Cr and O isotope systematics in carbonaceous chondrite chondrules

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The combination of $\Delta^{17}O$ (= $\delta^{17}O$–0.52× $\delta^{18}O$) and $\varepsilon^{54}Cr$ from bulk isotopic analyses of meteorites has been used to distinguish different isotope reservoirs among the various groups of meteorites [1]. To better understand environments of formation of meteorites and their chondrules, we obtained both $\Delta^{17}O$ and $\varepsilon^{54}Cr$ from 19 individual chondrules from Allende (CV3) and Karoonda (CK4).

Each chondrule was split in two halves; one for ultra-high precision Cr isotope analyses at UC Davis and the other for electron microscopy at AMNH and SIMS O isotope analyses at WiscSIMS. Cr was purified by chromatography and isotope ratios measured by a *Triton Plus* thermal ionization mass spectrometer as in [2]. Oxygen three isotope analyses were performed on multi-collection Faraday cups with external reproducibilities of 0.3-0.4‰. Average $\Delta^{17}O$ values were obtained from 8 analyses of olivine and pyroxene grains in each chondrule.

Most Karoonda chondrules cluster in a small region of the $\varepsilon^{54}Cr$- $\Delta^{17}O$ diagram at $\Delta^{17}O \sim -5$‰ (similar to majority of Allende chondrules by [3]) and $\varepsilon^{54}Cr$ of 0 to 0.5, which appears to be an extension of the carbonaceous chondrite (CC) trend. By contrast, Allende chondrule data distribute into four distinct regions: (1) FeO-poor POP and PP chondrules with $\Delta^{17}O \sim -3$‰ and $\varepsilon^{54}Cr \sim +0.8$, in the vicinity of bulk CV3 [1]. (2) FeO-rich BOs with $\Delta^{17}O \sim 0$‰ and $\varepsilon^{54}Cr \sim -0.5$ that fall on the non-carbonaceous bulk achondrite area [1]. (3) FeO-poor PO chondrules are intermediary between the carbonaceous and non-carbonaceous clusters [1], which might represent a mixing line between two reservoirs. (4) Finally, one Al-rich chondrule is internally heterogeneous in O-isotopes with an average $\Delta^{17}O$ of –17 ±8‰, but with an intermediate $\varepsilon^{54}Cr \sim 0$. These data indicate that chondrules in CV chondrites formed in two distinct Cr-O isotope reservoirs and some chondrules recorded mixing of the two reservoirs, whereas some other chondrules have a strong CAI affinity.

[1]Sanborn et al. (2015) LPSC XLVI #2241. [2] Sanborn & Yin (2014) LPS XLV #2018. [3] Rudraswami et al. (2011) GCA 75, 7596-7611.