Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.31283

The inventory of high field strength elements in chondrites

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Chondrites are derived from undifferentiated, chemically primitive bodies that sample the trace element inventory of the solar system and provide reference values for comparison with the bulk compositions of planets. For the refractory high field strength elements (HFSE, W-Nb-Ta-Zr-Hf), the chondritic reference abundances have yet remained poorly constrained in terms of precision and accuracy. We report a comprehensive high precision dataset for HFSE and other refractory elements (Sm, Nd, Lu, U, Th, all obtained by isotope dilution (except for Nb by isotope dilution standardisation). Samples investigated comprise carbonaceous, ordinary and enstatite chondrites as well as refractory inclusions, mainly from CV3 chondrites. Except for U, parent body processes and terrestrial alteration appear to have negligible effects on these elements. The CI chondrite data, including representative Orgueil powders [1], allow determination of canonical trace element ratios such as Nb/Ta, Zr/Nb, Zr/Hf, Hf/W or Th/U at unprecedented precision and accuracy. Apart from CV chondrites ratios of Nb/Ta are uniform between all chondrite groups (Nb/Ta ca. 19). In CV chondrites, Nb/Ta is significantly lowered by admixture of refractory inclusions displaying systematic depletions of Nb. Compared to carbonaceous and ordinary chondrites, enstatite chondrites exhibit resolvably lower Hf/W and Zr/Hf. Importantly, Nb partitioning into sulfides leads to heterogeneities in measured Nb/Ta and Zr/Nb, and only g-sized samples provide representative Nb data. With respect to parent-daughter ratios of the Lu-Hf, Sm-Nd, Hf-W, and Nb-Zr radioactive decay systems, ratios of Lu-Hf and Sm-Nd are overlapping between groups. The observed Hf-W and Nb-Zr variations in different chondrite groups were likely established in the solar nebula by separation of metal and silicate components and (re)condensation processes during CAI formation.

[1] Barrat et al. (2012): Geochimica et Cosmochimica Acta 83, 79-92.