PETROLOGY AND CHEMICAL COMPOSITION OF LUNAR MARE DIABASE NORTHWEST AFRICA 12839: COMPARISONS WITH APOLLO BASALTS.

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Background: Lunar meteorites expand the available material for studying the Moon beyond what the high-resolution yet spacially limited Apollo missions collected. The additional lunar meteorite compositions however are not proportional to the compositions collected by astronauts on the lunar surface. The Apollo 11 and 17 missions provided numerous mare basalts that are classified as high-Ti (TiO_2 >6 wt%), whereas those from Apollo 12, 14, and 15 returned predominantly low-Ti basalts. Of the ~150 recognized lunar meteorites only ~16 are classified as mare basalts and 15 are classified as basalt-rich mafic breccias, and of those, none have high-Ti basalt compositions. All basaltic lunar meteorites to date have been categorized as low-Ti basalts (TiO_2 <6 wt%) however high-Ti basalt clasts have been reported in some feldspathic breccias [1]. Basaltic lunar meteorite NWA 12839 has similarities to Apollo 12 (A-12) basalts (e.g., [2]). The A-12 ilmenite basalts have a TiO_2 content that is relatively high (3-5 wt% TiO_2) and is intermediate between low- and high-Ti basalts, as they have a higher abundance of ilmenite than other low-Ti basalts [3,4,5].

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Figure 1. *Cut NWA 12839 stone (original weight 68.8 grams). Note the dark shock melt pockets*

Petrography: The specimen has a diabasic texture (mean grainsize 0.5 mm) and is composed primarily of zoned clinopyroxene and maskelynite ($An_{87.5-88.2}Or_{0.3}$). (see **Figs. 1-3)**. Accessory phases include blade-like ilmenite, very sparse zoned olivine (~3 vol.%), Cr-Ti oxides, baddeleyite, zirconolite, troilite, merrillite, silica polymorph, fayalite ($Fa_{99.2}$, FeO/MnO = 95) and hedenbergite. Dark, vesicular shock glass is present in pockets and as cross-cutting veinlets. Pyroxene compositions include subcalcic augite (core $Fs_{28.8}Wo_{26.3}$, FeO/MnO = 50; rim $Fs_{72.4}Wo_{23.6}$, FeO/MnO = 77), augite (core $Fs_{21.2}Wo_{38.7}$, FeO/MnO = 47; rim $Fs_{81.5}Wo_{17.7}$, FeO/MnO = 81) and pigeonite (core $Fs_{41.8}Wo_{12.9}$, FeO/MnO = 65; rim $Fs_{69.8}Wo_{22.4}$, FeO/MnO = 77). Olivine is zoned from more magnesian cores ($Fa_{37.6-39.5}$, FeO/MnO = 92-94) cores to more ferroan rims ($Fa_{54.1-68.2}$, FeO/MnO = 93-110).

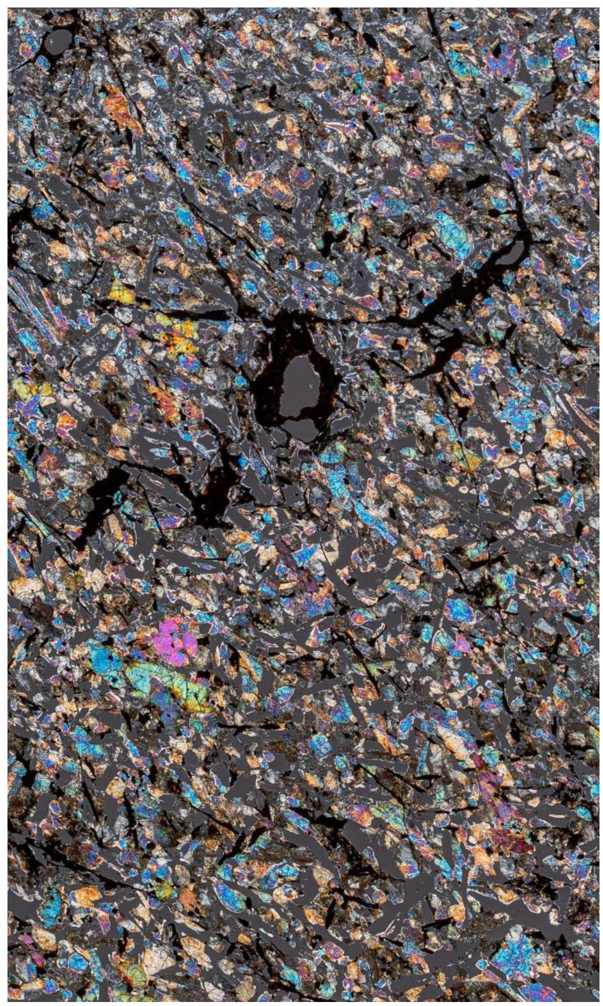

Figure 2. *Partially cross-polarized thin section image showing glassy impact melt veins and pockets.*

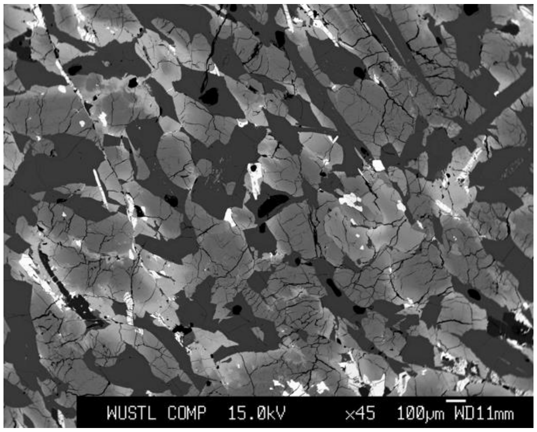

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Figure 3 *Back-scattered electron image showing zoned clinopyroxene, lath-like maskelynite (dark gray) and blade-like ilmenite (bright).*

Bulk Major and Trace Element Composition: Representative clean bulk cutting dust was analyzed for major elements by ICP-OES at the University of Puget Sound, and for trace elements by ICP-MS at the University of Notre Dame: (in wt.%) SiO_2 45.16, TiO_2 3.30, Al_2O_3 9.80, Cr_2O_3 0.34, FeO 21.99, MnO 0.29, MgO 6.82, CaO 10.80, Na_2O 1.46, K_2O 0.05, P_2O_5 0.06, SUM 100.0, ***mg*** = 0.356;. Chondrite-normalized rare earth element abundances exhibit a LREE-enriched profile (Fig. 4) .

Discussion: The mineralogy, petrography, and major element chemistry indicate NWA 12839 is a more evolved basalt than the other low-Ti basalts. This is also seen in the REE pattern, which is LREE enriched and is similar to Apollo 14 type C basalts (**Fig 4**), which formed through AFC of a KREEP/Granite-rich component [7]. NWA 12839 also plots above other low-Ti basalt samples with respect to FeO and plots with NNL meteorites with respect to TiO_2 vs FeO (**Fig 5**), which is distinct from A-14 basalts. NNL meteorites are a suite of LAP meteorites with similar compositions and are believed to be sourced from the same location. The Zr/Hf of NWA 12839 is well above chondritic and plots above the other A12 basalts, which is characteristic of high-Ti basalts [7]. Work is ongoing to define the petrogenesis of lunar basaltic meteorite NWA 12839.

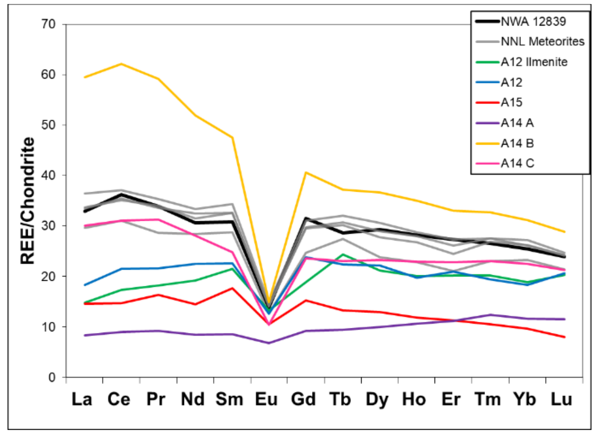

Figure 4. *Chondrite-normalized REE plot.*

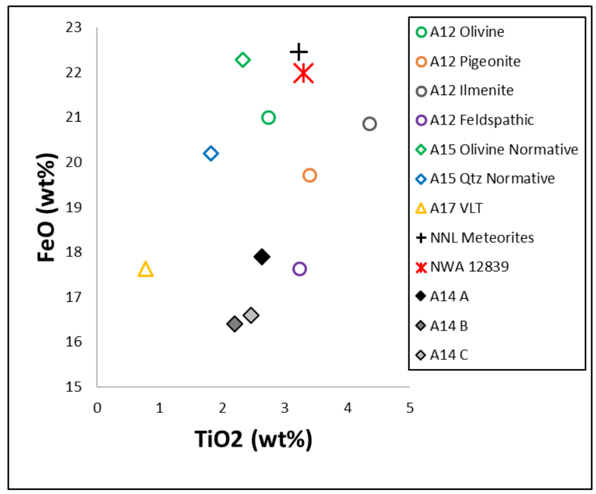

Figure 5. *FeO vs. TiO_2 plot for mare basalts.*

References: [1] Xue, Z. Et al. (2019) *GCA 266*, 74-108 [2] Neal C.R. et al. (1994) MaPS 29, 334-348. [3] James O.B. & Wright T.L. (1972) *GSA Bull*. 83, 2357-2382. [4] Snyder G.A. et al. (1997) *GCA 61*, 2731-2747. [5] Neal C.R. & Taylor L.A. (1992) *GCA 56*, 2177-2211. [6] Neal C.R. & Kramer G.Y. (20016) *Am. Miner. 91*, 1521-1535. [7] Neal, C.R. (2001) *JGR 106(E11)*, 27865-27885.