**Cr AND O ISOTOPE SYSTEMATICS IN CV/CK CHONDRITE CHONDRULES.** C. DEFOUILLOY[1*], M. E. SANBORN[2], A. YAMAKAWA[2], N. T. KITA[1], D. S. EBEL[3], Q.-Z. YIN[2], [1]WiscSIMS, Dept. of Geoscience, Univ. of Wisconsin-Madison, USA. (defouilloy@wisc.edu). [2]Department of Earth & Planetary Sciences, University of California, Davis, USA. [3]American Museum of Natural History, New York, USA.

**Introduction:** The combination of bulk $\Delta^{17}O$ (= $\delta^{17}O$–0.52× $\delta^{18}O$) and $\varepsilon^{54}Cr$ isotopic analyses of meteorites has shown two trends: (1) carbonaceous chondrites (CCs) and (2) the other meteorite groups (Fig.1), suggesting a disk-scale isotope heterogeneity in the early Solar System [e.g., 1]. Previous studies have shown that individual chondrules in a single CC group show a significant variabilities in $\Delta^{17}O$ and $\delta^{54}Cr$ compared to those of bulk CCs [2,3]. Here we report coordinated $\Delta^{17}O$ and $\delta^{54}Cr$ measurements of individual chondrules from carbonaceous chondrites (CC) along with their petrographic descriptions. These data are used to explore the origin of the distinct isotope reservoirs in the protoplanetary disk.

**Analytical procedures:** 10 chondrules from Allende (1.5-3 mm) and 9 chondrules (1-1.5 mm) from Karoonda were hand-picked for ultra-high precision Cr isotope analyses, electron microscopy and SIMS O isotope analyses.

**Results:** All chondrules but one are internally homogeneous in their O-isotope ratios. The range of data are similar to those previously obtained for CV chondrite chondrules [3], in which $\delta^{18}O$ and $\delta^{17}O$ values follow the PCM line [4], domain of CC chondrules. FeO-rich BO chondrules in Allende are off the PCM line, which plot on the TF line and near the ordinary chondrites (OC) domain. The $\Delta^{17}O$ values of Allende chondrules systematically increase with decreasing Mg#, similar to those in other CCs [5]. The $\Delta^{17}O$ values of Allende chondrules in this study distribute widely from –5‰ to 0‰, in contrast to previous data from CV chondrules [5] as well as to those of Karoonda in this study that cluster at –5‰. This systematic difference could be linked to the larger than average size of the Allende chondrules analyzed in this study.

Cr isotope ratios ($\varepsilon^{54}Cr$) are more variable for Allende chondrules (–0.5ε to 0.8ε) than for Karoonda (–0.3ε to 0.6ε). The majority of chondrules show $\varepsilon^{54}Cr$ values lower than the bulk CV and CK chondrite data.

**Discussions:** Fig. 1 shows the obtained $\varepsilon^{54}Cr$ and $\Delta^{17}O$ data. Most Karoonda chondrules cluster in a small region at $\Delta^{17}O$ ~ –5‰ and $\varepsilon^{54}Cr$ ~ 0ε, which appears to be an extension of the bulk CC trend. Two chondrules shift towards the non-CC meteorite region with higher $\Delta^{17}O$ and lower $\varepsilon^{54}Cr$. In contrast, Allende chondrule data distribute into four distinct regions: (1) POP chondrules with $\Delta^{17}O$ ~ –3‰ and $\varepsilon^{54}Cr$ ~ +0.8ε, in the vicinity of bulk CV3 [1]. (2) BOs with $\Delta^{17}O$ ~ 0‰ and $\varepsilon^{54}Cr$ ~ –0.5ε, close to the OC and achondrite area [1]. (3) PO chondrules with negative $\varepsilon^{54}Cr$ and negative $\Delta^{17}O$, intermediary between the non-CC cluster and the Karoonda cluster ($\Delta^{17}O$ ~ –5‰ and $\varepsilon^{54}Cr$ ~ 0ε), possibly belonging to the same mixing line between two reservoirs as the intermediary Karoonda chondrules. (4) Finally, one Al-rich chondrule is internally heterogeneous in O-isotopes with $\Delta^{17}O$ of from –10‰ to –20‰, but with an intermediate $\varepsilon^{54}Cr$~ 0ε.

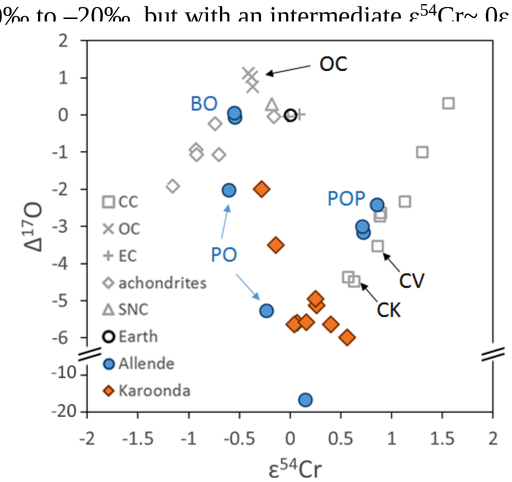


*Fig. 1: $\varepsilon^{54}Cr$- $\Delta^{17}O$ in Allende and Karoonda chondrules. Literature data from [1].*

**Conclusion:** Combined analyses of Cr and O isotopic ratios at the chondrule level reveal mixing trends that are not observed in bulk meteorite data. Precursors of chondrules in CV/CK chondrites might come from multiple Cr-O isotope reservoirs, including OC-like and CC-like isotope reservoirs. This is consistent with [6] who found chondrules with similar OC-like O isotopic composition in ungr. CC Yamato 82094, and with [3] who reported a large variability of $\varepsilon^{54}Cr$ in CV chondrites, indicating that precursor material for CV chondrites may have originated from various regions of the inner nebular disk.

The heterogeneous chondrule also shows a mixing between grains falling on the non-CC domain and a CAI-like refractory precursor ($\Delta^{17}O$ ~ –25‰ and $\varepsilon^{54}Cr$ ~ –6ε[7]), which indicates a complex history of mixing between different reservoirs over time and space.

[1]Sanborn et al. (2015) LPSC XLVI #2241. [2] Sanborn & Yin (2014) LPS XLV #2018. [3]Olsen et al. (2016) GCA, 191, 118-138 [4] Ushikubo et al. (2012) GCA 90, 242–264 [5] Rudraswami et al. (2011) GCA 75, 7596-7611. [6] Tenner et al. (2016) Meteor. & Plan. Sci. (in revision) [7] Trinquier (2007) Astr. J. 655, 2.