THE OXYGEN ISOTOPE SYSTEMATICS OF THE L3.00 ORDINARY CHONDRITE NWA 7731, AND A COMPARISON TO LL3.00 SEMARKONA. K. Ziegler[1], C. B. Agee[1,2], H. C. Connolly Jr.[3,4,5,6], [1]Institute of Meteoritics, University of New Mexico (UNM), Albuquerque, NM 87131 (kziegler@unm.edu), [2]Dept. of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131, [3]Dept. of Physical Sciences, Kingsborough Community College of CUNY, 2001 Oriental Blvd., Brooklyn, NY 100235, [4]Earth and Environmental Sciences, The Graduate Center of CUNY, 365 5th Ave., New York, NY 10016, [5]Dept. of Earth and Planetary Sciences, AMNH, Central Park West, New York, NY 10024, [6]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721.

Introduction: NWA 7731 is an 81 gram, single stone, with black, lightly weathered, fusion crust, and densely packed chondrules of variable size (mean 500 µm; consistent with L-group) set in a brown and a fine-grained opaque matrix; many chondrules contain igneous-zoned porphyritic olivines and mesostasis [1] (**Fig. 1**). It was recognized as an L3.00 Unequilibrated Ordinary Chondrites (UOC) in 2012 [1], and, thus, is the first and only approved L3.00 chondrite.

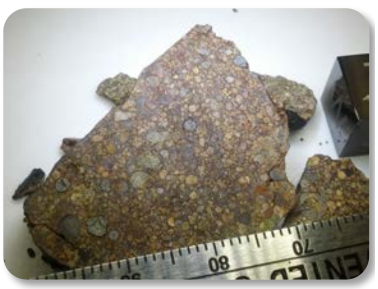

Figure 1. Slice of NWA 7731 showing dense packing of chondrules of varying sizes.

Classification was based on several parameters: (1) electron microprobe analyses of individual coarse ferroan chondrule olivines from NWA 7731 gave mean values $Fa_{15.0\pm5.7}$, Fe/Mn=42±13, Cr_2O_3=0.43±0.11wt.% [1]. Such high mean Cr_2O_3 contents with relatively low standard deviation are consistent with petrologic type 3.00 [2]. These results are strikingly similar to the LL3.00 Semarkona; and (2) sulfur-rich opaque matrix and igneous zoning of Cr in olivine correlating with Fe in NWA 7731 [1] are further features of the most primitive petrologic grade in type 3 chondrites, and the latter is also observed in Semarkona. Due to the highly unequilibrated nature, oxygen isotope analyses of bulk rock analyses are less unequivocal in classifying UOCs than for other meteorite groups.

Here, we present bulk oxygen isotope analyses of NWA 7731, and compare it with other UOCs. *In-situ* oxygen isotope analyses of individual chondrule minerals of NWA 7731 are presented in another abstract at this Conference by [4], which complements this abstract.

Analytical methods: All samples were acid-washed prior to isotope analysis. Oxygen isotope analyses ($\delta^{18}O$, $\delta^{17}O$) were performed on 1-2 mg bulk rock ample aliquots using laser fluorination [3] at UNM. $\Delta^{17}O$ values were calculated from $\Delta^{17}O = \delta^{17}O - 0.528 \times \delta^{18}O$. Molecular O_2 was extracted in a BrF_5-atmosphere, cryogenically and gas-chromatographically purified, and the isotope ratios measured on a gas source mass spectrometer (Delta PlusXL). Analytical precision for $\Delta^{17}O$ is 0.02 ‰. Isotope values presented here are all linearized.

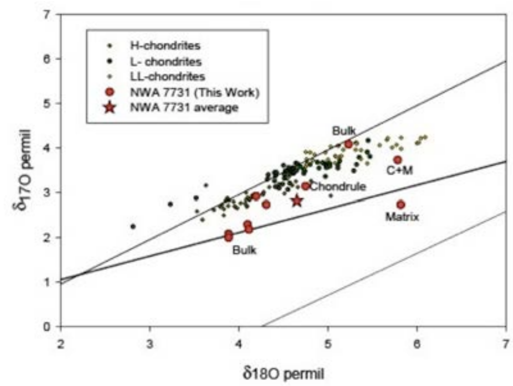

Figure 2. 3-oxygen isotope plot of NWA 7731 different types of bulk samples (in red) in comparison with Ordinary Chondrite Data [5].

Results: Bulk oxygen isotope analyses of a variety of NWA 7731 components are shown in **Figure 2.** The data show a large spread in both $\delta^{18}O$ and $\delta^{17}O$ values that cover all three groups of the Ordinary Chondrites (OC), and also fall outside these ranges, including some samples plotting close to the terrestrial mass-dependent fractionation line.

Comparison to LL3.00 Semarkona: Electron microprobe analyses on ferroan chondrule olivines in a sample of Semarkona from the UNM collection were compared with our results for NWA 7731. Results for Semarkona are $Fa_{14.5\pm4.9}$, Fe/Mn=45±14, Cr_2O_3=0.41±0.09wt%, illustrating a striking similarity between the compositions of LL3.00 Semarkona and L3.00 NWA 7731 ferroan olivines.

When a comparison of the NWA 7731 bulk oxygen isotope data is made to the LL3.00

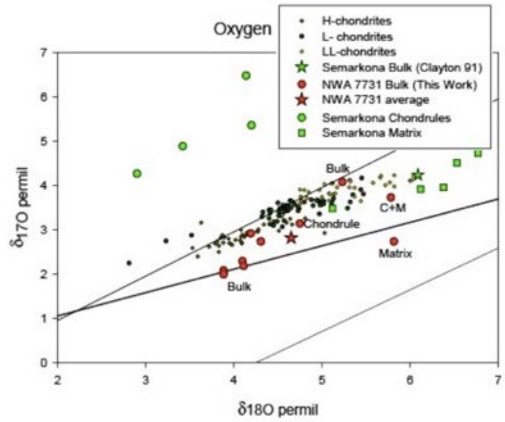

Figure 3. 3-oxygen isotope plot of NWA 7731 different types of bulk samples compared to results of different types of Semarkona bulk samples [5].

Semarkona bulk analyses [5, and refs. therein] (**Fig. 3**), the spread of NWA 7731 appears not that unusual. The overall range, and the difference between chondrule *vs.* matrix is even larger in the Semarkona data [5]. The different results of chondrules and matrix attest to the unequilibrated, very primitive nature of these components assembled within one rock.

Compared *in-situ* data of individual Semarkona chondrule minerals [6], the bulk NWA 7731 data fall in the center of a very large data array, spanning almost 30‰ on the $\delta^{18}O$ axis, and almost 25‰ on the $\delta^{17}O$ axis (**Fig. 4**). This spread of Semarkona data is due to the variable proportions and variable oxygen isotope signatures of type I and type II chondrules, and those of relict grains. The oxygen isotope variability due to the relative proportions of these phases is larger than that observed by the bulk analyses (cf. **Figs. 2, 3, 4**). A similar large distribution in *in-situ* data, although not as data-dense, has also been observed for NWA 7731 [4], and was previously also observed for MET 00526,9 and QUE 97008,14 (both L3.05) [7].

Discussion: UOCs have undergone only minor thermal processing on their parent bodies, and, therefore, provide unaltered isotopic records from early Solar System processes, as most of their minerals retain nebular composition. UOC oxygen isotope distributions are commonly modeled incorporating two reservoirs - one solid and one gas [e.g., 4-8]. Fluid movement along grain boundaries may produce secondary low-temperature minerals, such as phyllosilicates and/or magnetite [8, and references therein]. NWA 7731 matrix contains phyllosilicates in a visually recognizable abundance (**Fig. 5**), and as does Semarkona [9].

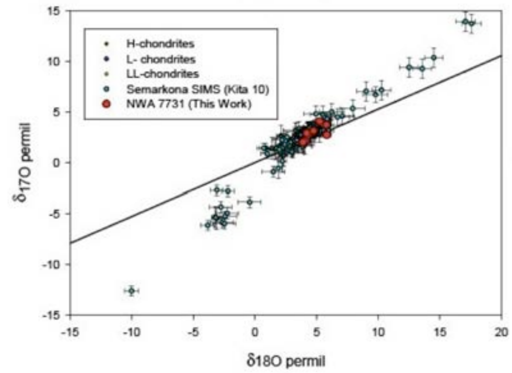

Figure 4. 3-oxygen isotope plot of NWA 7731 different types of bulk samples in comparison with *in-situ* Semarkona chondrule mineral analyses [6].

Matrix oxygen isotope data of NWA 7731 might represent the composition of H_2O ice at the time of accretion; bulk matrix $\delta^{18}O$ values of this study and especially that of [5] (**Fig. 3**) are the most positive values from each respective dataset. More oxygen isotopic work on the matrix *vs.* chondrule difference, and the characteristics of the phyllosilicates (**Fig. 5**) and other hydrated phases in the matrix in NWA 7731 is being carried out, and will provide more insights into the nature of processes operating on the UOC parent body. *In-situ* analysis shows that oxygen isotope abundances are within the range observed in other L chondrites [4].

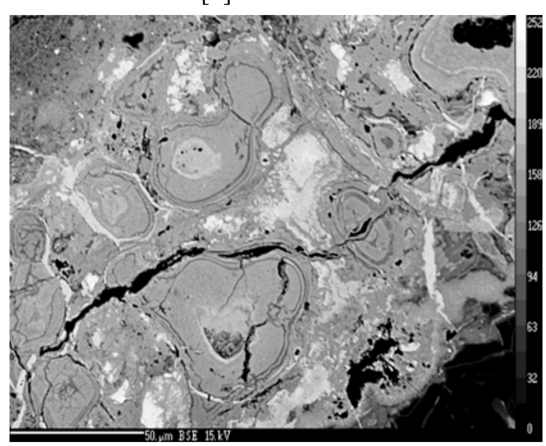

Figure 5: BSE image of NWA 7731 showing alteration with localized abundant phyllosilicate and other hydrated phases.

References: [1] Agee C. B. et al., (2013) *MaPS, # 5130*. [2] Grossman J. N. and Brearley A. J., (2005) *MaPS,* 87–122. [3] Sharp Z.D., (1990) *GCA* ***54***, 1353. [4] Connolly H.C. Jr. et al., (2014) *This Conference*. [5] Clayton R. N. et al., (1991) *GCA* **55**, 2317. [6] Kita N.T. et al. (2010) *GCA* **74**, 6610. [7] Connolly H.C. Jr. et al. (2012) *LPSC,* # 2204. [8] Choi B.-G et al., (1989) *Nature* **892**, 577. [9] Hutchison R. et al., (1987) *GCA* **51**, 1857.