

Regimes of Apollo 11 High-Ti Basalts through Quantitative Textural Analysis of Ilmenite and Plagioclase



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Goal: Study cooling regimes of different chemical groups of Apollo 11 high-Ti mare basalts by constructing ilmenite and plagioclase CSDs.

Method:

- Construct photomosaics of each thin section in plane polarized (Fig. 1), crossed polarized, and reflected light. Trace the all minerals of interest and the outline of the thin section. Save as .png files.
- Process .png files in *ImageJ* (Schneider et al., 2012) - determines major and minor axes for each crystal and the area of each crystal and that covered by the thin section (modal percent).
- Major and minor axis data exported to *CSDSlice* (Morgan & Jerram, 2006) to determine the 2D shape in 3D.
- All data exported to *CSDCorrections* (Higgins, 2000) to sort the crystals based on major axis length, plotting them in size bins based on the number of crystals present vs. the natural log of population density (e.g., Fig. 2).

Figure 2. Ilmenite (a-c) and Plagioclase (d-f) CSD profiles for all investigated samples, separated by chemical groups. Note two Group A basalts - 10069,92 and 10049,114 were not analysed with plagioclase CSDs. Errors were calculated from *CSDCorrections* (Morgan and Jerram, 2006), if error bars are not visible, they are within the size of the symbol.

Figure 1. Whole sample photomicrographs of A-11 high-Ti basalts (with group letter designation) in plane-polarized light, a to l are 10072,53 (A), 10017,12 (A), 10057,33 (A), 10049,114 (A), 10069,92 (A), 10062,45 (U), 10020,58 (B3), 10092,9 (B3), 10003,185 (B2), 10044,41 (B1), 10047,9 (B1), and 10058,253 (B1), respectively. Scale bar is 1 mm in all images.

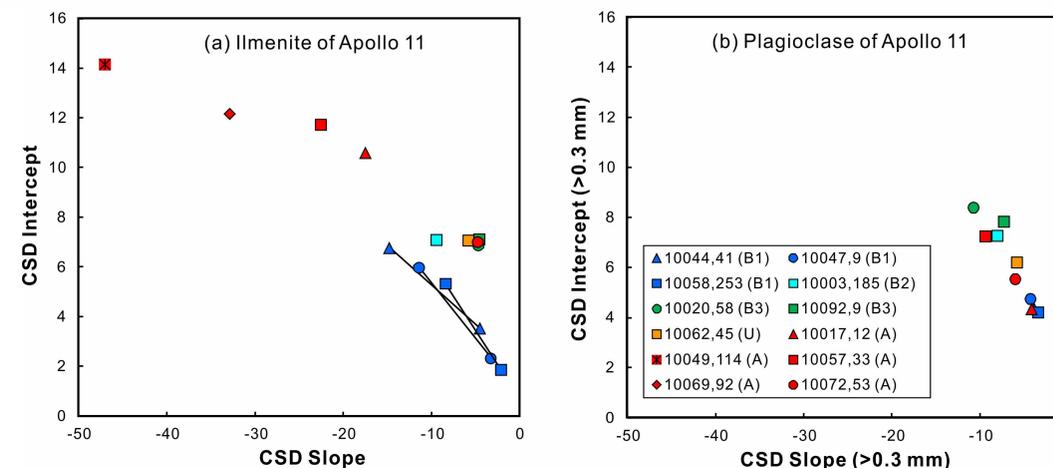
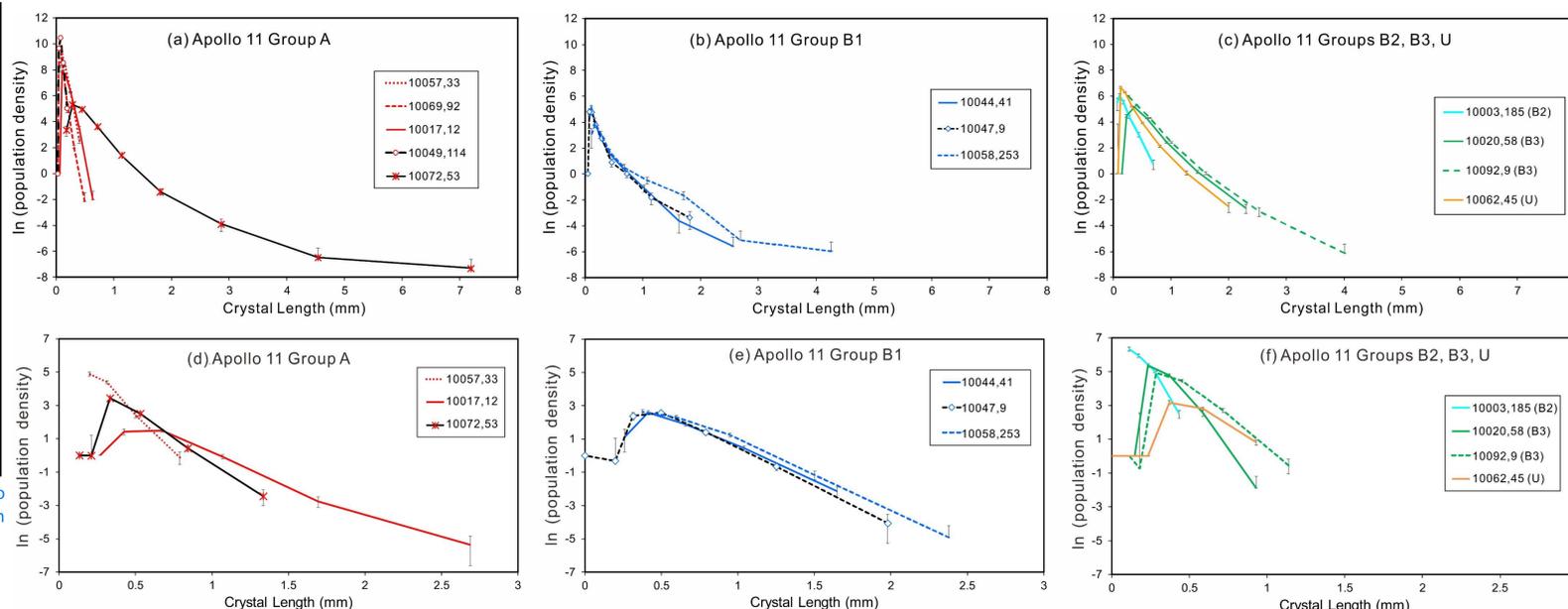
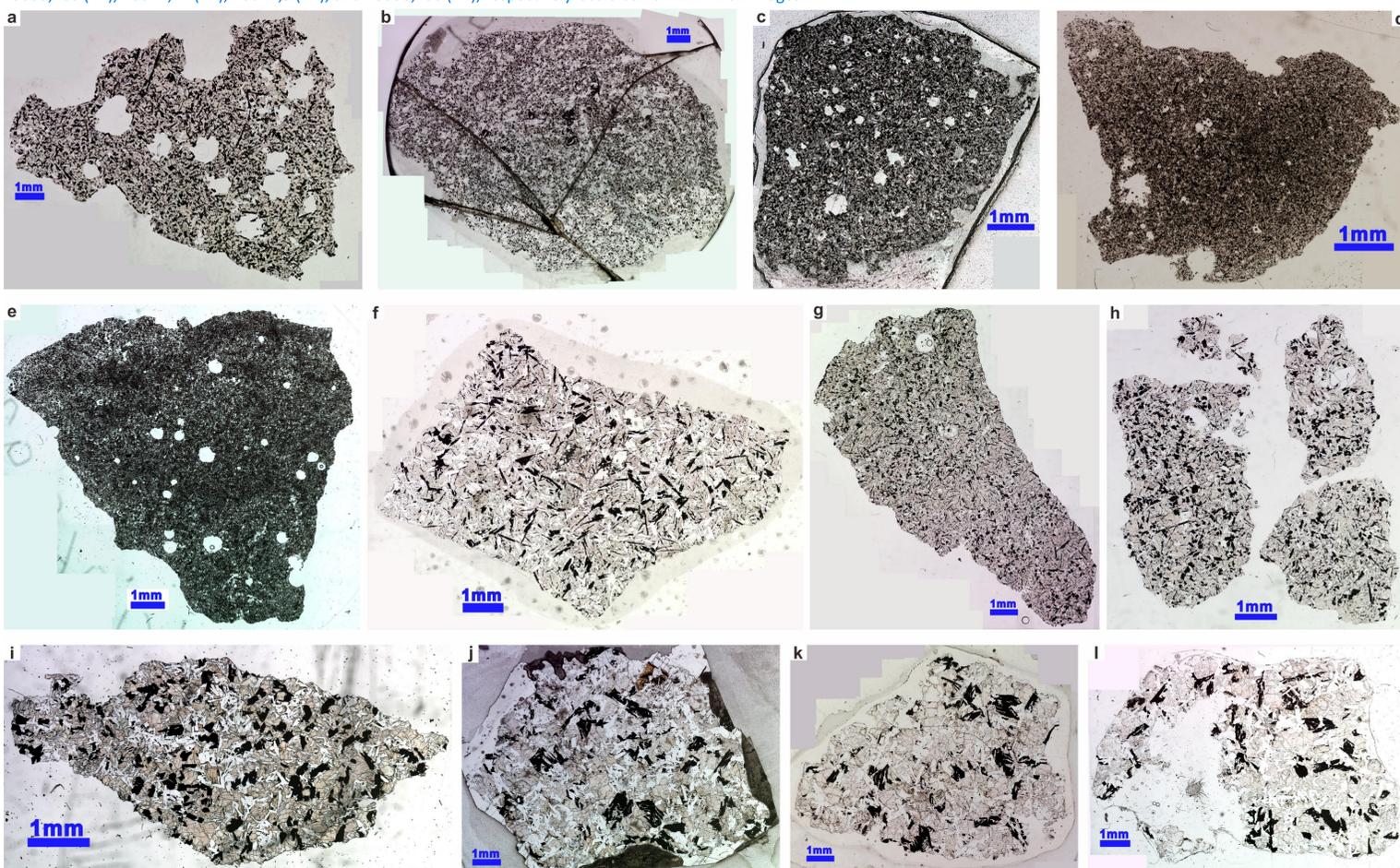


Figure 3. The slope-intercept relationship for ilmenite (a) and plagioclase (b) CSD profiles for all investigated samples. Note the same ranges of X and Y axes in (a) and (b). Each Group B1 sample has kinked ilmenite CSD and two ilmenite gradients, which are linked by line. Two Group A basalts - 10069,92 and 10049,114 were not analyzed with plagioclase CSDs.

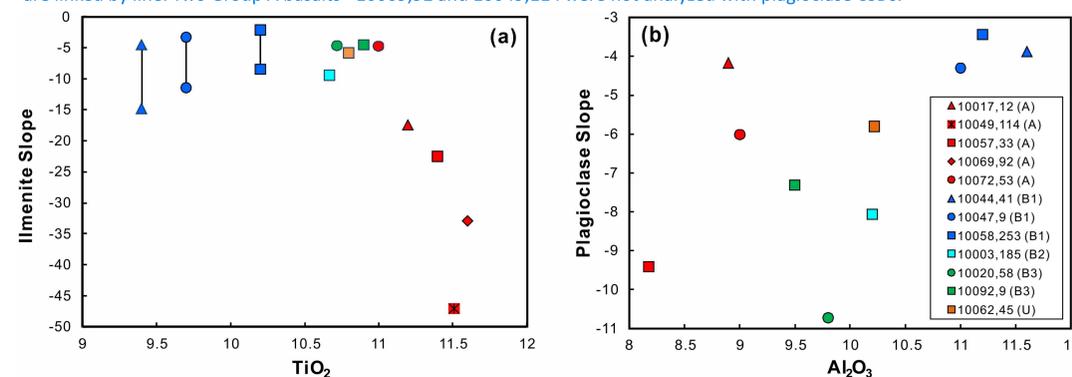


Figure 4. Ilmenite CSD slopes against bulk TiO_2 (a) and Plagioclase CSD slopes against bulk Al_2O_3 (b) for all investigated samples. Each Group B1 sample has kinked ilmenite CSD and two ilmenite gradients, which are linked by line. Two Group A basalts - 10069,92 and 10049,114 were not analyzed with plagioclase CSDs. TiO_2 and Al_2O_3 contents are average whole rock data of each sample from Mare-Basalt-Database (<https://www3.nd.edu/~cneal/Lunar-L/>).

References: Higgins M.D. (2000) *Amer. Min.*, 85, 1105-1116; Jerde E. A. (1994) *GCA*, 58, 515-527; Morgan & Jerram (2006) *JVGR* 154, 1-7; Schneider et al. (2012) *Nature Methods*, 9, 671. Welsh D. F. et al. (2018) *LPS XLIX*, #1689; Xue et al. (2019) *LPS XLX*, #2466; Donohue & Neal (2018) *Amer. Min.*, 103, 284-297; Donohue & Neal (2015) *GCA*, 149, 115-130.

Result and Discussion:

- ◆ Chemical difference is reflected in textural difference, and thus CSDs are powerful ways to distinguish among different chemical Groups of A-11 basalts.
- ◆ Group A basalts (except for the most coarse-grained 10072,53) have the fastest cooling rates among all the A-11 high-Ti samples. Group B1, on the other hand, show the slowest cooling rates.
- ◆ Two different cooling regimes (i.e. phenocrysts and matrix) are reported in Group B1, recorded by ilmenite instead of plagioclase. Groups B3, U and the most coarse-grained Group A (10072,53) show patterns of ilmenite accumulation and/or textural coarsening.
- ◆ Group U basalt 10062,45 has a similar ilmenite CSD to 10072,53 (A) and those from the Group B3 basalts.
- ◆ As the late crystallization phase in high-Ti basalts, plagioclase always show linear CSDs, indicating a single cooling regime.
- ◆ Textures and CSD slopes of minerals in A-11 high-Ti basalts are dependent on both bulk chemistry (Fig. 4) and cooling rates.