Mass transport regimes in the solar protoplanetary disk – evidence from meteoritic components

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Chondrite meteorites are fragments of asteroids that did not undergo melting and differentiation and, thus, provide a record of the earliest stages of the solar protoplanetary disk. Ordinary and enstatite chondrites sample parent asteroids that originated in the accretion region of terrestrial planets, whereas the parent asteroids of the water-rich carbonaceous chondrites most likely accreted in the giant planet region. The dominant constituent of chondrites are millimeter-sized chondrules formed by transient heating events in the protoplanetary disk. Recent high-resolution uranium-corrected Pb-Pb dates indicate that chondrule formation started contemporaneously with CAIs and lasted ~3 Myr [1]. Moreover, chondrules from individual chondrites show variability in $^{54}Cr/^{52}Cr$ ratios, which track genetic relationships between early-formed solids and their respective reservoirs. Collectively, these observations indicate that chondrules from individual chondrite groups originated in different regions of the protoplanetary disk and were subsequently transported to the accretion regions of their respective parent bodies.

We report new uranium-corrected Pb-Pb ages as well as $^{54}Cr/^{52}Cr$ ratios for chondrules from enstatite, ordinary and various classes of carbonaceous chondrites, including CV, CK and CR chondrites. Chondrule populations from individual chondrite groups show a comparable age range of ~3 Myr. Chondrules from enstatite and ordinary chondrites show $^{54}Cr/^{52}Cr$ ratios restricted to inner solar system compositions, defined as $\varepsilon^{54}Cr < 0.5$ i.e. lower than bulk CK. In contrast, CV and CK carbonaceous chondrite chondrules record greater $^{54}Cr/^{52}Cr$ variability, with both inner and outer solar system signatures, while CR-chondrules show a limited range of ^{54}Cr rich compositions. These data require different outward mass transport regimes but limited inward transport of outer solar system material in the formation region of terrestrial planets during the main accretion phase of chondrite parent asteroids. We explore the role of protostellar jets and disk winds as potential mass transport mechanisms to account for the observed meteoritic data.

[1] J. N. Connelly *et al*. (2012) *Science*. **735**, L37.