NUCLEOSYNTHETIC DIVERSITY OF CHONDRITES AND THEIR COMPONENTS – TRACKING DISK MASS TRANSPORT PROCESSES AND THE EARLY FORMAITON OF LARGE-SCALE SOLAR SYSTEM RESERVOIRS. M. Bizzarro[1], D. Wielandt[1], T. Haugbølle[1] and Å. Nordlund[1], [1]Centre for Star and Planet Formation, Natural History Museum of Denmark and NBI, Universirty of Copenhagen, Copenhagen, Denmark.

Introduction: Low-mass stars like our Sun form by the gravitational collapse of the densest parts of molecular clouds comprising stellar-derived dust and gas. Such collapsing 'prestellar cores' swiftly evolve into deeply-embedded protostars that rapidly accrete material from their surrounding envelopes via a protoplanetary disk. Recent astronomical observations of young protoplanetary disks suggest that the growth of planetary cores occurs in the earliest stages of disk evolution, namely at the time of significant mass accretion to the disk and protostar [1]. Thus, a better understanding of disk mass transport processes, including the effects of early planet formation on the disk structure, is key to elucidate the nature of the material precursor to rocky planets.

In the Solar System, a record of these processes is preserved in chondrite meteorites. 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 at most the first million years after formation of the Sun and that these existing chondrules were recycled for the entire disk lifetime [2]. These data require efficient mecanisms for the outward mass transport and storage of mm-sized objects during ~4 Myr of protoplanetary disk evolution. Here, we investigate the nucleosynthetic inventory of individual chondrules from various types of chondrites (OC, EC, CM, CV, CK and CR), believed to have formed in distinct disk regions, to constrain mass transport processes in the early Solar System.

Nucleosynthetic diversity of chondrites: 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 (10^6 deviations in the mass-independant ^{54}Cr/^{52}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 [3]. Chondrules from CM, CV and CK chondrites (N=62) record a range of μ^{54}Cr compositions comparable to that observed for inner Solar System primitive and differentiated meteorites. In contrast, enstatite and ordinary chondrite chondrules (N=30) display a narrow range of μ^{54}Cr values limited to compositions observed for inner Solar System asteroidal and planetary bodies. These data require that chondrules formed Sunward of the snowline were transported and stored in the accretion region(s) of CM, CV and CK chondrites. Conversely, the lack of outer Solar System chondrules in ordinary and enstatite chondrites requires a mechanism limiting the influx of mm-sized outer Solar System solids to the accretion of terrestrial planets during the disk lifetime.

The ^{54}Cr and ^{26}Mg* (decay product of ^{26}Al) systematics of metal-rich carbonaceous chondrites (CH, CB and CR) and their components suggest that these formed from a reservoir distrinct from most sampled Solar System objects [4]. This is based on the identification of primordial molecular cloud matter in their precursors. The lack of this signature in CM, CV and CK chondrules suggests a distinct, spatially-isolated formation region for metal-rich chondrites.

Outward mass-transport processes: Jets and disk winds are a generic feature of young strars and their disk and, hence, we have investigated their role in promoting the outward transport of mm-sized solids using zoom-in simulations [5]. Our result indicate that ~50% of mm-solids initially located at a distance of 0.05-0.2 AU in a young turbulent disk are entrained by disk winds and transported to distances ranging from ~1 to beyond 30 AU. Thus, disk winds provide an efficient means for transporting inner disk chondrules to the outer disk.

Early formation of gas giants: Our results requires 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, 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.

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