

### O-ISOTOPES OF MINERAL CONSTITUENTS OF CI-LIKE CLASTS FROM UREILITES.

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**Introduction:** Aqueously-altered carbonaceous chondrites such as CM, CI, and CR chondrites contain various minerals, which precipitated from fluids altering the respective parent body(ies) (e.g., [1]). The fluids modifying the CM chondrite parent body(ies) are suggested to have been of a rather local origin, because the calculated oxygen isotope compositions of these primordial waters must have been depleted in <sup>17</sup>O relative to <sup>18</sup>O ( $\delta^{18}\text{O} \sim -55$ ;  $\delta^{17}\text{O} \sim -35$ , not plotted in Fig. 1), i.e. are below the CCAM [2]. The processes which lead to this isotope fractionation is not fully understood and the oxygen isotope compositions of primordial waters altering the CI and CR chondrite parent bodies are even less understood [1,2]. However, CI-like clasts in ureilites have bulk oxygen isotope compositions plotting along the CCAM suggesting the incorporation of unfractionated ices from the parent molecular cloud [3-5].

**Analytical Techniques:** Oxygen isotope compositions of phyllosilicate-rich areas and of olivine and pyroxene grains from 16 CI-like clasts in five polymict ureilites (DaG 164, DaG 319, DaG 999, DaG 1000, NWA 6356, and EET 83309) were obtained by using a Cameca IMS 1280-HR at the University of Heidelberg. Errors of oxygen isotopic data of olivine and pyroxene are typically 0.2 ‰ in  $\delta^{18}\text{O}$  and 0.3 ‰ in  $\delta^{17}\text{O}$ . For standardless phyllosilicate analyses, a systematic error shifting data along the mass dependent fractionation line has to be added.

**Results:** Bulk oxygen isotope composition of CI-like clasts in polymict ureilites are plotting on the CCAM ranging from +0.86 to +1.8 ‰ in  $\Delta^{17}\text{O}$  [3-5]. The  $\Delta^{17}\text{O}$  data of phyllosilicate-rich areas obtained via SIMS are in a similar range (+1.4 to +5.7 ‰), but are more variable in their  $\delta^{18}\text{O}$  ranging from (-2.9 to +14.2 ‰). A simple regression line with a slope of  $\sim -0.54$  intercepts the CCAM at  $\Delta^{17}\text{O}$  of  $\sim +2.8$  ‰. Olivine and pyroxene grains (mostly  $>F_{095}$  and  $>E_{n95}$ , respectively) are plotting close to the CCAM with a slope of  $\sim -0.91$ . The  $\delta^{18}\text{O}$  ranges from  $-12.4$  to  $+8.2$  ‰. Two ilmenite grains (54 wt%  $\text{TiO}_2$ , 44 wt%  $\text{FeO}$ , and 1.5 wt%  $\text{MnO}$ ) found within one CI-like clast in EET 83309 have lower  $\delta^{18}\text{O}$  values (-3.9 and -6.1 ‰, respectively) and a positive  $\Delta^{17}\text{O}$  (+2.8 and +5.7 ‰, respectively; Fig. 1a). One of these grains has corroded edges and a porous appearance. Additionally, plaquettes of magnetite occur within the ilmenite grain (Fig. 1b). The oxygen isotope composition of the ilmenite grains plots within errors on the regression line defined by the phyllosilicate-rich matrix analyses (Fig. 1a).

**Discussion and Conclusion:** The slope of  $\sim -0.54$  for the phyllosilicate-rich matrix analyses indicates a mass-dependent fractionation of oxygen isotopes, which is probably established during the aqueous alteration on the parent body of the CI-like clasts. Oxygen isotope data of magnetite grains from CI-like clasts of a different ureilite exhibit higher  $\Delta^{17}\text{O}$  values than the phyllosilicate analyses ( $\sim +4$  to  $+6$  ‰ vs.  $+1.4$  to  $+5.7$  ‰, [6]) and plot on a regression line with a slope of  $\sim -0.6$ . Although, there is some scatter throughout the data (for phyllosilicate (studied here) as well as for magnetite analyses from [6]), the regression lines might reflect a mass-dependent fractionation of oxygen isotopes. The difference in  $\Delta^{17}\text{O}$  between phyllosilicates and magnetite might be attributed to different fractionation factors between water/magnetite and phyllosilicates/water or to different episodes of aqueous alteration, which needs further investigation.

**References:** [1] Fujiya W. (2018) *Earth and Planetary Science Letters* 481:264-272. [2] Brearley A. et al. (2006) In *Meteorites and the Early Solar System II* 587-624. [3] Patzek M. et al. (2018) *Meteoritics & Planetary Science* (this issue). [4] Goodrich C. A. et al. (2017) *Meteoritics & Planetary Science* 52:A107. [5] Brearley A. and Prinz M. (1992) *Geochimica et Cosmochimica Acta* 56:1373-1386. [6] Kita N. et al. (2017) *Meteoritics & Planetary Science* 52:A166

