ANOMALOUS EUCRITES NORTHWEST AFRICA 2824 AND NORTHWEST AFRICA 8671: MORE EVIDENCE FOR MULTIPLE EUCRITE PARENT BODIES. A. J. Irving[1,2], S. M. Kuehner[1], T. E. Bunch[3], J. H. Wittke[3], K. Ziegler[4], D. Rumble, III[5], B. Reed, M. Hmani and J. Kashuba [1]Dept. of Earth & Space Sciences, University of Washington, Seattle, WA (irvingaj@uw.edu), [2]Planetary Studies Foundation, Galena, IL, [3]Geology Program, SESES, Northern Arizona University, Flagstaff, AZ, [4]Institute of Meteoritics, University of New Mexico, Albuquerque, NM, [5]Carnegie Institution for Science, Washington, DC.

Introduction: Although the majority of eucrites have petrologic and isotopic attributes consistent with derivation from a single parent body, there is evidence that other eucrite specimens are samples from at least five different parent bodies [1-5]. The most widely cited criteria for distinguishing multiple types of eucrites are their different oxygen isotope compositions, especially for eucrites such as Ibitira, Asuka 881394, EET 92023, Bunburra Rockhole and Emmaville.

However there also are anomalous textural features and shock effects in some eucrite specimens which may signify the existence (current or former) of even more diverse parent bodies. We have already described features of Northwest Africa 2824 [6] that establish it as a highly shocked eucrite with an Ibitira-like oxygen isotope composition (and not a diogenite). Here we document further aspects of this anomalous specimen, and also shock(?)-melted eucrite Northwest Africa 8671.

Northwest Africa 2824 revisited: The specimen consists of ~80 vol.% low-Ca pyroxene (mostly pigeonite $Fs_{22.8-37.2}Wo_{13.5-8.5}$, FeO/MnO = 30±1) and ~18 vol.% anorthite ($An_{94.7-98.8}Or_{0.2-0.1}$), and appears to be an annealed breccia derived from a protolith dominated by a single diabasic eucrite lithology. Sparse angular grains of orthopyroxene (exhibiting more Mg-rich reaction rims) are also present. Accessory phases include silica polymorph, ilmenite, troilite and very rare olivine.

Plagioclase occurs as irregularly-shaped regions (former lath clusters) composed of complex spherulitic aggregates of birefringent grains (see Figures 1 and 2). Sparse vesicles are present in these regions, along with ellipsoidal "blobs" composed of acicular anorthite + zoned pyroxene + silica polymorph + fayalite + ilmenite + Ti-chromite + troilite + kamacite + taenite (see Figure 3). Similar features are present in shock-melted shergottite NWA 11509 [7]. Most pyroxene in regions between plagioclase has been recrystallized into polygonal mosaics, and grains larger than one millimeter exhibit irrational, "patchy" exsolution structures, reduced birefringence, mechanical twinning and possible PDFs.

Figures 2 and 3 (right). *Back-sattered electron images showing the primary subophitic texture and a quench-textured "blob" in a plagioclase-rich region with pyroxene clasts (see text for details).*

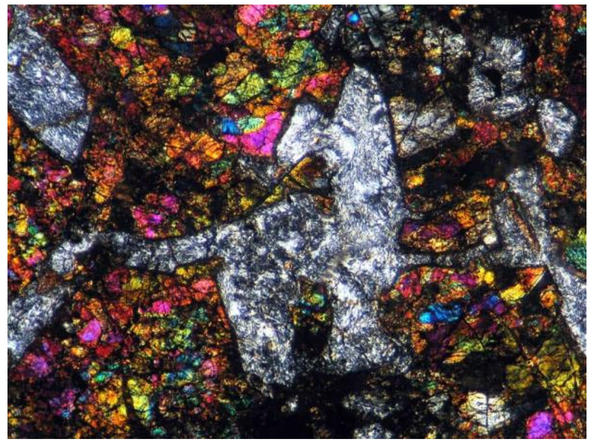
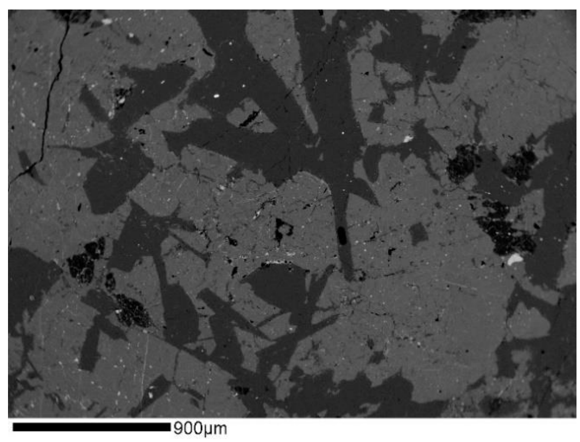
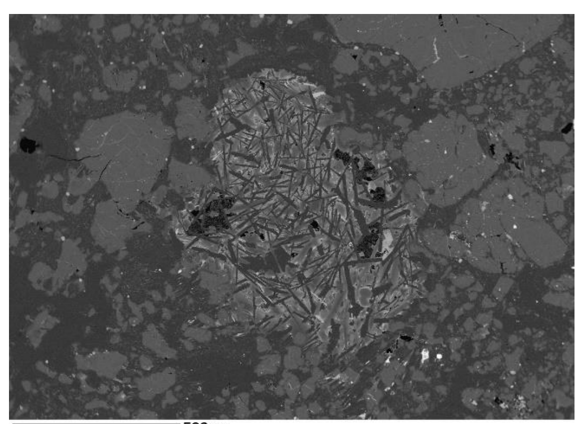


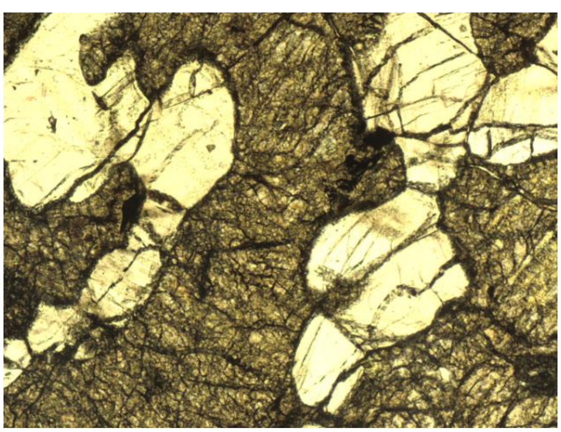
Figure 1. *Cross-polarized thin section image of NWA 2824 showing spherulitic plagioclase (gray) and recrystallized, polygonal-mosaic pyroxene (colors).*





Northwest Africa 8671: This is a very unusual specimen consisting of dispersed domains of coarse, polygranular, birefringent anorthite ($An_{91.4-93.0}Or_{0.1}$) separated by interstitial regions of finely recrystallized low-Ca pyroxene. The plagioclase-rich domains have irregular, rounded shapes with re-entrant embayments (see Figure 4), and exhibit marginal reaction zones against interstitial pyroxene composed of ferropigeonite ($Fs_{52.5-55.5}Wo_{21.6-16.5}$, FeO/MnO = 30) plus fayalite ($Fa_{82.2-82.9}$, FeO/MnO = 39). Pyroxene grains within the interstitial regions contain numerous irregularly-distributed, small patches with two distinctly different compositions: one low-Ca ($Fs_{47.9-49.1}Wo_{5.5-4.4}$, FeO/MnO = 29±1) and the other higher-Ca pigeonite ($Fs_{36.3-34.7}Wo_{10.8-7.6}$, FeO/MnO = 27±1), but ***no*** high-Ca augite. Silica polymorph, Al-bearing chromite and troilite are accessory phases.

Figure 4. *Optical thin section images of NWA 8671* (**A**, **above**) *Cross-polarized view (width 1.1 cm)* (**B**, **below**) *Plane-polarized view (width 2.37 mm) showing embayed polygranular plagioclase regions and interstitial microcrystalline pyroxene-rich regions.*



Oxygen Isotopes: Replicate analyses of acid-washed subsamples of NWA 8671 by laser fluorination gave, respectively, $\delta^{17}O$ 1.736, 1.642, 1.694; $\delta^{18}O$ 3.847, 3.688, 3.776; $\Delta^{17}O$ -0.295, -0.305, -0.300 per mil. These data plot just beyond the range for most eucrites at more negative $\Delta^{17}O$ values (see Figure 5).

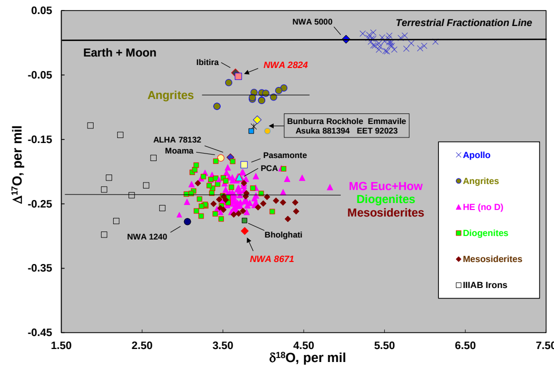


Figure 5. *Oxygen isotope plot for eucrites and diogenites. Data from [2-6, 8, 9], other literature sources and our unpublished laser fluorination analyses.*

Discussion: It is evident that NWA 2824 differs from the majority of eucrites in terms of both its oxygen isotopic composition and its degree of shock modification. In both of these aspects NWA 2824 can be interpreted to have close affinities to the anomalous vesicular eucrite Ibitira, especially if the latter is regarded as an impact melt rock rather than an endogenous lava specimen. Both of these meteorites plausibly are samples from the same parent body, and furthermore since their mineralogy and therefore spectral properties are indistinguishable from those for other eucrites, there is no *a priori* reason to not suppose that they (in lieu of other eucrites) are potentially samples from 4Vesta.

Different considerations apply to NWA 8671 and its texture is admittedly difficult to understand. We propose that a shock-induced melting event resulted in selective resorption and marginal reaction of plagioclase-rich portions of the protolith (evidently a relatively coarse-grained gabbroic eucrite), yet pervasive recrystallization of just the original pyroxene-rich regions.

Concluding Remarks: The documented diversity among eucrites can only mean that they represent samples from numerous early solar system differentiated bodies. Furthermore there is the real possibility that ***none*** of those already studied come from 4Vesta.

References: [1] Irving A. et al. (2014) *77th Meteorit. Soc. Mtg.*, #5199 [2] Wiechert U. et al. (2004) *EPSL* **221**, 373-382 [3] Scott E. et al. (2009) *GCA* **73**, 5835-5853 [4] Spivak-Birndorf L. et al. (2015) *MaPS* **50**, 958-975 [5] Barrett T. et al. (2017) *MaPS* **52**, 65-668 [6] Bunch T. et al (2009) *72nd Meteorit. Soc. Mtg.*, #5367 [7] Irving A. et al. (2018) *LPS* **XLIX**, *this conference* [8] Day J. et al. (2012) *Nature Geosci.* **5**, 614-617 [9] Clayton R. & Mayeda T. (1996) *GCA* **60**, 1999.