PETROLOGY AND GEOCHEMISTRY OF ANDESITIC UNGROUPED ACHONDRITES NORTHWEST AFRICA 6698 AND 11575. Z. Vaci[1], S. Yang[2], M. Humayun[2], C. B. Agee[1], [1]Institute of Meteoritics, University of New Mexico, Albuquerque, NM, USA, [2]National High Magnetic Field Laboratory and Dept. of Earth, Ocean & Atmospheric Science, Florida State University, Tallahassee, FL 32310, USA.

Introduction: We report here the major and trace element geochemistry of two ungrouped achondrites with unique evolved mineralogy and petrology, Northwest Africa (NWA) 6698 and 11575. NWA 6698 was originally characterized as "dioritic" rock containing mostly sodic plagioclase and pyroxenes [1]. NWA 11575 was characterized as a trachyandesite, likewise containing mostly sodic plagioclase and pyroxenes [2], along with a second "dark" lithology of glassy mesostasis and pyroxenes [3]. The oxygen isotopes of both rocks plot in the field of the LL chondrites [1,2], suggesting they are products of planetesimal melting potentially involving the LL chondrite parent body or bodies.

Modal Mineralogy: The modal mineralogy of NWA 6698 and 11575 were determined using BSE greyscale imagery. NWA 6698 consists of medium to fine (<1 mm) unzoned euhedral grains and contains 67% plagioclase, 16% low-Ca pyroxene, 10% high-Ca pyroxene, 5% glassy mesostasis with microlites, and trace chromite, sulfide, and phosphate. NWA 11575 consists of fine (<500 µm) subhedral grains and contains 62% plagioclase, 37% zoned pyroxene, and trace Fe oxides, sulfide, phosphate, alkali feldspar, and silica. The "dark" lithology consists of 65% glassy mesostasis with microlites and 35% zoned pyroxene grains with "hopper" morphology. The textures of both rocks reflect igneous origins.

Bulk Composition and Mineral Chemistry: The bulk compositions of NWA 6698 and 11575 were determined by rastering large representative areas of polished thick sections by LA-ICP-MS. The total alkali vs. silica (TAS) diagram (Fig. 1) shows NWA 6698 plotting in the trachyandesite field, with NWA 11575 in the basaltic andesite field. These evolved compositions sharply contrast with previously characterized achondrite groups such as the eucrites and angrites, showing more similarity to the evolved clast ALM-A [4] and GRA 06128/9 [7].

The pyroxene compositions show similar trends in both meteorites, although while NWA 6698 contains two distinct populations of pigeonite and augite, NWA 11575 contains a single population of zoned grains with pigeonite cores, magnesian augite mantles, and ferrous augite rims (Fig. 2). This type of pyroxene trend is also observed in Martian basalts and Apollo 15 mare basalts [2]. The feldspar compositions in NWA 6698 range from andesine to oligoclase, while those of NWA 11575 are predominantly oligoclase with trace amounts of K-feldspar found in association with silica (Fig. 2).

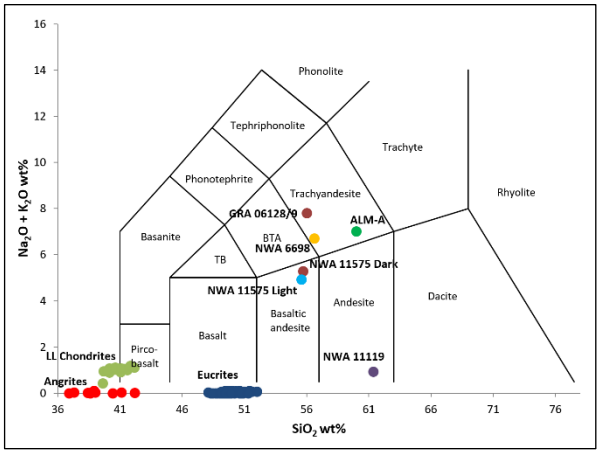

Figure 1 *showing total alkali vs. silica diagram for bulk compositions of NWA 6698 and 11575 and other achondrites. [4,5,6,7,8]*

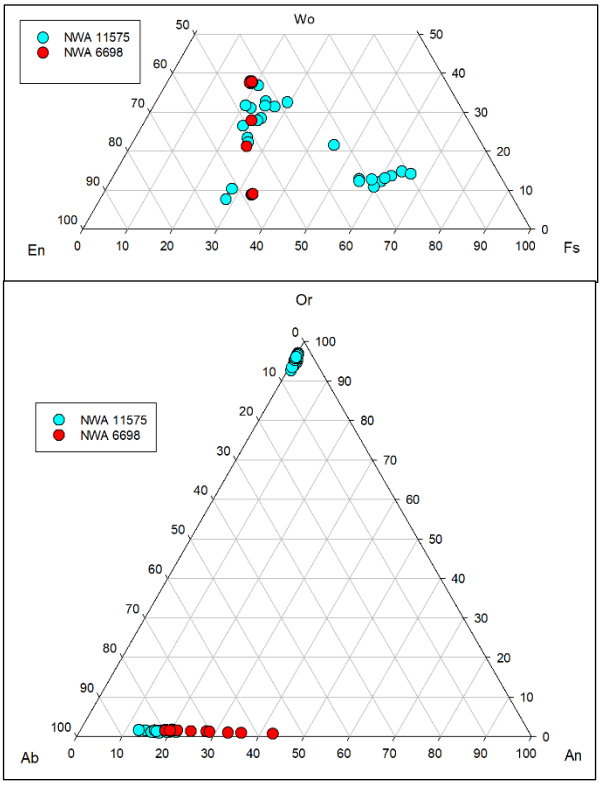

Figure 2 *showing pyroxene and plagioclase ternary diagrams for NWA 6698 and 11575.*

Both NWA 6698 and 11575 contain what appears to

be late-stage glassy mesostasis with microlites that is enriched in incompatible elements relative to the bulk compositions of each rock. Mesostasis appears interstitially in 6698 and as fragmented clasts in NWA 11575. While SiO_2 in the glassy material is enriched in both meteorites, Al_2O_3 is depleted in the NWA 6698 glass, likely because it was incorporated into the plagioclase. By contrast, the glassy material in NWA 11575 contains rapidly crystallized pyroxenes as the liquidus phase, and as such the glass is more plagioclase-normative.

Trace Element Analysis and Conclusions: The bulk rare earth element (REE) composition of NWA 6698 is slightly above chondritic, with a pronounced positive Eu anomaly (Fig. 3). Most of the REE budget is contained in the phosphates, while the major phases are depleted in light REE relative to the bulk value. The interstitial glass is somewhat elevated with a depletion in light REE. As the plagioclase shows a LREE enrichment, this suggests that the glass is late-stage residuum complementary to surrounding plagioclase grains.

Both the bulk composition and dark glassy lithology in NWA 11575 are elevated in REE relative to chondritic values (×10) and show negative Eu anomalies (Fig. 3). Pyroxene and plagioclase are depleted relative to the bulk composition, suggesting that the majority of the REE are contained in phosphates which unfortunately were not analyzed. Based on their similar oxygen isotopes, these two rocks could possibly share a parent body and therefore be petrogenetically linked. The complementary LREE enrichment and depletion in their glasses, overall REE enrichment and depletion, and negative and positive Eu anomaly, in NWA 11575 and 6698, respectively, suggest that the two rocks could have crystallized from the same melt, with NWA 6698 representing a plagioclase-rich cumulate. NWA 11575 appears to be a rapidly-cooled rock higher in the petrogenetic sequence and evolved by fractional crystallization.

Siderophile element concentrations in NWA 6698 and 11575 are highly depleted relative to ordinary chondrites (Fig. 4). The depletion patterns suggest that metal was separated from chondritic material prior to melting, as both meteorites show greater depletions with increasing siderophile character, and concentrations are lower than in L impact melt PAT 91501 [10].

Whether this suggests local melting or large-scale volcanism and formation of an evolved crust on an LL chondrite parent body remains to be seen. However, it attests to planetesimal melting, likely during the earliest phase of solar system history, much like similar evolved material such as NWA 11119 [8].

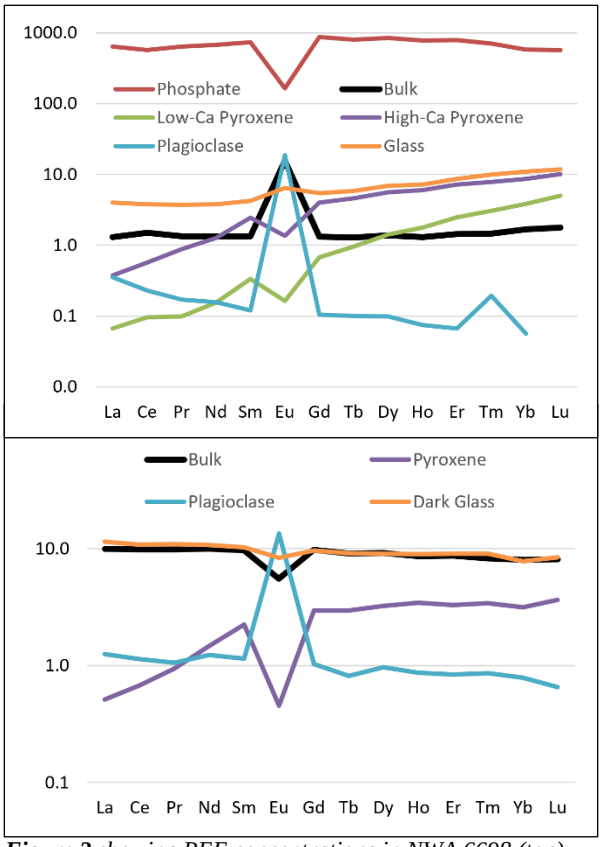

Figure 3 *showing REE concentrations in NWA 6698 (top) and 11575 (bottom) normalized to CI chondrites [9].*

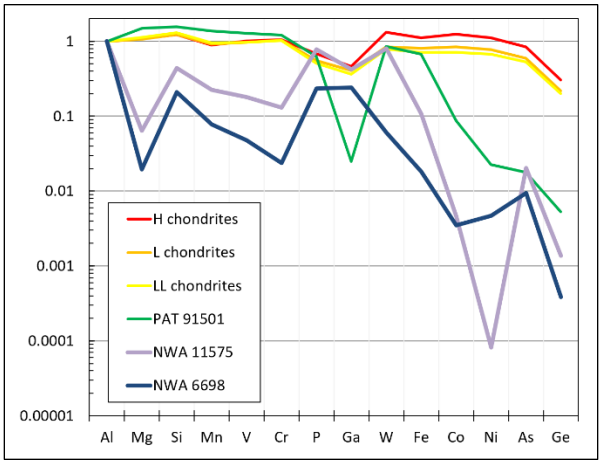

Figure 4 *showing concentrations of elements of increasing siderophile character to the right, normalized to CI chondrites and Al, for NWA 6698, 11575, ordinary chondrites, and the L impact melt PAT 91501.*

References: [1] Bunch T. E. et al. (2011) *74th Annual MetSoc* #5224. [2] Agee C. B. et al. (2018) *LPS XLIX* #2226. [3] Habermann M. A. and Agee C. B. (2018) *LPS XLIX* #2626. [4] Bischoff A. et al. (2014) *PNAS* 111-35. [5] Keil K. (2012) *Chemie der Erde* 72, 191-218. [6] Mittlefehldt D. W. (2015) *Chemie der Erde* 75, 155-183. [7] Day J. M. D. et al. (2009) *Nature* 457, 179-183. [8] Srinivasan P. et al. (2018) *Nature Comm.* 9:3036. [9] Anders and Grevesse (1989) *GCA* 53, 197-214. [10] Benedix G. K. et al. (2008) *GCA* 72, 2417-2428.