CRYSTAL SIZE DISTRIBUTION OF LOW-TI LUNAR BASALT NORTHWEST AFRICA 8632.

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Introduction: Northwest Africa 8632 is a porphyritic, low-titanium mare basaltic meteorite recently discovered in Morocco; it has a reported bulk composition that is similar to Northwest Africa 032/479 and Apollo 12 pigeonite basalts [1,2]. NWA 8632 is comprised of ~23% subhedral pyroxene phenocrysts (up to 2 mm in length and 1.5 mm in width) and ~15% elongated skeletal olivine grains (up to 2 mm in length and 0.3 mm in width) with olivine microphenocrysts scattered throughout a fine-grained groundmass (Fig. 1). No plagioclase is present in this subsample, nor has been reported in other splits [1]. Patches and long veins of yellow glass are also present across the sample.

Crystal size distributions (CSDs) can be used quantitatively evaluate the texture of igneous samples. The shape of a CSD profile can illustrate the nucleation and growth rates as well as whether the magma solidified in an open or closed system [e.g., 3,4]. Most recently, CSDs have been used to distinguish between phenocrysts and xenocrysts, as well as between endogenous basalts and igneous-textured impact melts in Apollo samples [5,6]. The slope of a CSD is proportional to the crystal growth rate (G), and residence time (τ), where slope=-1/Gτ, and the calculated intercept of the initial negative slope is equivalent to the nucleation density [4]. The traditional CSD profile in coordination with the slope and intercept of the CSD have been used to distinguish between different basalt groups in Apollo samples [5,6]. Here, we use these characteristics of CSDs to identify a petrologically similar group of basalts to the NWA 8632 sample to begin to constrain its formation history.

Fig. 1. PPL photomicrograph mosaic of NWA 8632.

Methods: CSDs were constructed of olivine and pyroxene crystals from a thin section of NWA 8632. Crystals were traced in *Adobe Photoshop* from digital photomicrographs of the thin section (Fig. 1). The resulting layers were imported into *Image J*, which measured the major and minor axes, roundness, and area of each crystal. Crystals with minor axes <0.03 mm were not included in the final analysis; they are more likely to be a projection of the crystal due to the thickness of the thin section [e.g., 7,6]. The major and minor axes of the remaining crystals were imported into *CSD-slice* to determine the best-fit short, intermediate, and long axes of the 3D crystal habit [8]. This data was used in *CSDcorrections 1.39* [7, 9, 10] to determine the 3D CSD using 5 bins per decade. Finally, CSDs were plotted as the natural log of the population density against the corrected crystal size length (Fig. 2, [3,11]). The slope and the intercept of the CSD was determined using the method of [6] for olivine. Pyroxene CSDs were not examined in [6], so there is no slope-intercept comparison data for these crystals; further work will be needed in the future to generate a slope-intercept database for pyroxene.

Results: The pyroxene CSD (Fig. 2a,b) shows a subtle concave-up curve, indicating minor crystal accumulation [7]. The residence time is calculated using the dominant slope of the CSD and an average growth rate of 1.74×10^{-9} cm s^{-1} [12], which yields τ~2.9 years. The olivine CSD (Fig. 2d,e) is linear, indicating a constant cooling rate [7]. The olivine residence time is calculated using an average growth rate of 3.16×10^{-9} cm s^{-1} [13], which yields τ~5.33 years.

Discussion: The olivine and pyroxene CSD profiles were compared to those from a range of Apollo basalts [5,6,14,15]. The slope of the olivine CSD is similar to that of a number of the Apollo samples (Fig. 2d,e, [5,6]), particularly from the Apollo 12 and 17 missions. The slope/intercept ratio is most similar to a pair of Apollo 17 high-Ti basalts (75115,4 and 77516,30, Fig. 2c [6]), but the samples are petrographically distinct from the low-Ti NWA 8632. These Apollo 17 basalts display Type 1A textures [16] with phenocrysts of olivine and do not contain skeletal grains as shown in NWA 8632 (Fig. 1). These samples are also compositionally distinct with TiO_2 12.6 to 13.7 wt% [17,18] in contrast to the 2.5 wt% of NWA 8632 [1]. This indicates that it may not be appropriate to compare only crystal length for such texturally distinct samples using the slope-intercept, and that the crystal widths should be examined in addition to the crystal length [e.g., 19].

The pyroxene CSD profile has a similar shape to some high-Ti Apollo 17 basalts [16] (Fig. 2a) and Apollo 12 low-Ti basalts [17], although the corrected crystal length is smaller than some of the Apollo 12 basalts.

Summary and Further Work: The olivine and pyroxene CSDs have similar profiles to both Apollo 12 and Apollo 17 basalts indicating similar cooling histories. The slope and intercept of the olivine CSD is also similar to the Apollo 12 and 17 basalts, but distinct from those of the Apollo 14 and 16 basalts [6]. In addition, the olivine have a lower slope than the petrographically similar skeletal grains of 12008 and 12015 [5].

The CSD dataset for skeletal olivine grains is limited [5], so it is challenging to compare the olivine from NWA 8632 to other crystals. To better understand the history of skeletal olivine crystals, and NWA 8632, it would be useful to obtain more CSD profiles of basalts with similar crystals, such as 12009.

References: [1] Korotev R.L. et al. (2015) *LPSC* 46, Abstract #1195. [2] Papike J.et al., (1998) *Rev. Min.*, **36**, 7-1-7-11. [3] Cashman K. V. and Marsh B. D. (1988) *Contrib. Mineral. Petrol., 99,* 292-305. [4] Marsh B. (1998) *J. Petrol.*, **39**, 553-599. [5] Fagan A. L. et al. (2013) *Geochim. Cosmochim. Acta, 106,* 429-445. [6] Neal C. R. et al. (2015) *Geochim. Cosmochim. Acta, 148,* 62-80. [7] Higgins M. (2000) *Amer. Mineral., 85,* 1105-1116. [8] Morgan D. and Jerram D. (2006) *J. Volc. Geotherm. Res., 154,* 1-7. [9] Higgins M. (2002) *Am. Mineral.*, **87**, 171-175. [10] Higgins and Chandrasekharam (2007) *J. Petrol.*, **48**, 885-900. [11] Marsh B.D. (1988) *Contrib. Mineral. Petrol.*, **99**, 277-291. [12] Burkhard D. J. M. (2005) *Eur. J. Mineral., 17,* 675-685. [13] Borell A. and Kiline A. (2012) *Geol. Soc. Amer. An. Mtg.*, Abstract 236-3. [14] Donohue P.H. (2013) *Univ. Notre. Dame PhD Thesis*. [15] O'Sullivan K. (2012) *Univ. Notre Dame PhD Thesis*. [16] Donohue P.H. and Neal C.R. (2015) *Geochim. Cosmochim. Acta*, **149**, 115-130. [17] Warner R.D. et al. (1975) *Proc. LPSC* 6, 192-220. [18] Warner R.D. et al. (1975) *Conf. Origin Mare Basalts Implic. Lunar Evol.*, 179-183. [19] Sarabadhikari A.B. et al. (2009) *Geochim. Cosmochim. Acta*, **73**, 2190-2214.

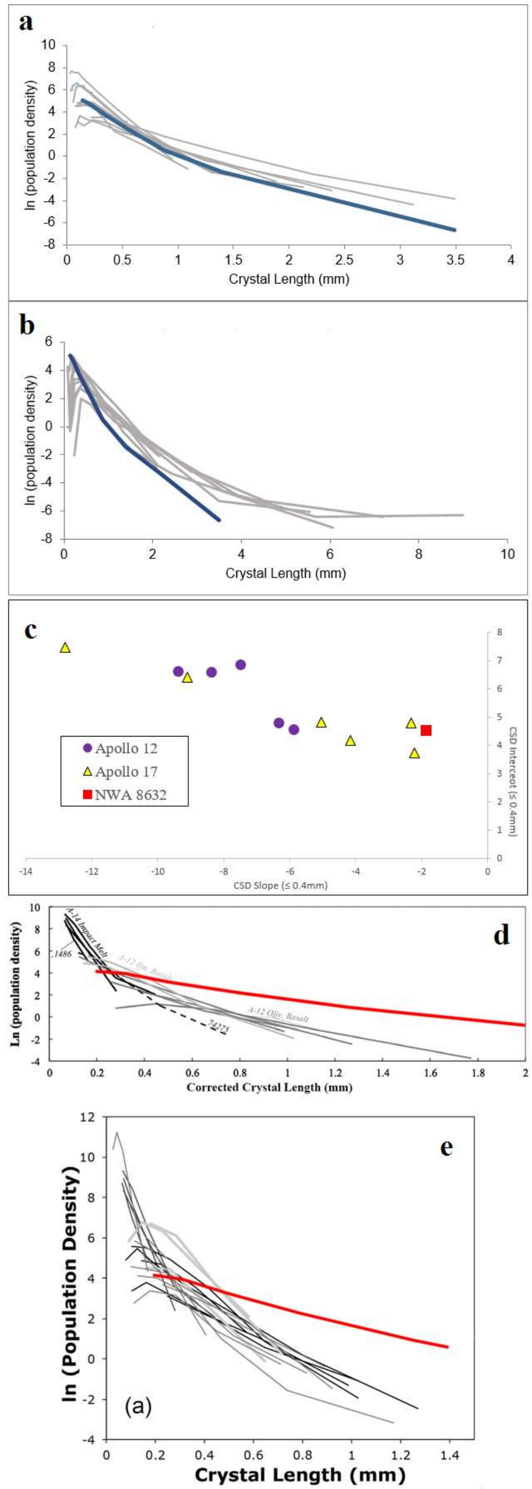

Fig. 2: Comparison of NWA 8632 to Apollo samples. Olivine: red, Pyroxene: blue. a) A-17 basalt pyroxene CSDs [14], b) A-12 basalt pyroxenes CSDs [15], c) Olivine slope/intercept of CSD comparisons [6], d) A-12 basalts and vitrophyres from A-14 (steepest slopes) [5], e) Apollo 12, 14, 16, and 17 basalts (steepest slopes A-14 vitrophyres and A-16 basalt) [5].