Using the ChondriteDB database to study chondrule – matrix complementarities

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Introduction: Chondrules and matrix are the major components in chondrites (~95 vol%). Their relationship is much debated, with some favouring an origin from a single, common reservoir [e.g., 1-7], while others argue for different reservoirs with subsequent mixing [e.g., 8-10]. A major argument to decide this question are complemenatry element [1-7] or isotope ratios [11,12] between chondrules and matrix, while the bulk chondrite has solar ratios. Here we expand this argument and show that element ratios are not only complementary between chondrules and matrix in various chondrite classes, but that these complementaries are even variable among individual chondrites of the same class. This further supports the complementary argument that chondrules and matrix likely formed from a single, common reservoir.

Method: The ChondriteDB database contains more than 3500 chondrule and matrix data from >160 meteorites and >80 literature sources [13]. We developed an algorithm to automatically search the database for complementary element relationships.

Results: We found a large number of known, but also new complementarities. The know complementarities confirm the reliability of our algorithm. So far unknown compmelentarities were e.g., found for Al/Ti ratios in CM, CR, CV and CO chondrites. Complementaritis in immobile, refractory elements are in particular strong arguments for the formation of chondrules and matrix from the same reservoir.

Discussion: A new, and particularly interesting aspect was found when studying the complementary element ratios of various chondrites of the same chondrite class. This was, however, only possible for very few chondrites and element ratios. Figure 1 displays the Mg/Si ratios of average chondrules (panel a), and average matrix (panel b) in various CV chondrites. Average chondrules in all chondrites have super-chondritic Mg/Si ratios, while average matrices always have sub-chondritic Mg/Si ratios. The Mg/Si ratios of average chondrules and matrix, however, vary across a significant range of ~1.02 to 1.4 for chondrules, and ~0.69 to 0.97 for matrices. There is no correlation between Mg/Si and reduced/oxidised CV type or the petrologic type. Therefore, the various Mg/Si ratios likely represent pre-accretionary nebula signatures. For example, formation conditions of chondrules and matrix might have varied slightly for the various CV chondrites, thereby producing the variable average chondrule and matrix Mg/Si ratios. Regarding complementarity, it is highly implausible that for each CV chondrite chondrules and matrix were always mixed in the required proportions to result in the CI chondritic bulk compositions. The variations of Mg/Si ratios in chondrules and matrix, together with their always complementary relationships therefore support the formation of chondrules and matrix not only in single, but also highly local environments. Mixing chondrules and matrix cannot explain this.

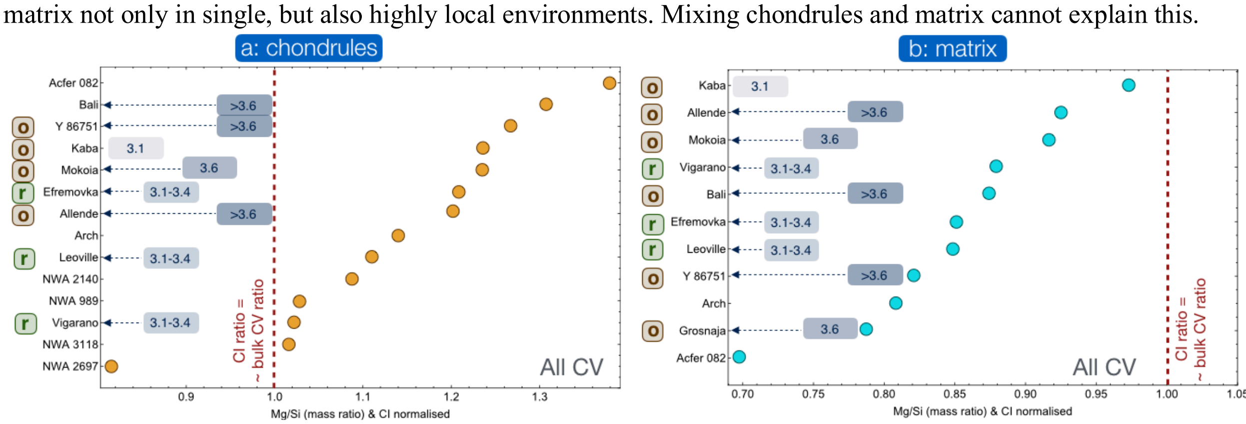

Fig. 1: Mg/Si ratios in average chondrules (a) and matrices (b) from various CV chondrites. o: oxidised; r: reduced; numbers designate the petrologic type of the chondrite (if known).

References: [1] Bland et al. 2005. *PNAS* 102:13755 [2] Hezel and Palme 2010. *EPSL* 294:85 [3] Palme et al., 2014. *CdE* 74:507 [4] Ebel et al. 2016. *GCA* 172:322 [5] Friend et al. 2018. *EPSL* 480:87 [6] Hezel et al., 2018. In: *Chondrules: Records of Protoplanetary Disk Processes*. CUP, pp. 457 [7] Braukmüller et al., 2018. *GCA* 239:17 [8] Zanda et al., 2018. In: *Chondrules: Records of Protoplanetary Disk Processes*. CUP, pp. 457 [9] Olsen et al., 2016. *GCA* 191:118 [10] Alexander 2019 *GCA* in press [11] Becker et al. 2015. *EPSL* 432:472. [12] Budde et al., 2016. *PNAS* 113:2886. [13] Hezel et al., 2018. *CdE* 78:1.