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Difference in the nucleation history of garnet-porphyroblasts: modelling the influence of bulk-rock composition

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For porphyroblasts to grow, at least four processes must occur: 1) breakdown of reactants, 2) nucleation of products, 3) transport of "nutrients" to growing crystals, 4) incorporation of "nutrients" in the products (growth). Models of garnet crystallization (e.g. Carlson 1989) address steps 2-4, but the first step has been examined less. In this study, a numerical model of garnet growth is developed which takes breakdown of reactants into account. The chemical compositions of garnet-bearing metapelites and metamarls from the Swiss Central Alps (garnet-zone of a Barrovian terrain) are used as input data for the model. Results of the model, notably **c**rystal **s**ize **d**istributions (CSD) are then compared with the CSD of these samples.

The model simulates garnet growth based on stable phase relations computed by the DOMINO-THERIAK software (de Capitani, 1987), a (measured, XRF) bulk rock composition, and an assumed P-T-path. Our algorithm computes crystal sizes by iterative calculation of nucleation and growth. At each P-T step the amount of precursor material, which must break down to maintain equilibrium, is considered to provide the nutrients for product formation, whether by nucleation of new particles or growth of existing ones. At each step *growth* is computed as limited by (a) a given growth rate (b) and the nutrients available. If growth in the time interval specified cannot accommodate all of the "nutrients" available, the leftovers are distributed in an assumed fluid. The *nucleation* rate is not predetermined, but is calculated dynamically by considering the "oversaturation" of garnet "nutrients" in their intergranular fluid. New nuclei are formed only if "oversaturation" exceeds a certain threshold.

Because dehydration reactions can produce high fluid/rock ratios, fluid-saturation is assumed for such systems, and surface-controlled mechanisms should dominate over

transport for porphyroblast growth. Nucleation (and growth) requires some amount of overstepping, the value of which is unknown. (It is expressed as “oversaturation” of components in the fluid in the model). To accommodate such uncertainties, our forward model has been used to test the sensitivity to assumed parameter values. Changes of two orders of magnitude have been used. Whereas absolute values change, these tests show that the general patterns of the CSD are robust, and that the volume ratio of new garnet *nuclei* relative to the volume of garnet *growth* is affected but slightly.

Compared with other parameters, the model results indicate that *bulk-rock composition* has a strong influence on the nucleation kinetics of prophyroblasts and hence the CSD patterns. Since our CSD for natural samples of different bulk composition are comparable with results from our preliminary model, this confirms that the bulk-rock composition has a major influence on garnet crystallization mechanisms. Variations in CSD depend mainly on the nucleation density. The model shows that changes in the nutrient production-rate influence the nucleation density, which in turn strongly affect the CSD. Changes in the nutrient production-rate are accomplished not only by changes in the bulk-rock composition but also by varying the P/T-path.

These results go beyond previous models, which have assumed a specific nucleation-density and interpreted the shape of CSD to be essentially a consequence of the governing growth mechanism.

Literature:

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