NORTHWEST AFRICA 8632 – CRYSTAL SIZE DISTRIBUTION VARIATION & POTENTIAL LINK TO NORTHWEST AFRICA 032. A.L. Fagan[1], A. Udry[2], J.P. Gannon[1], M.J. Cato[3], and the Spring 2017 WCU Petrology (GEOL 355) class[1]. [1]Geosciences and Natural Resources Dept., Western Carolina University, Cullowhee, NC 28723 (alfagan@wcu.edu), [2]Department of Geoscience University of Nevada, Las Vegas, Las Vegas, NV, 89154, [3]Dept. of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM, 87131.

Introduction: Northwest Africa (NWA) 8632 is a porphyritic lunar basaltic meteorite that is predominantly composed of large (up to ~2 mm) olivine phenocrysts, smaller (~0.05 to 0.3 mm) olivine microphenocrysts, and skeletal pyroxene in a fine-grained, glassy matrix [1, 2]. The bulk composition of NWA 8632 is similar to Northwest Africa (NWA) 032/479, as well as some Apollo 12 pigeonite basalts [1]. To better assess any potential relationships and similarities to NWA 032, we examine textural similarities here using quantitative Crystal Size Distributions (CSDs). In addition, to better understand variation in individual participants generating a CSD on a single sample, the students in the Western Carolina University (WCU) Spring 2017 Petrology (GEOL 355) class each constructed olivine and pyroxene CSDs for NWA 8632; these CSDs are compared to each other as well as to CSDs generated by an 'expert' who has constructed many prior CSDs [e.g., 3-6].

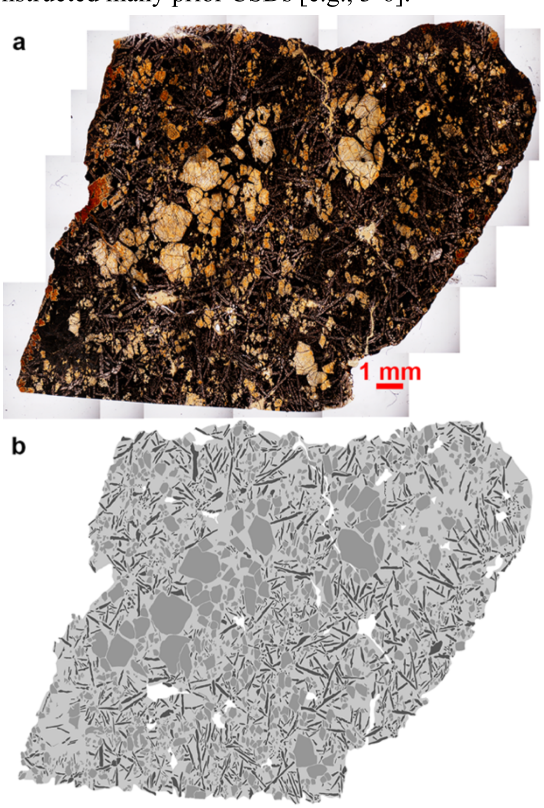

Fig. 1. (a) PPL image of NWA 8632 and (b) example shaded layers of NWA 8632 with pyroxene as dark grey, olivine as medium grey, and the full sample shaded as light grey.

CSDs quantitatively examine the texture of igneous (endogenous and impact melt [e.g., 7-8]) samples, where the shape of a CSD profile (e.g., Fig. 2 c-f) provides information of the nucleation and growth rate of a sample [e.g., 9-10]. A newer method has been developed more effectively compare CSDs of several samples at one time by examining the *slope* of a dominant portion of the CSD profile and its corresponding *intercept*, (i.e., Slope-Intercept plot [8]).

Methods: CSDs were constructed for olivine (N~1500) and pyroxene (N~2500) crystals from a thin-section of NWA 8632. Three overlain image layers were utilized: Plane-Polarized Light (PPL, e.g., Fig. 1a), Cross-Polarized Light (XPL), and a composite elemental X-ray map (R=Ca, G=Mg, B=Si). Each participant was instructed to use all of the layers to effectively follow the boundaries of the crystals.

Crystals were traced in *Adobe Photoshop* using new layers for each phase, which were then imported into a series of programs according to the method of [8]; these were used to construct the Slope-Intercept plot (Fig. 2a,b, [8]) as well as the traditional CSD profile (Fig. 2c-f) for comparison with NWA 032 (Fig. 2c, [9]). Due to the large crystal sizes of the olivine in NWA 8632, some student CSDs were unable to generate a Slope-Intercept data point because the profile either (1) contained a single data point in the stipulated size range (≤ 0.4 mm) and therefore a slope was unobtainable, or (2) the profile in the size range had a positive slope. Therefore, we also produced a *modified* Slope-Intercept plot (Fig. 2b) using all data ≤1 mm, as this best represented the dominant leg of the CSD profile. There is no protocol for producing a pyroxene slope-intercept plot [8], so we selected the dominant portion of the pyroxene CSD, (corrected crystal length ≤ 2 mm).

To better understand the variation of the CSDs between the participants, we performed a statistical analysis of the Slope-Intercept data. The distributions of slopes and intercepts for student characterizations were normally distributed according to a Shapiro-Wilk test for normality. Therefore, we used a one-sample t-test to compare the student CSDs to the 'expert' CSD.

CSD Slope-Intercept and Profile Results: The olivine CSD Slope-Intercept data are broadly similar to published data from Apollo 12 and Apollo 17 basalts [8], and show some variation from the "expert" data point (Fig. 2a,b). The *modified* slope-intercept data (grey squares, Fig. 2b) are more closely clustered than those generated using the protocol established in [8]. Using the *modified* method, a Slope-Intercept data point can be generated from each of the participants' CSDs; CSD profiles that were unable to generate such a data point using the protocol of [8] are shown in Fig. 2f. The pyroxene CSD data show a similar spread.

Variation of Student Data: The means of the student data are statistically different from the 'expert' CSD analysis according to a simple t-test (p-value < 0.05). Figs. 2a,b show the variation in student CSDs more clearly than traditional profiles (Figs. 2c-f), but also show that some student data is relatively close to the 'expert' value. Further statistical analyses will be performed on the student values closest to the 'expert' value to determine if the subset is statistically distinct. There are a variety of explanations for the data spread, such as: Difficulty in distinguishing grain boundaries between acicular and skeletal pyroxenes, proper utilization of the X-ray composite map to identify pyroxenes that were less easily seen in PPL or XPL, or how precisely and accurately each crystal was traced.

Northwest Africa 8632 versus 032: A subtle 'kink' can be seen in the olivine CSDs of both meteorites (Fig. 2c), which indicates two crystal populations (i.e., the phenocrysts and microphenocrysts) [9, 10]; the NWA 032 olivine profile has a lower overall crystal population than NWA 8632. The pyroxene CSD profiles from both meteorites are relatively linear indicating that both had a single cooling regime, but the NWA 8632 pyroxene profile has a lower overall slope than the NWA 032. Although the Slope-Intercept data for NWA 032 are not published, the slope is slightly shallower and the intercept will be lower than the 'expert' NWA 8632 CSD. Despite this, the NWA 032 Slope-Intercept data is likely generally similar to NWA 8632, suggesting that the olivine have similar crystallization histories. This, in conjunction with similarities in composition [1] and age [2, 11,12] imply that these two meteorites may represent basaltic material from a similar region on the lunar surface.

References: [1] Korotev R.L. et al. (2015) *LPSC 46*, Abstract #1195. [2] Fagan A.L. et al. (2018) *LPSC 49*, Abstract #2584. [3] Udry A. et al. (2012) *Meteoritics & Planet. Sci.*, 10, 1575–1589 [4] Balta J.B. et al. (2015) *Meteoritics & Planet. Sci.* 50, 63-85 [5] Udry A. et al. (2017) *LPSC 48 Abstract #2289 [6]* Rahib R.R. et al. (2017) *MetSoc Conf.,* Abtract #6063 [7] Fagan A.L. et al. (2013) *Geochim. Cosmochim. Acta*, **106**, 429- 445. [8] Neal C.R. et al. (2015) *Geochim. Cosmochim. Acta*, **148**, 62-80. [9] Day J.M.D. and Taylor L.A. (2007) *Met. Planet. Sci.*, **42**, 3-17. [10] Higgins M.D. (1996) *J. Volcanol. Geotherm. Res.*, **70**, 37-48. [11] Borg L.E. et al. (2009) *Geochim. Cosmochim. Acta*, **72**, 3963-3980. [12] Fernandes V.A. et al., (2003) *Meteorit. Planet. Sci.*, **38**, 555-564.

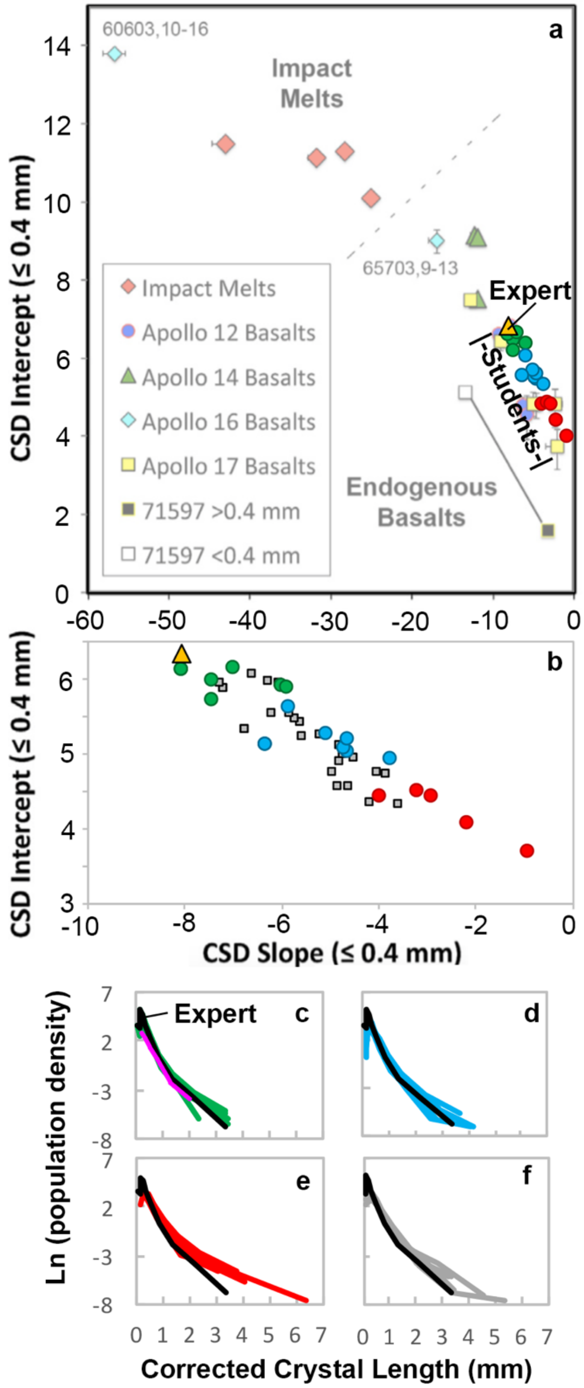

Fig. 2. (a) Slope-Intercept data for NWA 8632 olivine modified from [4] with the 'expert' analysis displayed as a yellow triangle and the student analyses displayed as colored circles corresponding to panels (c)-(f). (b) An enlarged view of the data in this study from (a) as well as the *modified* slope-intercept data (grey squares). (c)-(f) Student olivine CSD profiles for NWA 8632 compared to the 'expert' analysis (black line) and NWA 032 [9] (pink line).