NORTHWEST AFRICA 7135: AN UNUSUAL REDUCED, UNEQUILIBRATED CHONDRITE CONTAINING OLDHAMITE, DAUBREELITE, SCHREIBERSITE AND DJERFISHERITE, AND WITH A UNIQUE OXYGEN ISOTOPIC COMPOSITION. A. J. Irving[1,3], S. M. Kuehner[1], K. Ziegler[2], F. Kuntz and P. P. Sipiera[3] [1]Dept. of Earth & Space Sciences, University of Washington, Seattle, WA 98195 (irvingaj@uw.edu), [2]Institute of Meteoritics, University of New Mexico, Albuquerque, NM, [3]Planetary Studies Foundation, Galena, IL.

Introduction: Given the wealth of meteorites recovered in Northwest Africa over the past 15 years, it would not be surprising if rare and previously unknown sorts of specimens might be recognized. Among the very abundant specimens that appear to be typical ordinary chondrites, few would seem to warrant the detailed testing that might establish them to be something new and unique, which could in turn add to our knowledge of the diversity both within and among solar system parent bodies. The 51.3 gram stone described here was purchased by one of us (FK) after sorting through a "bag of dirty chondrites" offered by a Moroccan dealer at the 2010 Munich Mineral Show. Many collectors have sought such rare "gems", but few have been recognized, yet this specimen appeared "somehow different". Here we present evidence that NWA 7135 is a unique ungrouped chondrite, perhaps derived from a previously-unrecognized chondritic parent body.

Petrology: This specimen lacks a fusion crust and has experienced some desert weathering of original metal, but relatively small, mostly spherical chondrules are clearly evident (see Figures 1 and 2). Separated chondrules (predominantly 1.1±0.6 mm, with several larger up to 3.4 mm) are set within a metal-rich matrix representing ~30 volume% of the specimen. Some chondrules contain interstitial glass with microlites.

Figure 1. *Cut NWA 7135 stone. © F. Kuntz.*

This appears to be a relatively equilibrated Type 3 chondrite of high subtype, yet there is no olivine more magnesian than $Fa_{4.8}$ and only rare grains more ferroan than $Fa_{6.2}$ – see Figure 4. Chromium contents in more ferroan olivine are at or near detection limits, implying a subtype >3.7 [1, 2].

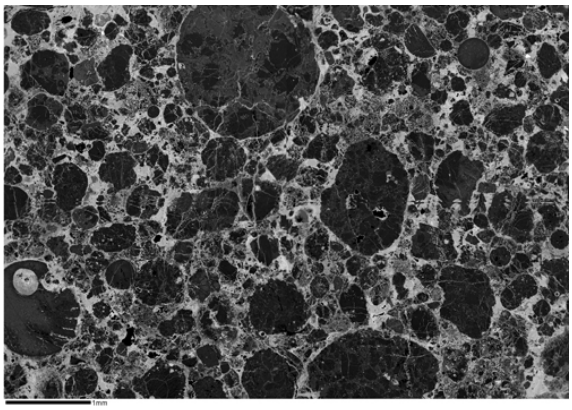

Figure 2. *BSE image of NWA 7135 highlighting the spherical, relatively homogeneous, magnesian chondrules (dark) within a matrix containing altered metal (light gray) and rare, small grains of schreibersite and daubreelite (bright, e.g., at upper left and upper right).*

In contrast, the pyroxenes exhibit a wide compositional range (orthopyroxene $Fs_{7.0\text{-}21.8}Wo_{0.4\text{-}1.5}$, pigeonite $Fs_{17.3}Wo_{6.9}$, diopside, subcalcic augite $Fs_{13.3\text{-}22.2}Wo_{25.4\text{-}29.9}$). Accessory phases include altered Si-free kamacite and Cr-free pyrrhotite, but more remarkably schreibersite, oldhamite, daubreelite and djerfisherite. Such reduced sulfides have not been observed previously in ordinary chondrites, but are quite characteristic of enstatite chondrites. Other phases such as alabandite, niningerite, osbornite or sinoite have not been found.

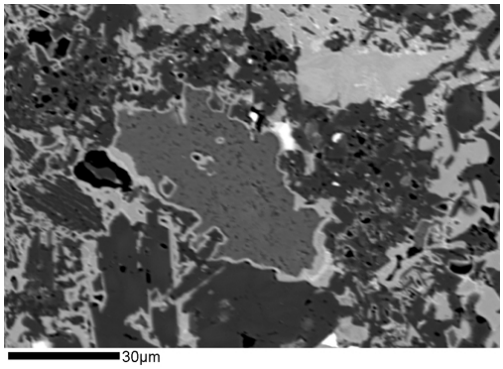

Figure 3. *BSE image of oldhamite grain associated with pyrrhotite (bright), orthopyroxene (dark gray) and altered metal (light gray).*

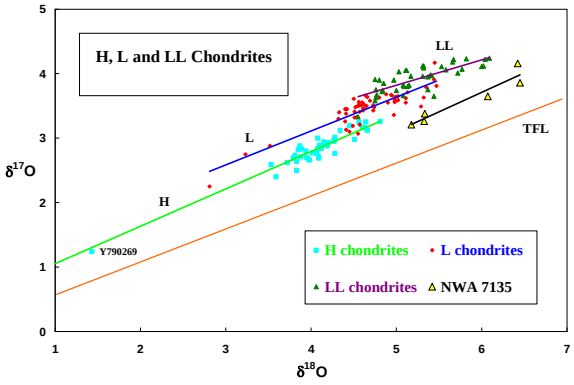

Figure 4. *Oxygen isotopic compositions. Data for LL, L and H chondrites from [3].*

Oxygen Isotopes: Analyses of six acid-washed subsamples by laser fluorination gave, respectively, $\delta^{17}O$ 3.207, 3.649, 3.262, 4.158, 3.379, 3.859; $\delta^{18}O$ 5.175, 6.072, 5.326, 6.424, 5.333, 6.450; $\Delta^{17}O$ 0.475, 0.443, 0.450, 0.766, 0.563, 0.453 per mil. These values plot above the terrestrial fractionation line, but are displaced from the well-established trends for ordinary chondrites (see Figure 4). Not only are the $\Delta^{17}O$ values much closer to the TFL than for H chondrites, the $\delta^{18}O$ values are elevated beyond those for H chondrites.

We do not attribute the anomalous oxygen isotopic results for NWA 7135 to effects from terrestrial weathering of primary metal, since the acid pretreatment protocol is designed to remove iron hydroxides. All subsamples (1.0-1.8 mg) were carefully examined under a microscope prior to laser fluorination, and were observed to be composed almost entirely of clear silicate grains. Any remaining material containing terrestrial oxygen would be in insufficient amount to shift the oxygen isotopic compositions from the field for H chondrites as far towards the TFL as the measured values. Besides that, analyses in the same laboratory using the same protocol on equilibrated ordinary chondrites exhibiting similar degrees of terrestrial weathering consistently yield results which fall in the appropriate fields for their classes (as deduced independently from mafic silicate compositions).

Discussion: The mean chondrule size in NWA 7135 is similar to that for typical H chondrites, but chondrule size by itself is hardly a reliable parameter on which to base the genetic affinity of such specimens. The degree of equilibration in olivine is approaching that in Type 4 chondrites, yet H4 chondrites have mean olivine compositions of $Fa_{16\text{-}19}$, i.e., much more ferroan than the $Fa_{4\text{-}6}$ values in NWA 7135. Such very forsteritic olivine compositions, although not as magnesian as in enstatite chondrites, would be consistent with the degree of reduction indicated by the accessory sulfides.

Oxygen isotopes do not support the hypothesis that NWA 7135 might be an unusually reduced ordinary chondrite, and instead we suggest that it represents a distinct kind of ungrouped chondrite belonging to a class not previously recognized. Analysis of chromium isotopes would be instructive to further assess the affinities of NWA 7135.

References: [1] Grossman J. and Brearley A. 2005 *Meteorit. Planet. Sci.* **40**, 87-122 [2] Bunch T. et al. 2012 *Lunar Planet. Sci.* **XLIII**, #2193 [3] Clayton R. et al. 1991 *Geochim. Cosmochim. Acta* **55**, 2317-2337.