Clast Size Distributions for Lunar Ferroan Anorthosite 60025 Provide Possible Explanation for Age Disparities.

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Background

- Ferroan anorthosites (FANs) are a suite of plagioclase-rich rocks that are considered to be flotation cumulates from the lunar magma ocean (LMO) [1].
- FANs are thought to represent the primordial lunar crust.
- Lunar sample 60025 is a highly brecciated, chemically pristine FAN.
- Analyses of 60025 have produced 2 **distinct** Sm-Nd crystallization ages (4.44±0.02 Ga [3] and 4.367±0.011 Ga [4]).
- Clast size distributions (CSDs) are a nondestructive quantitative petrographic analysis method that can reveal the crystallization history of igneous rocks [7-9,11].
- CSDs of clasts within impact breccias have been used to distinguish shocked and unshocked populations in terrestrial samples [10].
- **Goal:** Determine if lunar FAN 60025 is of mixed lithology through CSD analysis of four thin sections.

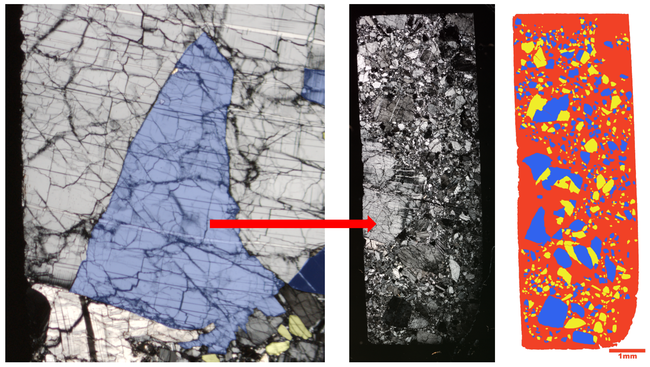

Figure 1. The clast trace highlighted in blue (left) was determined by rotating the thin section (60025,130) under XPL. This highlighted region went extinct at a different angle than the rest of the plagioclase grain, so it was traced as a separate clast. The red arrow points to the part of 60025,130 that is enlarged on the left. The trace image (right) is provided for comparison.

Methods

- CSDs are produced by tracing individual crystals on a thin section (all thin sections were imaged in cross polarized (XPL) and plane polarized light (PPL)).
- Plagioclase clasts were traced in this study, rather than crystals.
- Extinction in areas within large grains was used to identify borders between individual clasts.
- Use of extinction can be seen in **Figure 1**, where a portion of a plagioclase grain in ,130 was identified as a separate clast when rotated under the petrographic microscope.
- Traces were processed through ImageJ, CSDSlice, and CSDCorrections software packages [8,9].
- The blue and yellow coloring in **Figures 1 and 4** was used to distinguish clasts and enhance readability. They are not related to the different plagioclase populations discussed in this poster.
- **Table 1** gives the number of clasts traced for each of the four thin sections.

Results and Discussion

- The brecciated/cataclastic texture of 60025 has overprinted the original igneous texture between plagioclase grains making the original relationships between these grains unclear.
- Kinks, or abrupt changes in CSD slope, mark the intersection between distinct populations of clasts/crystals [11].
- **Figure 2** shows two kinks in 60025,21, 60025,130, and 60025,273 (three populations) as well as one kink in ,269 (two populations).
- The kinks found in these four CSDs are a result of mechanical mixing of distinct clast populations that have experienced different impact histories and potentially have different provenances.
- **Figure 3** the plot reveals three groupings of segments from the four CSDs, indicating that the segments within each group are possibly related plagioclase populations.
- The four thin sections studied here represent sampling of different areas of the whole rock of 60025.
- The disparities in ages [3,4] are either a result of error in dating methodology (unlikely), or of heterogeneity inherent within the sample itself (i.e. the sample is a mixed lithology [5,6]).

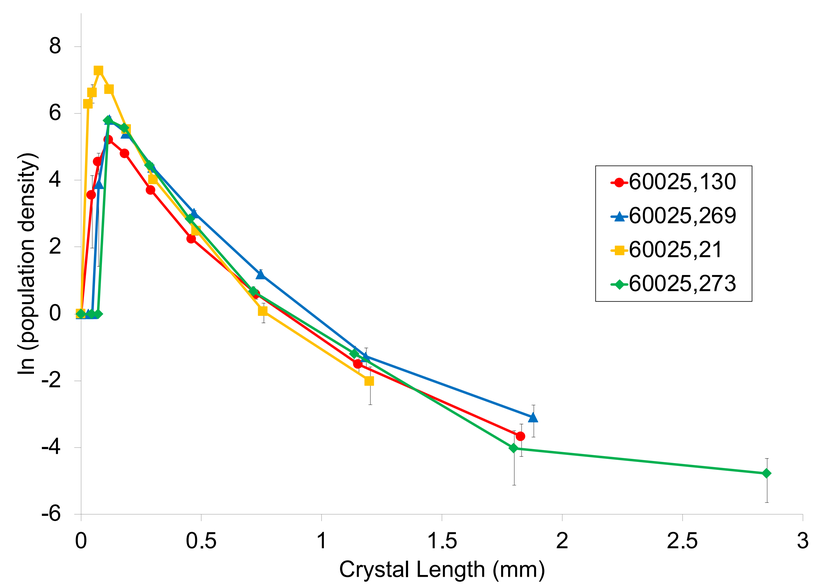

Figure 2. CSD profiles for thin sections 60025,21, 60025,130, 60025,269, and 60025,273.

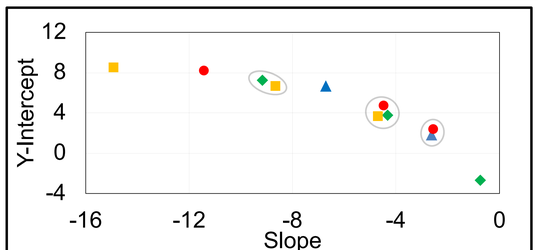

Figure 3. Slope vs. Y-Intercept plot of CSD segments (linear sections between kinks). Ellipses indicate potentially related clast populations.

60025 Thin Section	Number of Clasts Traced
,21	928
,130	730
,269	1,057
,273	1,605

Table 1. The number of clasts traced for each 60025 thin section.

Conclusions

- The results of the four CSDs indicate that lunar sample 60025 is heterogenous constituting multiple distinct clast populations.
- These multiple populations could explain the disparities in Sm-Nd ages yielded from this sample and supports the conclusion that 60025 appears to be a rock containing mixed lithologies [5,6].
- The distinct ages could be the result of sampling separate plagioclase populations (i.e. ages could depend on the specific area and clast population used in the individual studies [3,4]).

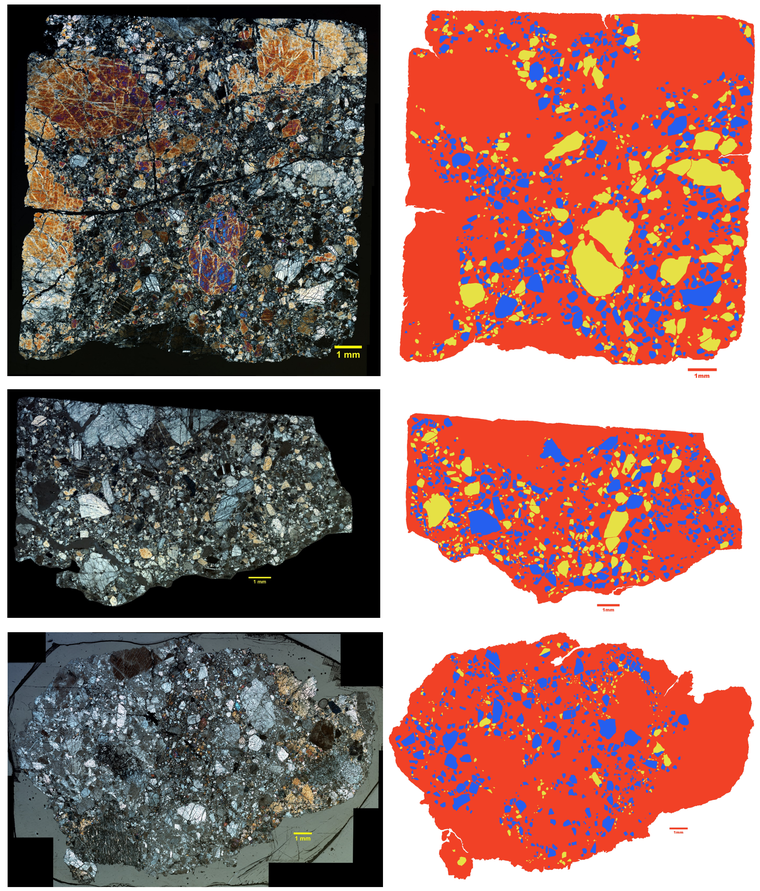

Figure 4. XPL thin sections (left) compared with trace images (right). From top, down: 60025,273, 60025,269, and 60025,21. See scale bars for size comparison. Blue/yellow colors are meant to enhance readability and do not represent different clast populations.

References

[1] Toksöz M. & Solomon S. (1973) *EMP* 7, 251-278. [2] Warren, P. (1993) *Am. Min.* 78, 360-376. [3] Carlson, R. & Lugmai, G. (1988) *EPSL* 90, 119-130. [4] Borg et al. (2011) *Nature* 477, 70. [5] James O.B. et al. (1992) PLPSC 21, 63-87. [6] Torcivia M.A. & Neal C.R. (2018) *LPSC 49*, #1331. [7] Marsh, B. D. (1988) *Cont. to Min. & Pet.* 99, 277–291. [8] Morgan D. J., & Jerram D.A. (2006) *JVGR* 154, 1-7. [9] Higgins M.D. (2000) *Am. Min.* 85, 1105-1116. [10] Pitarello L. & Koerbel C. (2013) *MaPS* 48, 1325-1338. [11] Marsh B.D. (1998) *Journal of Petrology* 39, 553-599.