent overlap. Based on Mo isotopes and Hf-W age dating, the separation of these two reservoirs is thought to have occurred ~1 Ma after solar system formation as a consequence of Jupiter's early formation. Chondrules are ubiquitous in both groups of chondrites and can therefore shed additional light into the nature and origin of the two groups. Although oxygen isotopes in chondrules have been widely studied, little is known about their ^{54}Cr compositions. ^{26}Al-^{26}Mg ages suggest that most chondrules formed ~2-3 Ma after CAIs, consistent with other decay schemes (Hf-W, Mn-Cr, U-Pb). However, rare cases of chondrules that are older than the main chondrule population do exist. The Al-Mg ages and $\Delta^{17}O$-$\varepsilon^{54}Cr$ systematics are therefore important for understanding the timescale of mixing in the early Solar System and constraining when the two reserviors separated. To investigate this further, we measured oxygen and Al-Mg isotopes by SIMS in five different chondrules from four primitive chondrites; Semarkona (LL3.0), MET 00452 (LL3.05), QUE 97008 (L3.05) and Allende (CV3). Chondrules were excavated out from the meteorites for combined SIMS and bulk $\varepsilon^{54}Cr$ analyses. The oxygen and Al-Mg isotopes were measured on the Cameca IMS-1290 at UCLA. The $\Delta^{17}O$ in the analysed chondrules varies between −6.3 to 1.5 ‰. In QUE 97008, we measured porphyritic olivine chondrule with $\Delta^{17}O$ varying between −5.7 to 0.9 ‰, which covers almost the entire range between the chondrules. The inferred initial $^{26}Al/^{27}Al$ ratios in the chondrules vary between 0.4 - 1.2 × 10^{-5} which are consistent with previously reported Al-Mg ages in chondrules. The oldest chondrules are the Semarkona chondrules with initial $^{26}Al/^{27}Al$ ratios of ~1×10^{-5}, corresponding to an age of ~ 2 Ma after solar system formation. Our initial results are consistent with data reported for other chondrules from the same chondrites and suggests they formed ~ 1-2 Ma after the two reservoirs had separated. ^{54}Cr analyses are currently underway to constrain the reservoir of origin of these chondrules.