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ELECTRONIC ARTICLE

Three-dimensional imaging of garnet porphyroblast sizes and chemical zoning: Nucleation and growth history in the garnet zone*

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ABSTRACT

The three-dimensional (3-D) growth history of two garnet zone samples (Grt + Chl + Bt + Ms + Pl + Qtz + Ilm) from southwestern Maine was examined by serial sectioning and 3-D reconstructions of compositional zoning from backscatter images and X-ray maps.

Mn, Fe, Mg, and Ca zoning is broadly concentric. The concentration of Mn in garnet cores generally correlates with size (d = 50 to 750 micrometers), indicating progressive nucleation. In detail, all elements show irregular, patchy zoning in the cores. Assuming constancy of Mn on the rims of all garnet crystals in a rock volume plus no subsequent diffusional modification, Mn concentration can be used as a "time line" for garnet growth. Examination of the evolution of individual garnet crystals reveals that multiple nuclei formed simultaneously in the core regions and that nuclei expanded by growth in amoeba-shape forms along preexisting mineral grain boundaries (primarily quartz and plagioclase), dissolving the interior grains until the grains were either gone or encapsulated, at which time dissolution ceased. Amoeba-shaped garnet crystals coalesced as they grew and, simultaneously, new nuclei appeared in the nearby matrix. The net result was a single garnet porphyroblast that formed by the growth and coalescence of multiple nuclei.

Radius-rate plots, constructed by counting pixels in 2-D images, reveal that crystals grew at the same radial rate, regardless of size. The observation of continuous nucleation in the vicinity of preexisting crystals plus the radius-rate plots rule out diffusion over length scales on the order of the garnet radius or greater as the rate-limiting step and are consistent with either diffusion over shorter length scales or interface control as rate-limiting to garnet growth. The strong clustering of garnet nuclei requires clustering of favorable nucleation sites, which may have been caused by favorable orientation of garnet precursor minerals (i.e., chlorite + quartz).

* This article is designed to be read on a computer with internet access. The full text of the article can be obtained in pdf format at http://gmr.minsocam.org/Papers/v1/v1n1/v1n1abs.html.

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