CONSTRAINTS FOR MIXING CHONDRULES FROM MULTIPLE PARENTAL RESERVOIRS.

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Introduction: Chondrules are a major component of chondritic meteorites and potentially populated the entire protoplanetary disk at an early stage of planet formation. Chondrules provide insights into the physical and chemical evolution of the protoplanetary disk. An important constraint for the protoplanetary disk is whether chondrules were transported and mixed throughout the disk, or whether chondrules formed in local environments. Both scenarios are debated extensively in the literature (e.g. [1-8]).

Here we use bulk chondrule compositional data from the recently published ChondriteDB database [9] in combination with a mixing model we developed to test whether the compositional distribution of chondrule populations in individual chondrites are (i) the result of mixing chondrules from multiple parental reservoirs, or (ii) originated from single parental reservoirs.

The sketch in Fig. 1 illustrates the two principle hypotheses of either chondrules originating from a single parental reservoir or from multiple parental reservoirs. It further illustrates the two possible sub-scenarios for each of the two hypotheses: (a) hypothesis 1, single reservoir case: one reservoir – one single reservoirs feeds chondrules to all chondrites from one chondrite group; (b) many reservoirs: – each chondrite from one chondrite group receives chondrules from only one, but always a different parental reservoir; (c) hypothesis 2, multiple reservoir case: (i) – a fixend number of parental reservoirs feed chondrules to all the chondrites of one chondrite group; (d) (ii) – each chondrite from one chondrite group receives chondrules from multiple, but always different multiple parental reservoirs.

Results & Discussion: The result from the mixing model is that scenarios (b) and (d) of Fig. 1 are both principally possible, while scenarios (a) and (c) do not work. In case of scenario (d), chondrules of individual chondrites could be mixtures of up to 3, and in rare cases up to 5 parental reservoirs.

Models of mixing chondrules from multiple parental reservoirs typically involve large spatial separation of these. This would rather suggest a scenario similar to (a) than to (d), which therefore seems unlikely, and, unnecessarily more complicated than scenario (b). Consequently, it seems reasonable that chondrules in individual chondrites originated from single, although different parental reservoirs for each chondrite, i.e., scenario (b).

Anomalous minor element and nucleosynthetic isotope chondrule compositions are possibly best explained by admixing of tiny ›nuggets‹ such as refractory grains with high Al and Ca, or presolar grains with distinct isotopic compositions as suggested by e.g. [10-12].

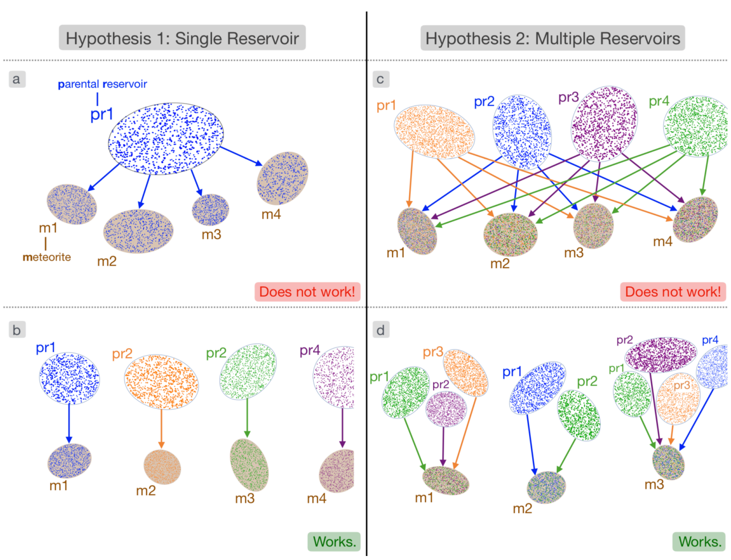

Fig. 1: Sketch illustrating the various possibilities of mixing chondrules from parental reservoirs. meteorite ≙ chondrite.

Conclusions: We provide a fundamental framework which each model that suggests chondrules are mixtures from multiple reservoirs needs to obey. Significant disk-wide transport and mixing of chondrules seems unlikely, and chondrule forming models that produce chondrules from single reservoirs seem to offer the most likely processes for chondrule formation.

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