An experimental inquiry into grossular nucleation rate: first results

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Summary
In an effort to better understand nucleation processes in metamorphic rocks, we have begun a program to induce nucleation experimentally. We focus on grossular nucleation, and despite the experimental challenges, the initial results are promising.

Introduction
In the study of metamorphic rocks, some details of crystallization remain murky despite decades of effort and study. Nucleation in particular is poorly understood, with numerous unanswered questions: What is the relationship of nucleation rate to driving force? What is the role of temperature? At what length scale does transport of nutrients become important? What are the surface energies that control heterogeneous nucleation (nucleation onto surfaces)? Although a theoretical framework for answering some of these questions exists, it has not been tested against any geological data.

Methods
An experimental program for the study of nucleation holds promise for answering many of these questions. Experimental nucleation is problematic for a number of reasons, chief among which is the fact that nucleation is a stochastic process. A pilot project has been undertaken to experimentally model nucleation, focusing on the reaction An + Wo = Grs + Qtz from a initial assemblage An+Wo+Qtz. This reaction is simple enough to make the experiments tractable (e.g., no worries about fluid composition or oxygen fugacity), and yet retains the basic features of reactions studied by others working on crystallization kinetics: aluminous garnet is the nucleating phase and the reaction involves multiple reactants and products. In order to remove temperature as a variable, all experiments are performed at constant temperature, and nucleation is initiated by a change in pressure only (Fig. 1).

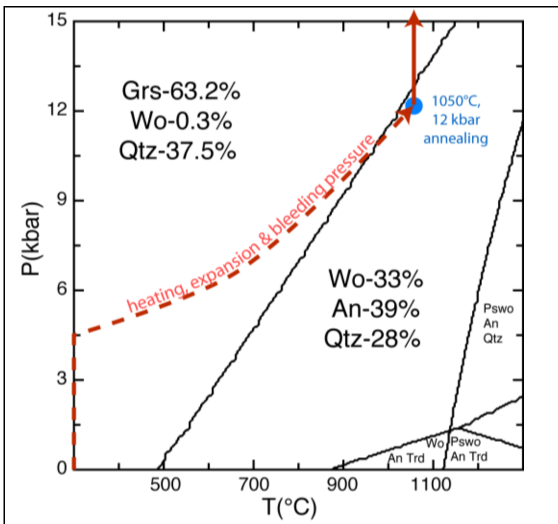

Figure 1: Pseudosection of run procedure illustrating initial annealing of glass to An+Wo+Qtz, followed by overpressuring to react An+Wo to Grs+Qtz.

Preliminary Results

The results of this pilot study suggest that nucleation rates are generally replicable from run to run, and that there is a systematic relationship between nucleation rate and driving force. Future experimental efforts will expand the data set for this reaction, quantify the relationship between temperature and nucleation rate, and explore hydrous and Fe-bearing assemblages, in an effort to more closely mirror natural systems.

Conclusions

We conclude that the conventional wisdom, which claims that nucleation kinetics cannot be studied experimentally is incorrect, and we encourage others to work on experimental studies of nucleation as well.