PETROLOGY AND OXYGEN ISOTOPES OF CHONDRULES IN NWA 5492 AND GRO 95551: A NEW TYPE OF METAL-RICH CHONDRITE. M. K. Weisberg[1,2,3], D. S. Ebel[2,3], D. Nakashima[4] and N. T. Kita[4]. [1]Dept. Phys. Sci., Kingsborough College, City University New York, Bklyn, NY 11235. (mweisberg@kbcc.cuny.edu). [2]Earth and Env. Sci., Graduate Center, CUNY, NY, NY 10016. [3]Dept. Earth Planet. Sci., American Museum Natural History, NY, NY 10024., [4]Dept. Geoscience, University Wisconsin-Madison, WI 53706.

Introduction: NWA 5492 and GRO 95551 are metal-rich chondrite breccias that may represent a new oxygen reservoir and new chondrite parent body [1-3] and thus, require further exploration and characterization. Although they have some textural similarities to CB and CH chondrites, such as high metal abundances and a large cm-size barred olivine (BO) clast in GRO, their silicates are more reduced, sulfides are more common and not associated with the metal, and metal compositions differ from CB and CH chondrites, showing a closer affinity to H chondrite metal [4-6]. Initial oxygen isotope ratios indicate that NWA 5492 and GRO 95551 components (chondrules and lithic fragments) plot in a region above the terrestrial fractionation (TF) line, below ordinary chondrite compositions and just above enstatite chondrites in 3-oxygen space [1-3]. One rare component in NWA 5492 plots near the CR, CB and CH chondrites [1, 2]. Here we present a detailed petrologic and oxygen isotope study of the chondrules in these two meteorites.

Results: We studied the petrology of 20 chondrules and fragments from GRO 95551, 51 and 47 objects from two thin sections of NWA 5492. Oxygen isotope analyses were performed using the IMS-1280 at the University of Wisconsin using an ~15μm spot size in Multi-collection FC mode with an average analytical precision of 0.4‰ (2SD) for $\delta^{17}O$, $\delta^{18}O$ and $\Delta^{17}O$ [7]. Oxygen isotope ratios were determined for olivine and pyroxene grains in 20 objects from GRO 95551 and 15 objects from NWA 5492.

Textures and mineral assemblages. NWA 5492 and GRO 95551 appear to be breccias composed of chondrules, lithic fragments and metal nodules. Chondrules in NWA 5492 are commonly 500 μm to 1 mm in size, with some up to 1.8 mm. Some angular lithic fragments are several mm in size. The section of GRO 95551 was dominated by a large (1.2 cm) BO chondrule (C27) surrounded by smaller (500 μm - 1mm) objects and metal nodules. Many of the smaller objects in GRO 95551 have chondrule textures but irregular outlines with no evidence of once being spherical. Chondrule textures in both GRO 95551 and NWA 5492 include porphyritic (olivine and pyroxene-rich), radial pyroxene, BO, cryptocrystalline and glass-rich. Some chondrules are peppered with tiny (micron-submicron) blebs of metal suggestive of reduction of Fe from the silicates. Some of the large angular fragments in NWA 5492 (e.g., C12) are fine-grained intergrowths of enstatite and FeNi metal, similar to textures observed in E chondrites [e.g., 8]. Some porphyritic and BO chondrules in NWA 5492 have metal or sulfide (troilite and daubreelite) interstitial to the silicates occurring where chondrule mesostasis is expected.

Mineral compositions. Silicates in NWA 5492 chondrules are highly magnesian. Average olivine (43 analyses) is $Fa_{0.3}$ with a range of $Fa_{0.1\text{-}0.7}$. Avg. low-Ca pyroxene (26 analyses) is near-endmember enstatite ($Fs_{0.8}$ $Wo_{0.4)}$ with a range of $Fs_{0.3\text{-}1.6}$ $Wo_{0.3\text{-}0.8}$. Average (range) of chondrule mesostasis is (wt.%) 61.4 (53.6-64.3) SiO_2, 21.8 (19.2-27.0) Al_2O_3, 4.0 (2.4-8.6) CaO, and 5.9 (2.1-8.6) Na_2O. In GRO 95551, silicates show a wider range in composition. Mean olivine is $Fa_{1.3}$ (21 analyses) with a range of $Fa_{0.7\text{-}3.5}$ and pyroxene ranges $Fs_{0.7\text{-}39.3}$,$Wo_{0.7\text{-}1.6}$. Chondrule mesostasis is (wt.%) 41.1-62.5 SiO_2, 20.1-35.7 Al_2O_3, 3.8-19.0 CaO and 0.5-8.1 Na_2O.

Oxygen isotopes. The oxygen isotope ratios for NWA 5492 chondrules form a cluster lying mainly between the TF and Y-R lines in 3-isotope space (Fig. 1). Olivines, dominantly from PO (type IA) chondrules, seem to show systematically lighter values than pyroxene, dominantly from PP (type IB) chondrules. The data overlap with olivine and pyroxene from chondrules in both enstatite and ordinary chondrites [7, 10]. However, the average deviation of data from the TF line expressed as $\Delta^{17}O$ (= $\delta^{17}O$ - 0.52 × $\delta^{18}O$) is similar to that of silicates in ordinary chondrite chondrules (average ~ +0.5 ‰) [e.g., 7]. C9 in NWA 5492 is an Al-rich (glassy) chondrule with minor olivine and it's olivine has the lightest oxygen of the chondrules we analyzed. C12 is a large (>4 cm) angular fragment consisting mainly of an intergrowth of enstatite and metal, similar to textures described in E chondrites Its pyroxene plots on the TF line, similar to E chondrites. Oxygen isotope ratios for GRO 95551 chondrules are similar to NWA 5492, supporting a close relationship between the two meteorites. Olivine $\delta^{18}O$ values range from 3.3-5.2 ‰ and $\delta^{17}O$ values from 1.9-5.4 ‰. Pyroxene $\delta^{18}O$ values range from 3.2-6.3 ‰ and $\delta^{17}O$ values are from 0.8-4.8 ‰. C27, the large BO chondrule that dominates our section of GRO 95551 has oxygen isotope ratios that plot on the TF line, similar to some EH3 chondrules [10]. C25, which has the highest Fe content (Fs_{39}), plots above the Y-R line near R chondrites, suggesting mixing of material from other reservoirs.

Discussion: NWA 5492 and GRO 95551 are unusual metal-rich chondrite breccias with highly reduced silicate compositions. Although they are metal-rich (>20 vol. % metal) like CH and contain large metal nodules and large BO chondrules like CB chondrites, their silicate compositions are mainly more reduced and they contain higher abundances of sulfides than CH or CB [1]. Their silicate compositions are similar to those of E chondrites. However, the Si content of the metal is low (below our electron probe detection of 0.03 wt. %), unlike metal in the enstatite chondrites. Also, NWA 5492 and GRO 95551 do not contain the sulfide minerals that are characteristic of E chondrites, such as oldhamite (CaS), niningerite (MgS) or alabandite (MnS) [e.g., 11]. Similarities in the oxygen isotope ratios of their components strongly support a close relationship between NWA 5492 and GRO 95551 and equilibration of their components with the same oxygen reservoir. However, mixing of E chondrite (e.g, C12 in NWA 5492) and R chondrite (e.g., C25 in GRO 95551) components is a possibility. In our previous study we reported a clast in NWA 5492 having oxygen isotope ratios similar to CB chondrites [1, 2]. We did not find such ^{16}O-rich oxygen isotope ratios in this study. We therefore conclude that such clasts are very rare components mixed into the meteorite during brecciation. The oxygen isotope ratios of most objects in both NWA 5492 and GRO 95551 appear to be sandwiched between and overlap with chondrules from the O and E chondrites. Some chondrules have oxygen isotope ratios that plot on the TF line, similar to E chondrites, e.g., pyroxene from the large BO chondrule C27 in GRO 95551. Oxygen isotope ratios of BO chondrules are thought to represent the composition of the ambient nebular gas because they form by complete melting of their precursors [12, 13].

NWA 5492 and GRO 95551 likely represent a new type of chondrite with affinities to both E and H chondrites. Oxygen isotope compositions that plot near the TF line combined with lack of any evidence of hydrous alteration suggest their formation in the inner solar system making them possible analogues of the materials that accreted to form the inner planets.

References: [1] Weisberg M. K. et al. (2012) *Meteoritics & Planet. Sci., in press*. [2] Weisberg M. K. et al. (2011) *LPS 42nd,* Abstract #1198. [3] Friend P. et al. (2011) *LPS 42nd,* Abstract #1095. [4] Weisberg M. K. et al. (2001) *Meteoritics & Planet. Sci. 36,* 401-418. [5] Campbell A.J. and Humayun M. (2003) *Geochim. Cosmochim. Acta 67*, 2481-2495. [6] Humayun M. and Weisberg M. K. (2012) *LPS 43rd,* this volume. [7] Kita N. T. et al. (2010) *Geochim. Cosmochim. Acta 74*, 6610-6635.. [8] Van Niekirk D., and Keil, K. (2011) *Meteoritics & Planet. Sci. 46*, 1487-1494. [9] Young E. D. and Russell S. S. (1998) Science 282, 452-455. [10] Weisberg M. K. et al. (2011) *Geochim. Cosmochim. Acta 75*, 6556-6569. [11] Keil K. (1968) *J. Geophys. Res. 73*, 6945-6976. [12] Clayton R. T. et al. (1983) In Chondrules and their Origins (ed. E. A. King). LPI, Houston, 37–43. [13] Chaussidon M. et al. (2008) *Geochim. Cosmochim. Acta 72*, 1924-1938.

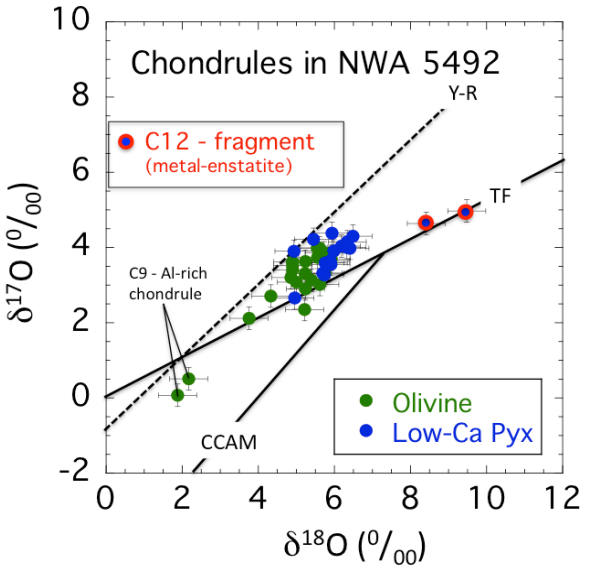

Figure 1. Oxygen 3-isotope diagram showing ratios for 15 chondrules from NWA 5492. Data include 2-5 points (analyses) per chondrule. Most data plot between the terrestrial fraction (TF) and Young-Russell (Y-R) lines [9]. C12 is a 4 cm fragment containing enstatite intergrown with metal.

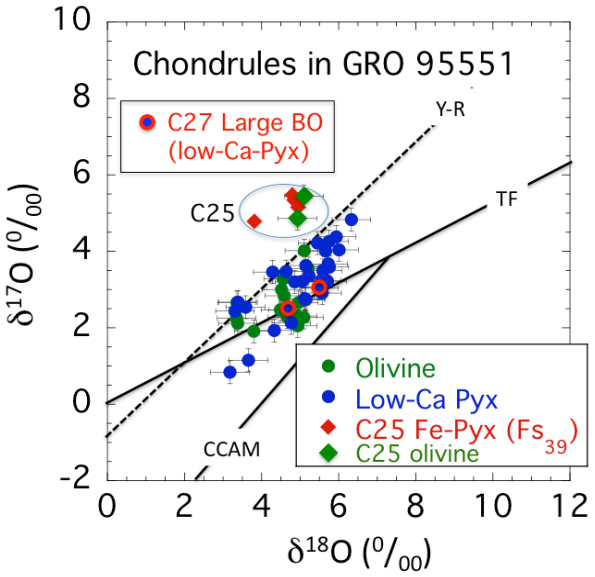

Figure 2. Oxygen 3-isotope diagram showing ratios for 20 chondrules from GRO 95551. Data include 2-5 points (analyses) per chondrule. Most data plots between the TF and Y-R lines similar to the NWA 5492 data. C27 is a 5 cm BO chondrule. C25 consists of Fe-rich pyroxene.