Nucleosynthetic diversity of chondrules – tracking disk mass transport and the formation of large-scale Solar System reservoirs

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The most abundant constituent of chondrites are chondrules, millimetre-sized glassy spherules formed as free-floating objects by transient heating events. Pb-Pb dating indicates that primary chondrule production was restricted to the first million years after formation of the Sun and that these existing chondrules were recycled for the entire disk lifetime [1]. These data require efficient outward transport and storage of mm-sized objects during ~4 Myr of disk evolution.

The dichotomy in the abundance of the ^{54}Cr nucleosynthetic tracer between carbonaceous and non-carbonaceous chondrites is thought to reflect distinct accretion regions of their parent bodies. Carbonaceous chondrites, characterized by μ^{54}Cr excesses relative to the terrestrial composition formed beyond the snow line whereas the non-carbonaceous material recording μ^{54}Cr deficits originated Sunward of the snow line [2]. Here, to better understand early disk mass transport processes and recycling, we investigated the nucleosynthetic inventory of Pb-Pb dated individual chondrules from various chondrites (OC, EC, CM, CV, CK and CR) believed to have formed in distinct disk regions.

Our results require the existence of three large-scale, isolated disk reservoirs. The early growth of planetary cores and the opening of disk gaps potentially provides an efficient mechanism for storage by limiting the inward drift of mm-sized solids through the establishment of pressure bumps. We suggest that the early formation of Jupiter and Saturn spatially isolated three disk regions, an inner terrestrial planet disk region where EC and OC formed, a reservoir located between Jupiter and Saturn where CM, CV and CK chondrites accreted and, lastly, a region beyond Saturn where metal-rich chondrites and comets formed. The chondrule age-data requires isolation of these reservoirs within 500,000 years of proto-Sun collapse.

[1] Bollard J. *et al.* (2017) *Science Advances*, submitted. [2] Warren, P.H. (2011) *EPSL, 311*, 93–100