OXYGEN ISOTOPIC COMPOSITION OF RENAZZO CHONDRULE OLIVINE AND COMPARISON WITH EXTENT OF CHONDRULE MELTING. L.R. Varley[1], L.A. Leshin[1,2], Y. Guan[1], B. Zanda[3,4], and M. Bourot-Denise[4], [1]Dept. of Geological Sciences, Arizona State University, PO Box 871404, Tempe, AZ , 85287-1404 (lora.varley@asu.edu), [2]Center for Meteorite Studies, ASU,. [3]Geological Sciences, Rutgers University, Piscataway, NJ, 08855-1179, [4]Laboratoire de Minéralogie, Muséum d'Histoire Naturelle, 75005 Paris, France.

Introduction: Renazzo contains abundant large, type I chondrules [1,2] that appear to have undergone various degrees of melting during their formation [3]. The least melted chondrules have convoluted outlines and are typically fine-grained with metal and silicates dispersed throughout (Fig. 1a). As the extent of melting increases, chondrule outlines become more rounded and the grain size becomes coarser (Fig. 1b). Chondrule oxygen isotopic compositions have been attributed by [4] to be the result of increased melting for the most ^{16}O-poor chondrules. It was suggested that the more FeO-rich nature of the ^{16}O-poor chondrules lowered their liquidus temperatures, allowing them to remain molten longer and thus exchange more with ^{16}O-poor nebular gas, during their formation [4]. This study utilizes Renazzo to quantify and compare extent of chondrule melting with O-isotopic composition to explore the relationship between these parameters. An initial assessment was reported in [5], and here we report data from 16 additional Renazzo chondrules.

Techniques and samples: Extent of chondrule melting was characterized using the method of [3], which involves determination of a convolution index (CVI) for each chondrule studied. The CVI is defined as the ratio of a chondrule's perimeter to that of a circle with the same area as the chondrule, such that a perfectly spherical chondrule would have a CVI of 1. Calculating a given chondrule's CVI twice constrains a reasonable CVI measurement error to be ± 0.15. Alteration induces uncertainty into CVI calculations for some chondrules by obscuring their boundaries. Chondrules on section edges and those obviously broken after formation result in additional uncertainty. The size and shape of these "missing" portions were estimated and included in calculations. Although these sources of error lead to slightly subjective CVI calculations for some chondrules, the CVI is still a useful indicator of extent of chondrule melting as evidenced by its definite distinction between chondrules that have visually undergone different melting histories (Fig. 1a,b).

O-isotopic compositions were determined *in-situ* with the Cameca IMS 6f ion microprobe at ASU. See [6] for details of the analysis procedure. Typical 1σ uncertainties are 1 – 1.5‰ in both δ^{18}O and δ^{17}O. Spot size was ~15μm. Between one and eight olivine grains were analyzed from each chondrule. All chondrules studied are type I: nine type IA, twelve IAB, and two IB. Chondrule average olivine compositions, determined by EPMA, range from ~$Fa_{0.4}$ to $Fa_{4.5}$.

Results and discussion: Chondrule weighted mean δ^{18}O values range from –17.0 to +1.8 ‰ on the three-isotope plot (Fig. 2a). Weighted mean δ^{17}O values range from –18.0 to –0.7 ‰, while weighted mean Δ^{17}O ranges from –9.3 to –1.2 ‰. The results are consistent with previous CR and carbonaceous chondrite studies [1, 5, 7], but extend the range of previously analyzed CR chondrules to more ^{16}O-rich values .

Although the range of ^{16}O-enrichment is variable at a given CVI value, there appears to be a slight correlation between ^{16}O-enrichment and extent of melting (Fig. 2b), such that less melted chondrules are on average more ^{16}O-enriched. However, the results suggest that chondrule O-isotopic compositions are not a simple function of exchange between ^{16}O-rich precursor material with ^{16}O-poor nebular gas during melting. Instead, the data support the hypothesis that a complex mixture of other factors, including isotopically variable chondrule precursor material, evaporation and re-condensation, and multiple melting events, probably also play an important role in determining chondrule O-isotopic compositions.

Chondrule O-isotopic composition and mineral chemistry (Fig. 2c) were found to be unrelated, suggesting a decoupling in the behavior of O-isotopes and FeO. The lack of an observable relationship between chondrule melting history and olivine FeO content (Fig. 2d), is also suggestive of the influence of heterogeneous chondrule precursor material, evaporation / re-condensation, and/or oxidation / reduction on chondrule compositions.

One chondrule was found to contain an extremely ^{16}O-rich olivine grain with weighted mean δ^{18}O = –46.0 ‰, δ^{17}O = –48.0 ‰, and Δ^{17}O = –24.2 ‰ . This is the first evidence in CRs of chondrule olivine with ^{16}O-enrichment similar to that of CAIs [8]. The grain appears in texture to be melt-grown. Its $Fa_{2.2}$ composition is the same as the average of all grains analyzed for the chondrule. Its low abundances of refractory elements are also not consistent with its being a refractory forsterite as suggested by [9, 10] to possibly represent primary nebular condensates. Chondrule olivine grains with similar ^{16}O-enrichments and textures have also been observed in CV Mokoia [11]. The presence of such ^{16}O-rich, apparently melt-grown grains in chondrules, as well as the large spread in chondrule ^{16}O-enrichment observed here, suggests that chondrule O-isotopic compositions were influenced, at least in part, by O-isotopic exchange with nebular gas during chondrule formation, but that this exchange cannot be easily related to a measure of chondrule melting.

References: [1] Weisberg M. K. et al. (1993) *GCA 57*, 1567-1586. [2] Krot et al. (2002) *Meteorit & Planet Sci 37*, 1451-1490. [3] Zanda B. et al. (2002) *LPS XXXIII*, Abstract #1852. [4] McSween H. Y. (1985) *Meteoritics*, *20*, 523-540. [5] Varley L. R. et al. (2002) *Meteorit & Planet Sci 37* A143. [6] Cosarinsky et al. (2001) *LPS XXXII*, Abstract #1859. [7] Leshin L. A. et al. (2000) *LPS XXXI*, Abstract #1918. [8] Clayton R. N. et al. (1973) *Science*, *182*, 485-488. [9] Steele I. M. (1986) *GCA 50*, 1379-1395. [10] Weinbruch S. et al. (2000) *Meteorit & Planet Sci*, *35*, 161-171. [11] Jones R. H. et al. (2002) *LPS XXXIII*, Abstract #1571.

Figure captions: Fig. 1a. Backscattered electron (BSE) image of a little melted chondrule (CVI=2.17). Fig. 1b. BSE image of an extensively melted chondrule (CVI=1.17). Fig. 2a. 3-isotope plot for Renazzo data expressed as a weighted mean for each chondrule. Bars represent range in O-isotopic composition measured for each. Allende CAI and terrestrial fractionation (TF) lines shown for reference. Fig. 2b. Δ^{17}O vs. extent of chondrule melting expressed as CVI. Vertical bars show range in O-isotopic composition of each chondrule. Horizontal bars show uncertainty in CVI. Fig. 2c. Δ^{17}O vs. olivine mineral chemistry expressed as % Fa. Bars represent compositional ranges for each chondrule.. Fig. 2d. Olivine mineral chemistry, expressed as % Fa, vs. extent of chondrule melting, expressed as CVI. Vertical bars show range in % Fa. Horizontal bars show uncertainty in CVI.

Figure 1a.

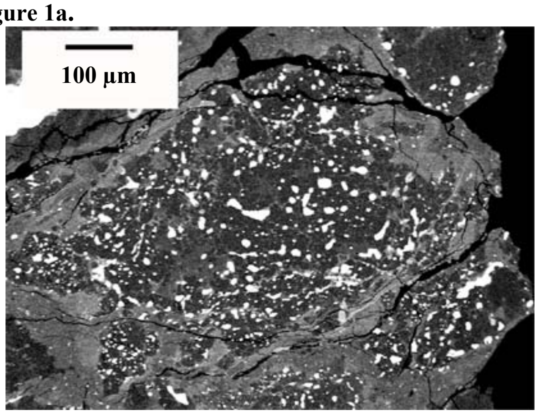

Figure 1b.