THE CHONDRULE – MATRIX COMPLEMENTARITY, A BIG DATA APPROACH

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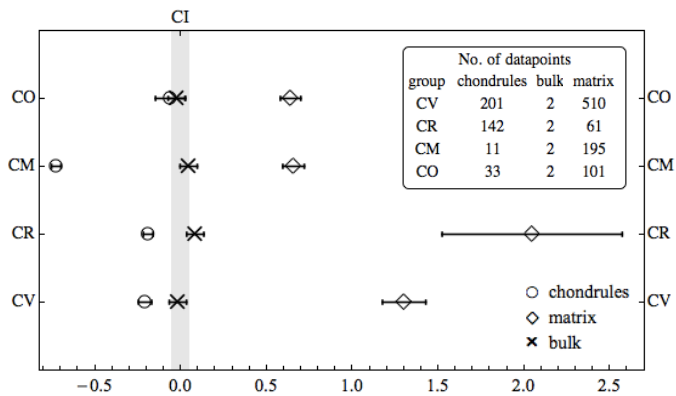
Introduction: Chondrules and matrix are the major components in chondrites (~95 vol%). Much effort has been made in studying the two components, but the chemical relationship of chondrules and matrix is still debated, e.g. [1-3]. The most important question is, whether chondrules and matrix are formed in the same or in different regions of the protoplanetary disk (PPD). Arguments for and against a single parental reservoir for chondrules and matrix have been discussed in the literature for decades, e.g. [4-6]. However, recently there are many more published arguments in favour of a single reservoir, e.g. [7], [8].

The elemental compositions of average chondrules and average matrix are usually different within a single chondrite. It has been recognised by several authors that for some element pairs, the bulk chondrite has, however, a solar element ratio. It has then been argued that it might not be a coincidence that the bulk is solar. Rather, the parental reservoir from which the chondrite formed was solar, and fractionations during chondrule and matrix formation lead to the different, but complementary compositions among these two components. Several complementary relationships were reported in the literature: the most prominent example is the complementary Mg/Si ratio observed in various carbonaceous chondrites, e.g. [4], [5]. Further, in Murchison (CM), [9] used the Fe/Si ratio, in Allende (CV), [2] used the Fe/Cr ratio, and in various CV chondrites [3] used the Ca/Al ratio.

Method: We collected more than 3500 chondrule and matrix data from >160 meteorites and almost 80 literature sources [10] to identify additional complementary element ratios in all chondrite classes. The data contains elemental abundances as well as metadata like e.g. petrological types or separation and analytical techniques. We developed an algorithm that automatically searches the database and identifies potential complementary relationships, i.e. different chondrule and matrix, as well as solar bulk chondrite composition.

Results: We found so far unknown complementary relationships for a series of element ratios. More than 50 element ratios of refractory lithophile elements from different meteorite groups meet the criteria of complementarity. For example, CM, CR, CV and CO chondrites have complementary Al/Ti ratios (see figure). Chondrules from these chondrites have sub-chondritic ratios while their matrix is supra-chondritic. This relationship excludes mixing of chondrules and matrix from different reservoirs as well as redistribution of Al and Ti between chondrules and matrix. The Al/Ti complementarity of CM, CR, CV and CO chondrites was probably established in a single solar nebular region by extraction of a Ti-rich component from a CI-chondritic reservoir to form the chondrule precursors. This relationship also suggests that these chondrites are formed by the same processes which took place before the parent body accretion.



Complementary Al/Ti ratios. Errorbars represent variation in the database.

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