OXYGEN ISOTOPES IN UNGROUPED ACHONDRITE NWA 1500 AND COMPARISON TO BRACHINITES. N. T. Kita[1], C. A. Goodrich[2], M. J. Spicuzza[1] and J. W. Valley[1], [1]Wisc-SIMS, Department of Geology and Geophysics, University of Wisconsin, 1215 W. Dayton St., Madison, WI 53706, USA (noriko@geology.wisc.edu), [2]Department of Physical Sciences, Kingsborough Community College, 2001 Oriental Blvd., Brooklyn, NY 11235, USA.

Introduction: North West Africa (NWA) 1500 is an olivine-rich achondrite that is currently classified as ungrouped, based on petrography and oxygen isotope ratios [1-2]. Although some petrographic characteristics of NWA 1500 suggest a relationship to the augite-bearing ureilites, it shows a distinct thermal history (equilibration to much lower T) that rules out derivation from the ureilite parent body [2]. Nevertheless, evidence of internal reduction processes suggest that it may have been derived from a parent body with a similar differentiation history. The first oxygen isotope data reported for this meteorite [3] showed a bulk composition intermediate between the IAB/winonaite trend and the region of acapulcoites/lodranites. A more recent report indicates a similarity to brachinites [4]. In order to clarify this discrepancy and further check its homogeneity in oxygen isotope ratios, we performed both ultra-high precision (~0.03‰) laser fluorination analyses of bulk chips and high precision (~0.3‰) SIMS analyses of minerals in a thin section of NWA 1500.

Method: Two bulk analyses of ~2mg chips of NWA 1500 were performed using laser fluorination mass spectrometer at the University of Wisconsin [5]. Reproducibility of the UWG-2 standard is 0.05‰, 0.02‰ and 0.03‰ for $\delta^{18}O$, $\delta^{17}O$ and $\Delta^{17}O$ (=$\delta^{17}O$ - 0.52 × $\delta^{18}O$), respectively (in 2SE). Because of low degree of weathering [2], we did not perform acid leaching. The SIMS analyses were made using the IMS-1280 at the University of Wisconsin (Wisc-SIMS Laboratory). The method is similar to that described previously [6-7]. The primary Cs+ ion beam was focused to ~15μm diameter with 6nA current and secondary $^{16}O^-$ signal was ~ 5×10^9 cps. The precision of single analysis was ~0.3‰ for $\delta^{18}O$ and $\delta^{17}O$. We analyzed a thin section of NWA 1500 containing a large (~3 mm) poikilitic plagioclase (~An_{37}) grain [2]. We used a thin section of San-Carlos olivine as a running standard. Three plagioclase standards (An_{22}-An_{49}) were used to calibrate instrumental bias between analyses of olivine and plagioclase.

Results: SIMS analyses of olivine (n=11) and plagioclase (n=5) are shown in Fig. 1. Oxygen isotope ratios in individual minerals are homogeneous within analytical uncertainty, though the average $\delta^{18}O$ in plagioclase is higher than that of olivine by 1.7‰ along a slope 0.52 mass dependent fractionation line. The two laser fluorination bulk chip analyses and the average of SIMS olivine and plagioclase analyses are shown in Fig. 2 along with to previously reported bulk analyses by [3-4]. Our new bulk chip data plot slightly above IAB/Winonaite trend and nearly on the same mass dependent fractionation line as brachinites, which are quite different from the value reported by [3], but very similar to that of [4]. Our new bulk chip data yield a $\Delta^{17}O$ value of -0.20‰, identical to the brachinite group.

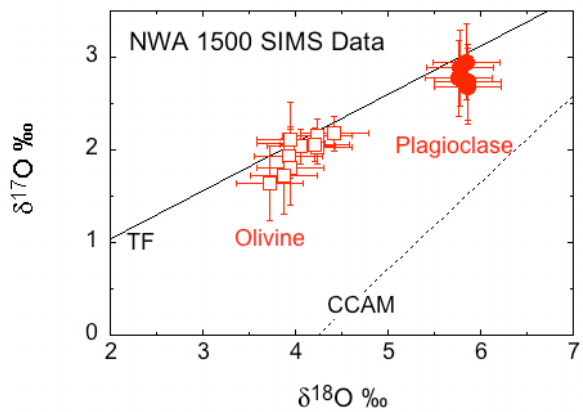

Fig. 1. Individual SIMS spot analyses of olivine and plagioclase from NWA 1500. TF=Terrestrial Fractionation line, CCAM= Carbonaceous chondrite anhydrous minerals line, along which ureilites are located [8].

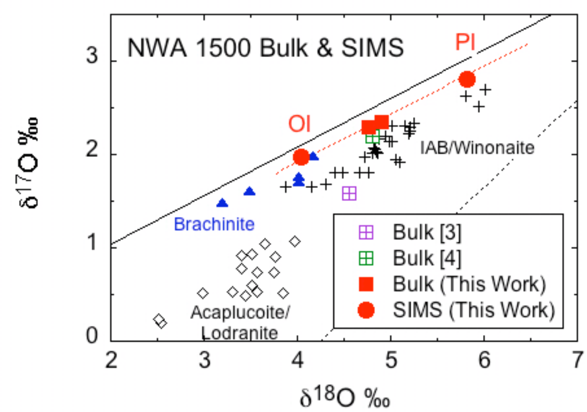

Fig. 2. Oxygen three isotope data of bulk chips by laser fluorination method and the average olivine and plagioclase data by SIMS analyses. Bulk data from [3-4] are shown. Other achondrite data are from [8].

Discussion: Assuming oxygen isotope equilibrium between olivine (average $\delta^{18}O$ =4.05 ±0.12 ‰) and plagioclase (average $\delta^{18}O$ =5.82 ±0.16 ‰), the equilibrium temperature is estimated to be 880±70˚C from in situ SIMS data. This temperature is in good agreement with the equilibration temperature of 800-1000˚C obtained for NWA 1500 from two-pyroxene and olivine-chromite thermometry [2]. This lower temperature of equilibration is one of the main differences from ureilites, which show high equilibrium temperatures (1200-1300˚C [9]).

As shown in Fig. 2, the new bulk data and SIMS mineral data all plot along the slope 0.52 line that extend to brachinite data by [8]. Therefore, NWA 1500 could be related to brachinites.

Petrologic and chemical comparison to brachinites: We have compared petrographic, mineral chemical and bulk chemical characteristics of NWA 1500 with those of brachinites, using data from [2] for the former and data from various published sources [10 and references therein, 11- 14] for the latter. Results show that in terms of modal mineral abundances, texture and grain size, olivine major (peak Fo = 68-69) and minor (Cr_2O_3, CaO and MnO) element compositions, augite and orthopyroxene major element (*mg*, Wo) compositions, Cr/(Cr+Al) and Fe/(Fe+Mg) of chromite, plagioclase (An-Ab) compositions, and bulk siderophile element abundances and pattern, NWA 1500 is within the range of brachinites and (when all these characteristics are taken as a whole) unlike any other group of achondrites. However, one of the most distinctive features of NWA 1500, the presence of reverse zoning in olivine grains (Fo 65 to 73), has not been reported in brachinites. This zonation defines a nearly pure redox (FeO↔Fe) trend, which is easily distinguished from a normal igneous fractionation trend on a plot of Fe/Mg vs. Fe/Mn (Fig. 3). Available data suggest that a similar redox trend may exist among brachinites, although we caution that this conclusion rests largely on preliminary data for recently described samples [12-14]. Furthermore, the diversity of petrographic characteristics among brachinites suggests that they may not all derive from the same parent body.

Conclusions: New bulk and SIMS oxygen three isotope analyses of ungrouped achondrite NWA 1500 support a proposed genetic link to brachinite [4], and contrast with the earlier data that are more similar to IAB/Winonaite [3]. The SIMS analyses of olivine and plagioclase indicate that they equilibrated at 800-1000˚C, which is consistent with petrographic observations [2]. High precision SIMS oxygen isotope analysis of individual minerals in achondrites more accurately reflect the formation conditions that might not be revealed solely by bulk analyses. This yields more accurate and precise in situ oxygen isotope thermometry than has previously been possible. Our study of NWA 1500 suggests the possibility that other achondrite groups in addition to the ureilites may show internal redox relationships. This possibility should be tested and new brachinites examined for internal redox trends.

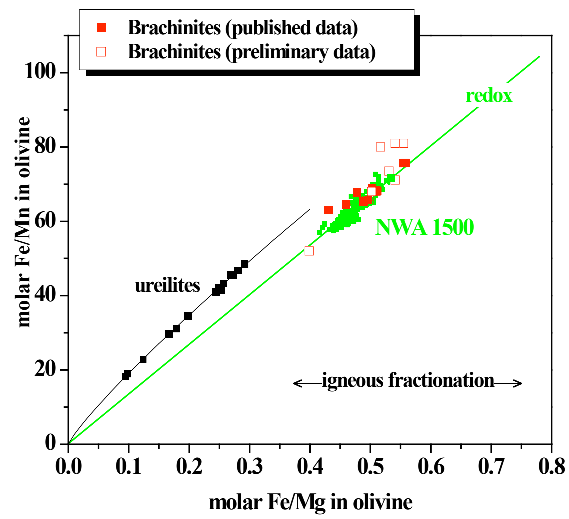

Fig. 3. Plot of molar Fe/Mg vs. Fe/Mn in olivine. Zoned olivines in NWA 1500 (green) show a nearly pure redox trend (similar to that seen among ureilites), rather than an igneous fractionation trend. Available data suggest that a similar trend may exist among brachinites.

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