NORTHWEST AFRICA 8535 AND NORTHWEST AFRICA 10463: NEW INSIGHTS INTO THE ANGRITE PARENT BODY. A. R. Santos[1], C. B. Agee[1], C. K. Shearer[1], and F. M. McCubbin[2], [1]Institute of Meteoritics, 1 University of New Mexico, MSC03-2050, Albuquerque, NM 87131, [2]NASA Johnson Space Center, Mail Code XI2, 2101 NASA Parkway, Houston TX 77058, (asantos5@unm.edu).

Introduction: The angrite meteorites are valuable samples of igneous rocks formed early in Solar System history (~4.56 Ga, summarized in [1]). This small meteorite group (~24 individually named specimens) consists of rocks with somewhat exotic mineral compositions (e.g., high Ca olivine, Al-Ti-bearing diopside-hedenbergite, calcium silico-phosphates), resulting in exotic bulk rock compositions. These mineral assemblages remain fairly consistent among angrite samples, which suggests they formed due to similar processes from a single mantle source. There is still debate over the formation process for these rocks (see summary in [1]), and analysis of additional angrite samples may help to address this debate. Toward this end, we have begun to study two new angrites, Northwest Africa 8535, a dunite, and Northwest Africa 10463, a basaltic angrite.

Methods: Thin sections and probe mounts of each meteorite were examined using the FEG SEM and electron microprobe at the University of New Mexico. Modal mineralogy was determined from phase maps constructed from qualitative x-ray maps collected using Energy Dispersive Spectroscopy on the FEG SEM. Quantitative mineral analyses and qualitative element maps were collected using Wavelength Dispersive Spectroscopy with the electron microprobe.

Results: *Northwest Africa 8535.* NWA 8535 is a dunite, containing 92% olivine as well as pyroxene (1%), spinel (7%), and accessory Fe-sulfide and iron-nickel metal (0.3%). Olivine grains are subhedral to anhedral, have variable grain size in different regions of the sample, and are present in a sutured texture with no apparent preferred orientation. Several ~120° triple junctions are present (Fig. 1A). Most large olivine grains have distinctly zoned cores and rims. Pyroxene and spinel both have extremely anhedral morphologies, appearing in most cases to be interstitial grains or poorly formed inclusions (Fig. 1B). Sulfide and metal grains are small and ubiquitous.

Olivine compositions vary over a relatively small range of Fo content (Fig. 2). Magnesium number ranges from 70 to 88, with higher values derived from the olivine cores (average core composition $Fo_{84.5}Fa_{15.4}Lrn_{0.2}$, average rim composition $Fo_{75.3}Fa_{23.8}Lrn_{1}$). Maximum larnite content reaches ~3% in some small grains and rims of larger grains, with an average of 0.4%. Chromium content averages 0.17 wt% Cr_2O_3. No major difference in chemistry was seen between olivines of different sizes, but the small olivine grains tend to be unzoned and are compositionally more similar to the rims of the large olivine grains. Exsolution is not present. Pyroxene has the high Ca, high Al contents typical of angrites and does not appear to have any zoning or lamellae. Spinel is dominated by chromite and hercynite components and is strongly zoned, with portions of grains containing substantial chromite grading into hercynite (Fig. 1C). This zoning is present in all portions of the meteorite observed thus far. In several locations pyroxene is found in contact with the hercynitic portion of the spinel, although this is not exclusively the case. The chromite-rich portion of the spinel is often in contact with, or closer to, the Mg-rich portions of olivine grains.

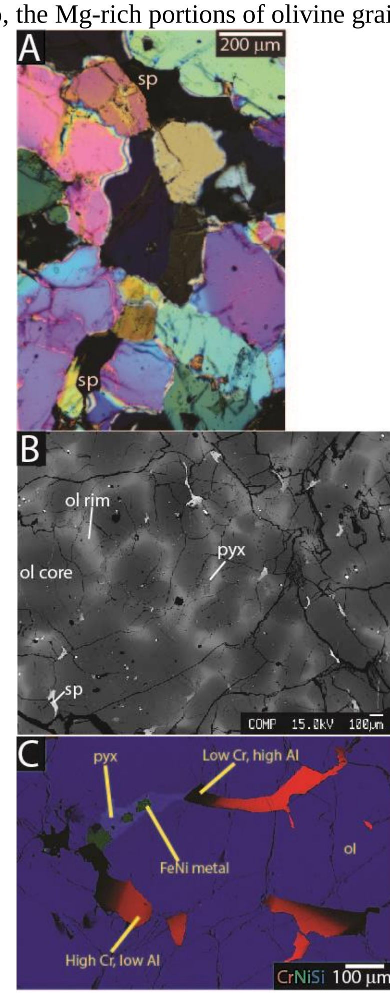

Figure 1: Images from NWA 8535. A: Cross polarized light image showing olivine texture. sp-spinel grains. B: Backscat-

tered electron image showing typical mineral textures. C: X-ray map of Cr (red), nickel (green), and Si (blue). Note zoning in spinel.

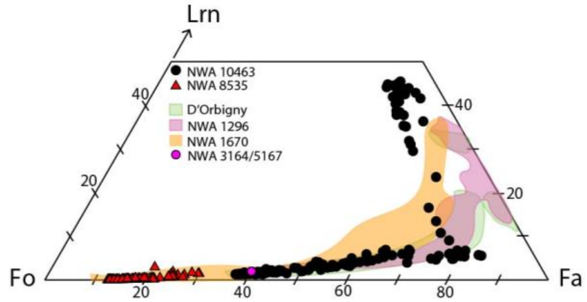

Figure 2: Olivine compositions in NWA 10463 and NWA 8535 (black dots and red triangles, respectively) compared to compositional ranges for other angrites (data from [2-5]).

Northwest Africa 10463. NWA 10463 consists of olivine (26%), pyroxene (28%), feldspar (37%), and minor phases such as spinels and iron oxides (primarily iron-titanium oxides, 3%), Fe-sulfides (3%), and a silico-phosphate (<1%). The sample is texturally similar to the plutonic angrites, however it contains a population of olivines that are chemically zoned, along with olivines containing exsolution lamellae. The zoned grains have Mg rich cores ($Fo_{56.7}Fa_{41.6}Lrn_{1.7}$) grading into Fe rich rims ($Fo_{36.3}Fa_{59.1}Lrn_{4.6}$). Thin lamellae of Ca rich olivine are exsolved in some of these rims (Fig. 3). These lamellae are typically less than 2 µm in width. Other olivine grains are composed of a high Ca olivine host ($Fo_{8}Fa_{48.6}Lrn_{43.4}$) exsolving low Ca lamellae ($Fo_{17.4}Fa_{76.9}Lrn_{5.5}$) (Fig. 3). These lamellae tend to be larger, ranging from 1-9 µm wide. Chromium is not above the detection limit (~0.018 wt% Cr_2O_3) in any type of olivine within this sample. Pyroxene is also Al-Ti-bearing diopside-hedenbergite, and is unzoned. Spinel and iron oxides occur as individual grains often with subhedral to euhedral morphologies. Spinels appear dominated by the magnetite component based on EDS analysis, although some rare grains with high chromite component are present. The chromite-rich spinels are found within feldspar grains and consist of a core surrounded by a partially reacted rim.

Preliminary Discussion: The two meteorites presented here represent new additions to the angrite meteorite group. NWA 10463 appears to represent an intermediate stage between volcanic angrites and plutonic angrites based on the presence of both zoned olivine and olivine with exsolution lamellae. The presence of the zoned olivine grains and larger range in Ca content between host and lamellae compositions might reflect a cooling/reheating history for this sample that is different from most other angrites.

While NWA 8535 is the only dunite angrite, the olivine within this sample is not compositionally exotic relative to that in other angrites. It has an average of 0.173 wt% Cr_2O_3, which is near the high end of what has previously been reported for calcic olivine in angrites [1], and the range in mg# (70-88) is seen in some angrite samples, but is high relative to many others. It is possible this sample represents an early formed cumulate derived from an angrite melt.

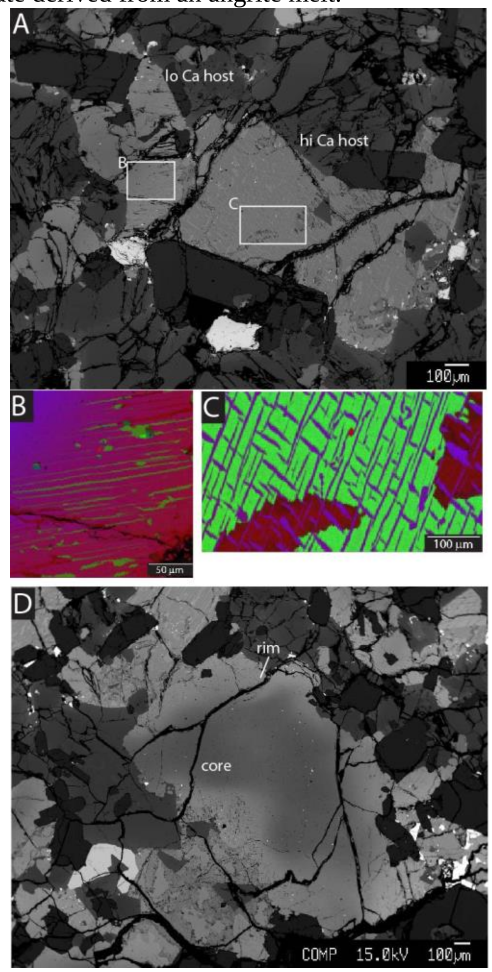

Figure 3: Olivine grains from NWA 10463. A: Olivine containing exsolution lamellae, boxed regions are shown in B and C. B: Fe(red)Ca(green)Mg(blue) X-ray map showing high Ca lamellae exsolving from a high Fe host. Higher Mg contents are found near the core of this grain (upper left). C: FeCaMg X-ray map showing low Ca lamellae exsolving from a high Ca host. Note the lamellae persisting through patches of high Fe within the host. D: Olivine showing a high Mg core and high Fe rim.

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References: [1] Keil K. (2012) *Chemie der Erde*, 72, 191-218. [2] Mittlefehldt D.W. et al. (2002) *MAPS*, 37, 345-369. [3] Jambon A. et al. (2005) *MAPS*, 40, 361-375. [4] Jambon A. et al. (2008) *MAPS*, 1783-1795. [5] Baghdadi B. et al. (2015) *Geochim. et Cosmochim. Acta*, 168, 1-21.