PETROLOGY AND EXTREME OXYGEN ISOTOPIC COMPOSITION OF TYPE 3.00 CARBONACEOUS CHONDRITE NORTHWEST AFRICA 5958: A UNIQUE, PRIMITIVE, ^{16}O-RICH EARLY SOLAR SYSTEM SAMPLE. T. E. Bunch[1], A. J. Irving[2], J. H. Wittke[1], D. Rumble, III[3] and G. Hupé [1]Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86011 (tbear1@cableone.net), [2]Dept. of Earth & Space Sciences, University of Washington, Seattle, WA 98195, [3]Geophysical Laboratory, Carnegie Institution, Washington, DC 20015.

A very fresh, dark gray meteorite found in fragments in Algeria (total weight 286 grams) is a unique, highly unequilibrated, ungrouped carbonaceous chondrite possessing extreme isotopic signatures. This remarkable specimen should hold important information about the nature and variety of materials in the earliest solar nebula, and deserves systematic study.

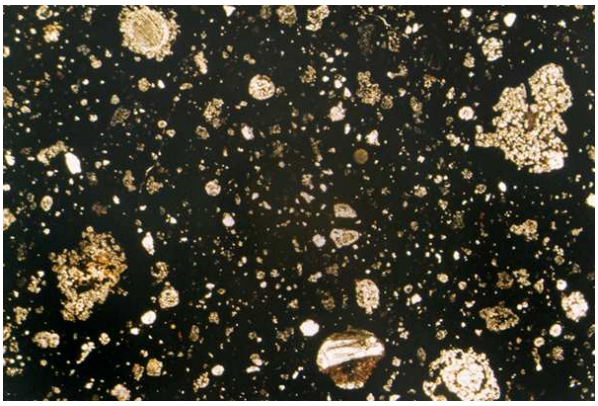


Figure 1. *Plane polarized light thin section image of NWA 5958 (width 14 mm) showing numerous small, diverse objects in a very dark matrix.*

Petrography: The overall texture of NWA 5958 is fragmental/clastic, with a variety of small objects (mostly 0.05-2.5 mm) set in a dark, very fine grained matrix (see Figure 1). Chondrules are predominantly enstatite PP, forsterite PO, Mg-rich POP, with other unique types. Intact chondrules have multiple (up to 5) accretion rims that increase in grainsize outwardly. Mesostasis is not abundant within chondrules, but where present consists of interlaced quench crystals of fayalite or ferrohortonolite and subcalcic ferroaugite. Some chondrule fragments have discontinuous "veins" of acicular/bladed fayalite. Some enstatite PP chondrules contain interstitial grains of carbon-rich material (4-16 vol.%; grain size = 0.001 0.024 mm; some hexagonal or pseudohexagonal in shape). Other rare objects are xenoliths of different fine grained carbonaceous chondrite lithologies, small CAI composed of fine grained (0.005-0.05 mm) spinel+perovskite cores mantled by Ti-augite, and an irregularly-shaped 2.5 mm clast of fragmented calcite.

Mineral Compositions: The overall compositional range for olivine is $Fa_{0.15\text{-}88}$ (FeO/MnO = 77-148; Cr_2O_3 = 0.15-0.86 wt.%). Olivine of intact PO chondrule phenocrysts (N = 8) is $Fa_{0.15\text{-}2.5}$, and in zoned chondrule fragments: rims $Fa_{25\text{-}58}$, mean Fa_{46} (Cr_2O_3 = 0.23-0.75 wt.%, mean 0.48 wt.%), cores $Fa_{10\text{-}28}$, mean Fa_{21} (Cr_2O_3 = 0.32-0.86 wt.%, mean 0.54 wt.%). More ferroan olivine is $Fa_{68\text{-}88}$. PP chondrules contain enstatite ($Fs_{0.2\text{-}2.5}Wo_{1.3}$), diopside ($Fs_{3.4}Wo_{46}$), and mesostasis subcalcic ferroaugite ($Fs_{67}Wo_{19}$). Kamacite (Ni = 5.5 wt.%, Cr = 1.05 wt.%); chromite [Cr/(Cr+Al) = 0.94-0.96]; troilite (Ni = 2.3 wt.%).

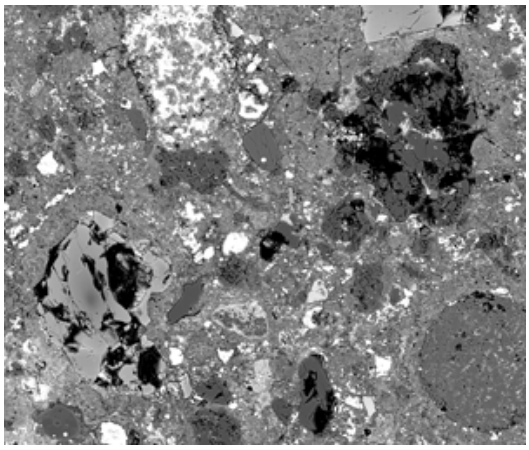
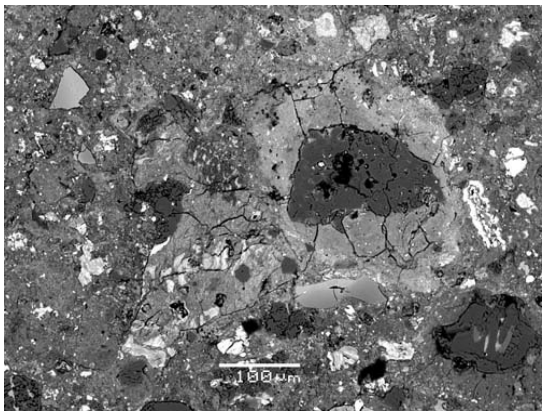
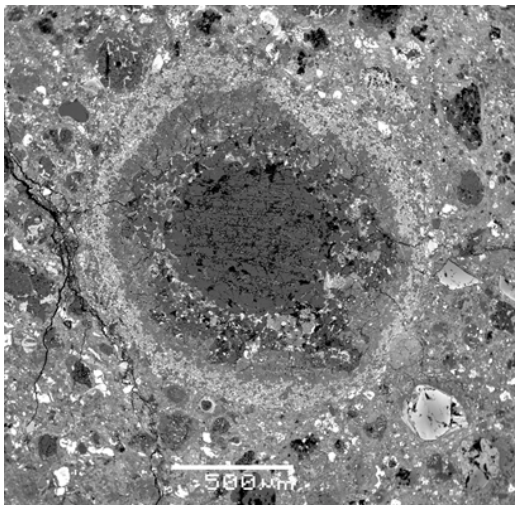
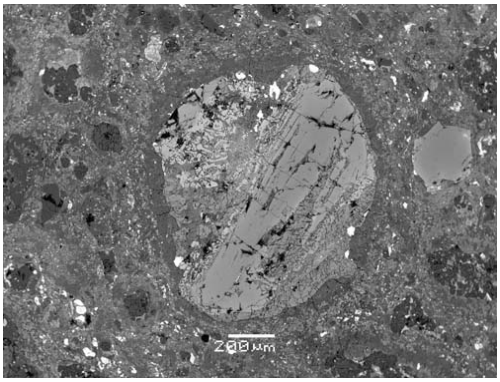
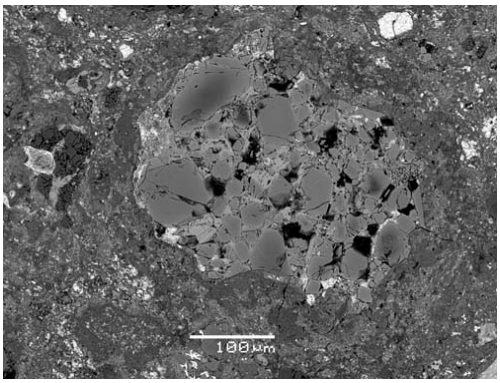


Figure 2. **(above)** *BSE image of a typical region showing the textural and compositional diversity of chondrule-like objects and fragments. Width 0.75 mm.* **(below)** *Xenolith with lower porosity and more Fe-rich matrix compared with host specimen matrix, against Mg-rich inclusion (light gray)*









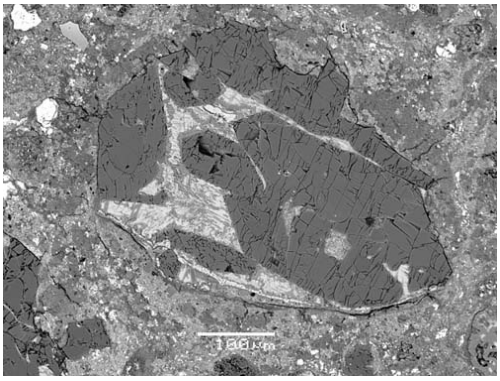


Figure 3. **a**. **(top)** *Multiple rimmed enstatite chondrule with coarse-grained rim, overlain by 3 successive layers of increasing Fe content and grain size*

b. *Chondrule-like object with elongate enstatite grains set in a complex matrix of vermicular fayalite, ferroaugite, Na-rich glass and chromite*

c. *Chondrite-like object of zoned olivine ($Fa_{2.5}$ to $Fa_{24.6}$) in a coarse matrix of light gray fayalite*

d. **(bottom)** *Chondrule–like object of enstatite phenocrysts in a mesostasis of fayalite and ferroaugite*

Oxygen Isotopes: Replicate analyses of acid-washed NWA 5958 whole rock material by laser fluorination gave, respectively: $\delta^{18}O$ = -11.398, -12.530; $\delta^{17}O$ = -8.803, -9.869; $\Delta^{17}O$ = -6.768, -7.339 per mil. These extreme compositions plot on an extension of the CCAM line (see Figure 4), about one-sixth of the way from the fields for other carbonaceous chondrites towards the Genesis solar value [1]. Results for unrelated CO3 chondrite NWA 6156 also are reported here: $\delta^{18}O$ = -3.22, -3.42; $\delta^{17}O$ = -6.20, -6.61; $\Delta^{17}O$ = -4.510, -4.810 per mil, respectively. It is evident that NWA 5958 is isotopically very distinct from CO3 chondrites (despite having very small chondrules reminiscent of those in such specimens). It appears likely that component materials in NWA 5958 (very few of which are CAI) might span a very wide range of extreme oxygen isotopic compositions.

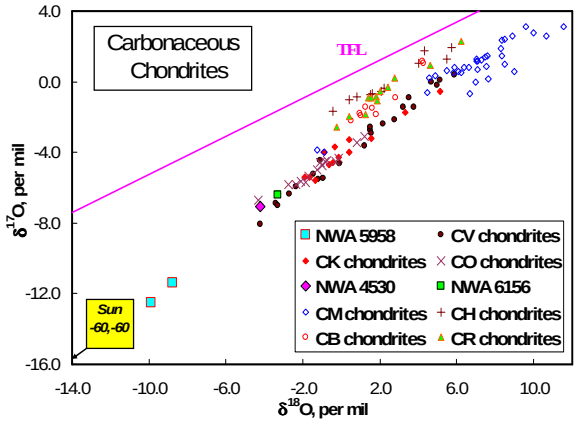


Figure 4. *Oxygen isotope compositions for NWA 5958 and other carbonaceous chondrites [2] (including CO3 chondrites NWA 4530 and NWA 6156).*

Conclusion: It is evident that NWA 5958 is a very special early solar system sample, based not only on the data presented here, but on trace element and isotopic data presented in a companion abstract [3].

References: [1] McKeegan K. et al. (2009) *Lunar Planet. Sci.* **XL**, #2494 [2] Clayton R. and Mayeda T. (1999) *Geochim. Cosmochim. Acta* **63**, 2089-2104; Bunch T. et al. (2010) *73rd Meteorit. Soc. Mtg.*, #5329 [3] Ash R. et al. (2011) *Lunar Planet. Sci.* **XLII**, this conference.