

**IDENTIFICATION OF HIGHLY FRACTIONATED  $^{18}\text{O}$ -RICH SILICATE GRAINS IN THE QUEEN ALEXANDRA RANGE 99177 CR3 CHONDRITE.** A. N. Nguyen<sup>1,2</sup>, L. P. Keller<sup>2</sup>, S. Messenger<sup>2</sup>, and Z. Rahman<sup>1,2</sup>. <sup>1</sup>JETS, NASA JSC, Houston TX. <sup>2</sup>Robert M. Walker Laboratory for Space Science, ARES, NASA JSC, Houston TX. lan-anh.n.nguyen@nasa.gov.

**Introduction:** Carbonaceous chondrites contain a mixture of solar system condensates, presolar grains, and primitive organic matter. The CR3 chondrite QUE 99177 has undergone minimal alteration [1], exemplified by abundant presolar silicates [2, 3] and anomalous organic matter [4]. Oxygen isotopic imaging studies of this meteorite have focused on finding submicrometer anomalous grains in fine-grained regions of thin sections. Here we present results of an O isotopic survey of larger matrix grains.

**Experimental:** A silicate-rich size-separate of QUE 99177 matrix grains of target diameter 0.5–2  $\mu\text{m}$  was produced by freeze-thaw disaggregation and centrifugation. The grains were deposited onto clean Au foil and dense regions were chosen for simultaneous analysis of the O and Si isotopes and  $^{27}\text{Al}^{16}\text{O}$  by raster ion imaging using the JSC NanoSIMS 50L. A 1.4 pA  $\text{Cs}^+$  primary ion beam of  $\sim 150$  nm was rastered over  $69\ 20 \times 20\ \mu\text{m}^2$  areas. An electron flood gun was used to mitigate sample charging. The O isotopic ratios of 4 large anomalous grains were re-measured and confirmed. SEM-EDS analyses were conducted and the mineralogy of one grain was characterized by focused ion beam extraction and TEM analysis.

**Results and Discussion:** Six grains <400 nm with O isotopic compositions clearly consistent with origins in evolved stars were identified. Four grains 3–10  $\mu\text{m}$  in size with moderate  $^{18}\text{O}$  enrichments ( $\delta^{18}\text{O} = 37\text{--}55\%$ ) relative to the surrounding matrix were also found. Isotopic heterogeneity in  $^{18}\text{O}/^{16}\text{O}$  across grain 13\_5 was observed. The O isotopic ratios fall within  $2\sigma$  of the terrestrial fractionation line (average  $\Delta^{17}\text{O} = -11 \pm 18\%$ ;  $2\sigma$ ). SEM-EDS analysis indicates these grains are silicates. FIB-TEM analysis of 13\_5 shows it to be an anhydrous aggregate of two platy pyroxene grains separated by a  $\sim 0.2\ \mu\text{m}$  layer of fine-grained Fe-rich olivine. The larger pyroxene consists of Cr- and Mn-bearing enstatite with thin internal exsolution and surface lamellae of more Ca-rich pyroxene. The smaller plate is homogeneous high-Ca pyroxene. The olivine contains Fe metal and chromite inclusions. The textures of the olivine layers and the exsolution in the pyroxene are consistent with formation at high temperatures and relatively slow cooling.

Some secondary CAI minerals [5] and calcite [6] in aqueously altered CR chondrites have  $^{18}\text{O}$  enrichments ( $\delta^{18}\text{O} < 35\%$ ) resulting from hydration but there is no petrographic evidence that 13\_5 has been hydrated. A hibonite-rich CAI from a metamorphosed R chondrite has a similar fractionation to our grains ( $\delta^{18}\text{O} \sim 47\%$ ; [7]) and was proposed to have undergone heating and melting, followed by evaporative loss. However, the texture of grain 13\_5 is inconsistent with such an origin, suggesting condensation from a  $^{16}\text{O}$ -poor gas. In this case, the reservoir may have been isotopically fractionated from initial isotopic compositions on the CCAM line and  $\delta^{18}\text{O} \sim -30\%$ . Alternatively, the  $^{18}\text{O}$ -rich composition of the grains could be a signature of supernova origins. However, the large sizes, small  $^{18}\text{O}$  enhancements relative to SN silicates, and similar isotopic ratios among the grains are unusual. Mg isotopic analysis and additional TEM studies of these highly fractionated silicates are planned to further constrain their origins.

**References:** [1] Abreu N.M. and Brearley A.J. (2010) *GCA*, 74, 1146. [2] Floss C. and Stadermann F. (2009) *GCA*, 73, 2415. [4] Floss C. and Stadermann F.J. (2009) *ApJ*, 697, 1242. [5] Aléon J. et al. (2002) *MPS*, 37, 1729. [6] Jilly C.E. et al. (2014) *LPS*, 45, #1642. [7] Rout S.S. et al. (2009) *GCA*, 73, 4264.