FORMATION OF CHONDRULES AND MATRIX IN KAKANGARI CHONDRITES.

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Introduction: The K (Kakangari-like) chondrite grouplet is chemically and isotopically distinct from other chondrite classes. Nonetheless, similar to many primitive meteorites, the major components are chondrules and matrix. We present a comprehensive dataset, containing petrographic and chemical data to understand the origin and formation of chondrule textures, bulk chondrule compositions and chondrule-matrix complementarities in Kakangari chondrites. The chondrule-matrix complementarity in particular has been recognized as a key characteristic of carbonaceous and Rumuruti chondrites [1,2]. Various element and isotope ratios are different in chondrules than in matrix, while at the same time the bulk chondrite has close to CI chondritic ratios. As a consequence, chondrules and matrix must have formed from a single (solar) reservoir, which is a key constraint for all chondrule-forming models.

Methods: All samples were investigated with an electron microprobe by spot analyses and element mapping. Contiguous X-ray frames were stitched together, creating single element maps of the entire sample for image segmentation following the protocol of [1]. All sample objects were categorized, i.e. classified as chondrules, fragments, metal, matrix, etc. The components of each category were subsequently characterised for statistical evaluation (e.g. object abundances, sizes, compositions). Furthermore, we created phasemaps of all samples. A phasemap shows every mineral phase in false-colour. This is used to easily identify chondrule textures and mineral distributions throughout the samples. Bulk chondrule compositions were obtained from mineral spot analyses using modal recombination.

Results: We analysed four Kakangari sections and determined the bulk compositions of 60 chondrules. Matrix material is highly abundant (~70 vol%). Chondrules (~25 vol%) are mostly heavily fragmented. Only 7% of the chondrules are mineralogically zoned (e.g. ol cores with low-Ca px rims; Fig. 1). Chondrule bulk compositions vary strongly (e.g., Si: ~20–30 wt%, Mg: ~15–30 wt%). Average chondrule and matrix compositions agree with the few literature data available [3]. Preliminary results show that chondrule-matrix complementarities likely exist for Al/Ca, Al/Mg (Fig. 1), and possibly for Fe/Mg ratios.

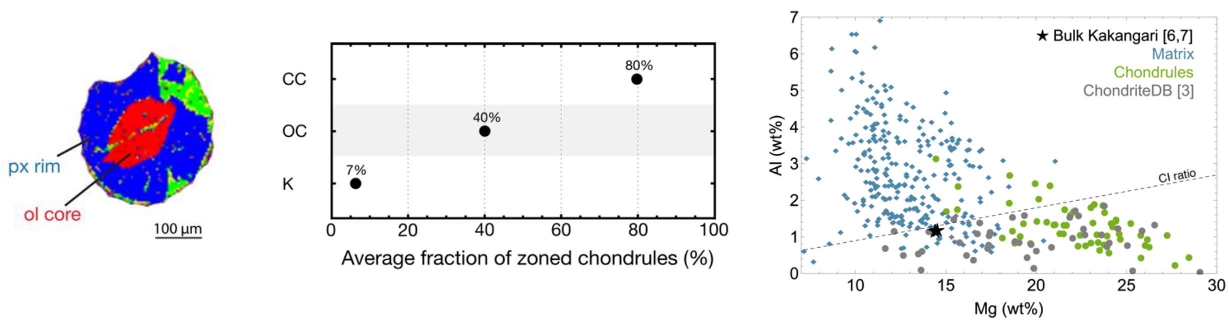

Fig. 1: Left: Phasemap of a mineralogically zoned chondrule (ol core, low-Ca px rim) in Kakangari. Center: Average fractions of mineralogically zoned chondrules in chondrites [4,5]. Right: Al/Mg chondrule-matrix complementarity in Kakangari. Bulk K composition was taken from [6,7].

Discussion: Our study emphasises and expands on the unique properties of Kakangari: (i) Mineralogically zoned chondrules are textural evidence for chondrule open system exchange, which also explain bulk compositional variations [4,5]. Zoned chondrules dominate all major chondrite groups, however, almost none were observed in Kakangari (Fig. 1). Thus, either Kakangari is the first meteorite without textural evidence for chondrule open system behaviour, or chondrules lost their initial zonation. The latter might be related to the widespread fragmentation most chondrules in Kakangari experienced, which is not seen in any other major chondrite group. (ii) We found chondrule-matrix complementarities for Al/Ca and Al/Mg. This suggests that chondrules and matrix likely formed from a single, common reservoir. Interestingly, no complementarity is observed for Mg/Si ratios, which is a prominent example for complementarity in carbonaceous chondrites [1,2], and although the Mg/Si ratio of Kakangari in average chondrules, matrix and bulk appears to be CI chondritic.

References: [1] Ebel et al. (2016) *Geochim. Cosmochim. Acta, 172,* 322–356. [2] Hezel et al. (2018) *Chondrules: Records of Protoplanetary Disk Processes,* 91–121. [3] Hezel et al. (2018) *Chemie der Erde 78,* 1–14. [4] Friend et al. (2016) *Geochim. Cosmochim. Acta, 173,* 198–209. [5] Barosch et al. (2019) *Geochim. Cosmochim. Acta, 249,* 1–16. [6] Mason & Wiik (1966*) American Museum novitates, 2272*. [7] Weisberg et al. (1996) *Geochim. Cosmochim. Acta, 60,* 4253–4263.