Quantitative petrography of ilmenite in lunar mare basalts

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OVERVIEW

- CSD Profiles and Cooling Rate
  - Type U
  - Type C: Sampled two regions of a single flow.
  - Type A: Two samples from different flows; Combine CSD and experimental data to
  - Type B2: At least two flows sampled; Combine with isotope data to discern whether

Creating a Crystal Size Distribution

Thin section mosaics made for transmitted, reflected, and cross-polarized light views:

70275,35 example
- Two textural regions:
  - “Fine” in yellow;
  - “Coarse” in blue.

Traced ilmenite in reflected light in Adobe Photoshop®:
- Note similar size of largest crystals.
- Fewer small ilmenites in “Coarse” region.

Measured best-fit ellipse dimensions in ImageJ:
- Length, width and area.
- Edge crystals not analyzed.

Estimated 3D crystal shape in CDSSlice:
- “Fine” area: 1:4.10, R² = 0.84.
- “Coarse” area: 1:2.39, R² = 0.74.

Generated CSDs in CSDCorrections:
- Both concave up
- Similar slope at larger size bins.
- “Fine” area has steeper slope and higher intercept at smaller size bins.

Quantified CSD to utilize slope-intercept relationships:
- Y-intercept a function of nucleation density [7].
- Slope is a function of growth rate (G) and residence time (t).
- Downturn at smallest size likely an artifact of intersection effects.

Creating a Crystal Size Distribution

CSD Profiles and Cooling Rate

- CSDs are (sub)linear (n=12) or concave up (n=15):
  - Subparallel at large crystal lengths;
  - Fanning-out pattern below ~0.6mm (inset plot).
- Much like the 70275 example, finer-grained samples have steeper profiles (and thus higher intercepts).
- Larger crystals formed at shallow depths pre-eruption or at slow cooling rates.
- Smaller crystals (groundmass phase) affected by post-eruption crystal nucleation and growth:
  - High nucleation rate raises population density.
- To investigate further, we calculate CSD profile slope and intercept for <0.6mm size bins (below).

Relative Timing of High-Ti Volcanism

- Initial-Sr [11-19] increases with decreasing slope in Types A and B2:
  - Multiple source regions produced multiple flows.
  - Two Type C basalt have same Sr, different cooling rate:
  - Single Type C flow sampled?
  - If so, samples from different locations within flow.

Conclusions

- Petrography of ilmenite is a powerful tool in reconstructing high-Ti basalt crystallization:
  - Combine CSD and experimental data to estimate cooling rate in high-Ti basalts.
  - Combine with isotope data to discern whether suites represent single or multiple flows.

- Implications for relative timing of volcanism:
  - Type A: Two samples from different flows;
  - Type B2: At least two flows sampled;
  - Type C: Sampled two regions of a single flow.

REFERENCES