INSIGHTS FROM HIGH PRECISION OXYGEN ISOTOPIC ANALYSES OF REDUCED CV METEORITE SEPARATES: CV MATRIX HOMOGENEITY AND PRESERVATION OF NEBULAR HETEROGENEITY. K. A. Dyl[1] and E. D. Young[2,3]. [1]Department of Earth Sciences and Engineering, Imperial College, Exhibition Road, London SW7 2AZ (kdyl@imperial.co.uk) [2]Department of Earth and Space Sciences, UCLA, Los Angeles, CA 90095 [3]Institute of Geophysics and Planetary Physics, UCLA, Los Angeles, CA 90095.

Introduction: Interactions with nebular gas prior to accretion [1], as well as secondary processing on the parent body [2], may have resulted in the oxygen isotopic signatures in carbonaceous chondrites. We may be able to elucidate these trends using high-precision isotopic data and varying oxidation state amongst chondrite components. CV3 meteorites are ideally suited to study these processes. Both oxidized and reduced lithologies are found in this group [3]. They contain both calcium,aluminum-rich inclusions (CAIs), thought to be the earliest nebular condensates, and abundant matrix, nebular dust formed in a more evolved solar nebula. By comparing data between CAIs and matrix, we can determine whether the nebular processes of oxidation and ^{17,18}O-injection are recorded by these objects or whether parent-body processes are responsible for their oxygen isotope ratios and oxidation state.

Missing from this data set is the oxygen isotopic composition of matrix in reduced CV3 meteorites. Most CAIs, as well as matrix from oxidized CV3 meteorites, have oxygen isotopic compositions that fall on the CCAM (carbonaceous chondrite anhydrous mineral) line with slope = 0.94 [4]. Recent work on E44, a type B CAI from reduced CV3 Efremovka, found this object hads an inter-mineral fractionation line of slope = 0.92, distinctly different from CCAM [5]. High-precision oxygen isotopic measurements of reduced CV3 matrix have not been previously reported.

We have determined the oxygen isotopic composition of matrix in the reduced CV3s Efremovka and Vigarano using high-precision laser fluorination. We used electric pulse disaggregation to crush the sample, with the goal of removing CAI and chondrule material. Matrix from both objects are indistinguishable from Allende matrix, suggesting that parent body alteration is not responsible for matrix oxygen isotope ratios. We conclude that reduced CV3 meteorites record more heterogeneity in oxygen isotopic composition amongst chondritic components, and that matrix from both lithologies share a similar nebular history.

Electric Pulse Disaggregation: We attempted to separate matrix from other chondritic components in Allende, Efremovka, and Vigarano using electric pulse disaggregation (EPD) [6]. A Spark-2 device generated voltages in excess of 50 kV, electrically crushing the samples along grain boundaries. A bed of high-purity quartz was added to the chamber to ensure electrical conductivity. Experiments were run in distilled water. Sample sizes ranged from 0.24 – 8.49 g.

Crushed samples were removed and dried prior to density separation with heavy liquids. The resulting high (>3.3 g/cc) and low (2.7-3.3 g/cc) density fractions were then size-sorted. Characterization of these grains reveals that high-density separates are a mixture of matrix and Mg-rich chondrule/igneous fragments (e.g., forsterite) while low-density separates contain ~90% chondrule fragments (such as pyroxene and mesostasis).

Oxygen Isotopic Analyses: *Methods:* We chose grains to analyze from the EPD separates using a binocular microscope. We defined matrix as fine-grained, opaque material with no obvious crystalline inclusions. While this did not succeed in removing chondrule fragments, residual quartz grains and CAI minerals were excluded.

The CO_2 laser fluorination system at UCLA was used to measure 1-2 mg samples of Efremovka and Vigarano EPD separates of varying densities and sizes. The infrared heating of samples in the presence of fluorine gas achieves an analytical precision of ± 0.02‰ in both δ^{18}O and Δ^{17}O. Isotope ratios were measured by a ThermoFinnigan Delta-Plus dual inlet mass spectrometer.

Results: Data for 14 Efremovka separates and 9 Vigarano separates were measured. We previously measured 5 Allende and 3 Efremovka samples using only mechanical crushing and hand-picking. All data fall along the CCAM line of slope m=0.94.

Oxygen isotopic composition varies as both a function of density and grain size. The high-density samples are enriched in ^{17}O and ^{18}O. While the low-density separates seem to have a consistent Δ^{17}O regardless of size, the high-density separates decrease in Δ^{17}O as grain size decreases.

Oxygen Isotopic Composition of Reduced CV3 Matrix: We have attempted to arrive at the true isotopic composition of matrix for both Vigarano and Efremovka by considering all separates to be a mixture of matrix, chondrule fragments, and metal. For each population, we used grain counting to determine the fractions of matrix and chondrule material present. An oxygen isotope measurement of a given sample can therefore can be described as:

$$X_{mtx}\,\delta^{17,18}O_{mtx} + X_{chd}\,\delta^{17,18}O_{chd} = \delta^{17,18}O_{sample}.$$

If we assume matrix and chondrule fractions have the same isotopic composition in all samples of a given meteorite, we can use two different separates (e.g., high-density and low-density, different grain size) to calculate the isotopic composition of pure matrix. This is shown in Figure 1. The black "X" symbols, calculated matrix compositions of reduced CV3 matrix, plot along CCAM as well. Its isotope ratios are indistinguishable from those of Allende matrix. Chondrule oxgen isotope ratios plot in the region of the low-density separates.

Discussion and Conclusions: Reduced and oxidized CV3s display distinctly different mineralogies, especially in their matrices [3]. One interpretation is that pervasive aqueous alteration affected the oxidized lithology while the reduced one remained largely unaffected [2]. Despite these different lithologies and suggested histories, we see no difference in the oxygen isotopic composition of the matrix. This suggests that widespread aqueous alteration is not responsible for the differences between these two subgroups. Aqueous alteration would result in elevated $\Delta^{17}O$ values in oxidized CV3 matrix.

Furthermore, our results indicate that heterogeneity between chondritic components is preserved in reduced CV3 meteorites. Both Efremovka and Vigarano contain CAIs whose individual mineral phases do not fall on the CCAM line [5,7]. Our study, however, shows that the matrix of both these meteorites has isotope ratios consistent with CCAM. If both components exchanged oxygen with the same nebular gas, they would fall on the same mixing line. Therefore, some CAIs and matrix found in meteorites of the reduced subgroup do not share a common nebular history.

References: [1] R. Clayton and T. Mayeda *Geophys. Res. Let.*, 4, 7, 295-8 (1977) [2] A. Krot et al. *MAPS*, 33, 5, 1065-85 (1998) [3] H. McSween and S. Richardson *GCA*, 41, 8, 1145-61 (1977) [4] R. Clayton and T. Mayeda *GCA*, 63, 13-14, 2089-104 (1999) [5] K. Dyl et al. *LPSC XXXIX* 2486 (2008) [6] L. Cabri et al. *Min. Engin.* 21, 6, 463-70 (2008) [7] K. McKeegan and L. Leshin *MAPS*, 33, 4, A102-3 (1998).

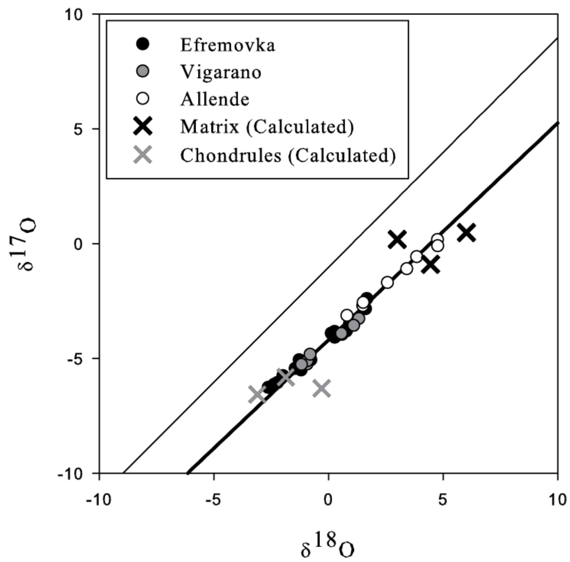

Figure 1: Oxygen 3-isotope space. The solid line represents the Young-Russell (slope-1) line while CCAM is the bold line shown. Circles represent high-precision oxygen isotopic measurements of CV3 matrix: Allende (white), Efremovka (black), Vigarano (grey). An "X" symbol is used to plot the calculated matrix (black) and chondrule (grey) oxygen isotope ratios using EPD separate data and linear algebraic techniques.