A COMPARISON OF NUCLEATION AND GROWTH BEHAVIOR IN EXPERIMENTAL AND LUNAR QUARTZ NORMATIVE SYSTEMS; T. L. Grove, Dept. of Earth and Space Sciences, State Univ. of New York, Stony Brook, N. Y. 11794 and G. E. Lofgren, Johnson Space Center, NASA, Houston, Texas 77058

Introduction

We report a comparison of the pyroxene nucleation and growth behavior in dynamic crystallization experiments using the iron capsule technique (1,2,3) and the wire loop technique (4). The purpose of this study is to understand the differences in nucleation and growth in the two experimental systems and to compare the experiments to the lunar samples. Hopefully, the result will be an understanding of the complex nucleation behavior in a crystallizing lunar lava flow and the manner in which our experiments relate to this process.

Experimental

The experiments are those of Grove and Bence (2) performed in Fe capsules held in evacuated sealed silica tubes and a set of dynamic crystallization experiments carried out by G. Lofgren on the same 15597 synthetic starting material using a glass bead suspended from both Pt and Fe loops in a $CO-CO_2$ gas mixture. The initial superheat and annealing time before cooling for the loop experiments are identical to those used in the iron capsule experiments (2).

Pyroxene Nucleation and Growth

The nucleation of early pyroxene phenocrysts can be compared in Fig. 1, where the data from (3) are plotted along with the results of the Pt and Fe loop experiments. The most striking difference is that the Pt loop experiments have lower nucleation densities for similar cooling rates than the Fe capsule experiments. The Fe loop experiments have higher nucleation densities than those of the Fe capsule experiments.

Pyroxene phenocryst size is compared in Fig. 2. The Fe capsule and Fe loop experiments have similar pyroxene phenocryst sizes, but the Pt loop experiments contain larger and more skeletal pyroxenes. The larger crystals in the Pt loop experiments are consistent with lower pyroxene nucleation density. For a particular cooling rate total pyroxene growth is a function of the number of nucleii present, and a lower nucleation density results in larger crystals for a given amount of pyroxene growth.

The differences in nucleation and growth behavior between the three dynamic crystallization techniques may be summarized as follows: (1) Fe capsule and Fe loop experiments result in similar pyroxene phenocryst sizes and morphologies, but nucleation density is higher in the loop experiments than the Fe capsule experiments. (2) Fewer nucleii form in the Pt loop experiments and the resulting phenocrysts grow to larger sizes, and exhibit a skeletal habit.

Comparison of Dynamic Crystallization Experiments to Lunar Samples

Pyroxene sizes and nucleation densities of Apollo 15 quartz normative basalts (QNBs) and the experiments are compared in Fig. 3 on a log-log plot. For the most part Fe capsule experiments contain smaller crystals for a given nucleation density than do the lunar samples, but the Fe loop and Fe capsule experiments bracket the variation of nucleation and growth shown by vitrophyres 15597, 15125 and 15595. Rapidly cooled (224° and 150°C/hour) Pt loop experiments also contain smaller crystals for a given nucleation density than the lunar analogs. However, the 28°C and 4°C/hour Pt loop experiments are similar in phenocryst nucleation density, growth size and in textural appearance to the vitrophyres 15486 and 15499.

No single set of experimental conditions seems to match the variation in phenocryst nucleation and growth displayed by the lunar basalts. However, the nucleation and growth of pyroxene in some QNB vitrophyres does seem to correspond to the Fe capsule and Fe loop behavior and, in some cases, the behavior

displayed in the Pt loop experiments is reproduced by the basalts. For example, Hadley Rille vitrophyres 15597, 15595 and 15596 correspond in nucleation and growth covariation and in phenocryst and groundmass textures to the Fe capsule and Fe loop experiments. The pyroxene phenocrysts in these lunar samples are euhedral and generally are single crystals. The Dune Crater vitrophyres (15485, 15486, 15499), on the other hand, show a phenocryst size variation without a nucleation density variation, and phenocrysts are skeletal, often with a complex morphology. These morphological characteristics are quite similar to those produced in the Pt loop experiments.

Lofgren et al. (5), Walker et al. (6), and Nabelek et al. (7) have shown that an increase in the initial degree of superheat before cooling results in a substantial variation in basalt texture. For the QNB experiments the degree of superheat was the same, but the nucleation process in the Pt loop experiments is different from that in the Fe loop and capsule experiments. The phenocryst textures produced in the Pt loop experiments probably correlate with a high degree of supercooling of pyroxene appearance. A smaller degree of supercooling is produced in the Fe loop and capsule experiments, and abundant nucleii were available for pyroxene phenocryst growth. Hence, the initial presence (or ease of nucleation) of pyroxene may be the controlling factor producing the differences in texture between the Dune Crater vitrophyres and Pt loop experiments and the Hadley Rille vitrophyres and the Fe loop and capsule experiments.

References

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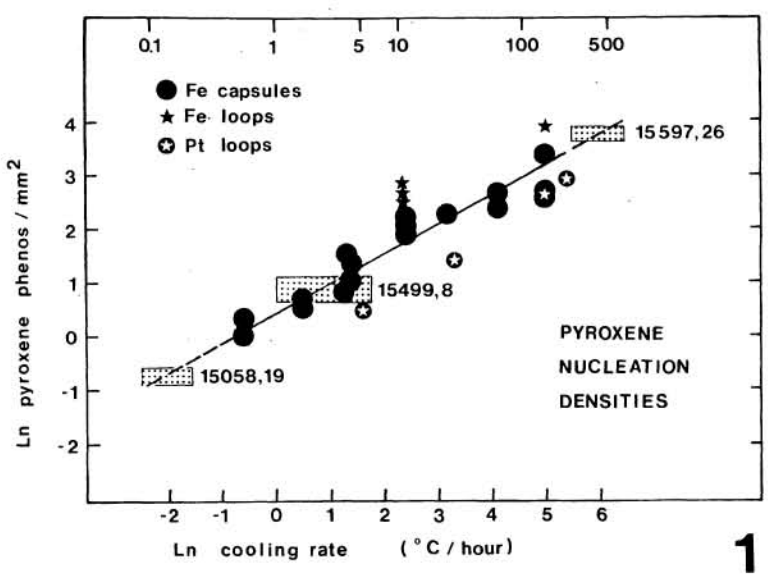

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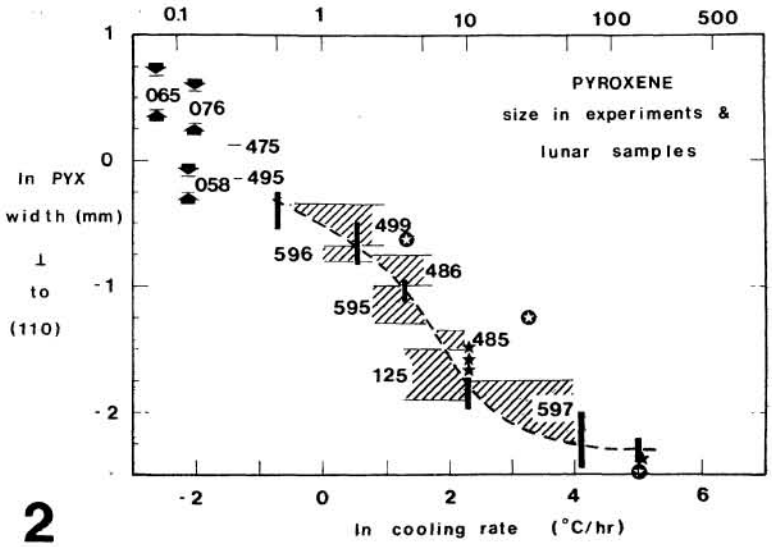

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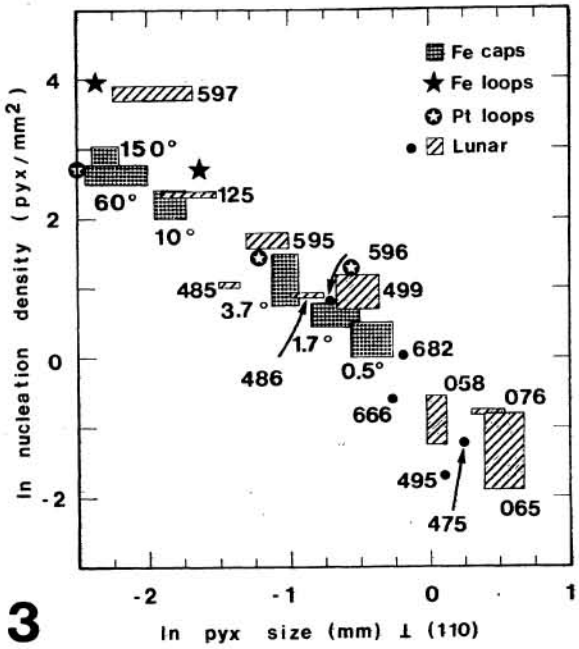

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