Simulating Planetary Crystallization Igneous Environments (SPICEs): A Suite of Planetary Igneous Crystallization Programs

Jesse Davenport,1,2 John Longhi,3 Clive R. Neal,2,4 Diogo Bolster,4 and Bradley Jolliff5

1CRPG, Vandouvier-les-Nancy, France, 2NASA Lunar Science Institute, LPI, Houston, TX 77058, 3Lamont-Doherty Earth Observatory, Palisades, NY 10964, USA, 4CEEES, University of Notre Dame, Ntcre Dame, IN 46556, USA, 5Dept. of Earth and Planetary Sciences, Washington University, St Louis, Missouri 63130, USA (jessed@crpg.cnrs-nancy.fr; neal.1@nd.edu)

Introduction

Understanding the chemistry of magma is important for understanding how planets differentiate into crusts, rocky mantles, and metallic cores.

The Programs

- FORTRAN versions of MAGFOX/POX have been used repeatedly on lunar igneous suites.
- [5] and [6] give detailed information on the applicability of different programs on various magmas.
- MAGFOX → Rayleigh fractional crystallization; MAGFOX enters equilibrium crystallization
- 1% crystallization steps — to calculate the major element oxide evolution of liquid and mineralogy in several projections (e.g., the Ol-Pi-Wo-Si system).
- Programs can be used to derive crystallization sequences of different magmas.
- FXMOTR → combined of equilibrium and fractional crystallization in 1% crystallization steps to calculate the evolution of major and trace elements of a liquid and crystallizing mineralogy of a magma.
- BATCH runs the pressure version of MAGFOX.
- SPICEs provides a graphical interface that users with no programming experience can harness to model crystallization processes [7, Fig. 1].
- This user-friendly code, when combined with geochemical analyses, can help scientists to better understand the petrogenesis of many igneous suites [7].

Using MAGFOX to model Apollo 17 basalt crystallization

- Rhodes et al. [8] first attempted to categorize Apollo 17 high-Ti basalts into Type A, B, and C on the basis of whole-rock geochemistry.
- Type A basalts contain 50-60% higher abundances of incompatible trace elements compared to Type B basalts, although both possess similar trace element concentrations [9].
- Neal et al. [10] further divided the Type B group into Type B1 and B2 and proposed a simple petrogenetic model of closed-system fractional crystallization.
- Both [10] and [11] only modeled the evolution of trace elements. Here, we model major elements using MAGFOX and compare these results to those previously published (Table 2).

Conclusions & Future Work

- SPICEs has been used in many places: terrestrial, lunar, asteroids, etc.
- We converted source code from FORTRAN 77 into MATLAB.
- The SPICEs code allows the user to quickly calculate the crystallizing phases of a magma based on its initial composition, pressure (depth), crystallization step, and model terminus.
- The SPICEs code is a valuable tool for understanding the evolution of a number of varied magmas on a variety of planetary bodies.

Future Work

- Bug fixes/continued testing with the help of the planetary community.
- Keep the SPICEs code updated with the latest published techniques. For example, updating the methods for which MAGFOX and MAGFOX calculate partition coefficients.

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References


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http://www.lpi.usra.edu/lunar/tools/crystallizationcalculation