Testing chondrules using non-traditional stable isotopes

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Chondrules are a major component of chondrite meteorites, and represent a key step in the formation of planets. Understanding the origin and thermal history of chondrules provides important insights into the physical and chemical conditions of the early solar system. However, chondrules have a number of features that have yet to be accounted for by any single formation model. To date, much research on chondrules has focused on radiogenic isotopes to refine the time of their formation. However, recent results have suggested that heterogeneity in the isotopic systematics exist due to thermal processing and possible partial melting (Bollard et al., 2017). Our research is focused on the subsequent thermal histories of chondrules, using non-traditional stable isotopes combined with experimental studies.

Four chondrules have been separated from the matrix of the LL4 ordinary chondrite Bjurbole. Data from these natural chondrules are paired with synthetic experiments, with starting material compositions determined by analysis of silicate, metal and sulphide compositions of the Bjurbole chondrules. Experimental conditions were constrained by pyroxene thermometry in the natural chondrules, which indicates temperatures ranging from 1080–1120˚C.

The experiments are doped with a selection of elements (selenium, tin, molybdenum, zinc and germanium) that have similar volatilities but have varying geochemical behaviour (i.e., chalcophility, siderophility). Elemental and isotopic fractionation of these elements are therefore likely to be strongly controlled by the availability of metals and sulphur. Phases from these experiments will be subsequently separated for analysis. We will present preliminary elemental and isotopic data from this suite of experiments. These data will provide insights into the role and movement of sulphur in the early solar system, track thermal reprocessing events, and provide estimates of temperature variations experienced by chondrules.