Factors affecting porphyroblast size along a regional metamorphic field gradient

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Textural Analysis

Quantitative analysis of textures in garnet-bearing schists from the Waterville Formation of south-central Maine demonstrates that prograde differences in garnet crystal sizes and number densities cannot be simply linked to onset temperature for garnet nucleation, nor are they the result of post-crystallization annealing, as previously proposed [1, 2].

Three-dimensional sizes and locations for all garnet porphyroblasts were determined by high-resolution X-ray computed tomography for three specimens along the metamorphic field gradient, representing lowest garnet (160A), middle garnet (191A) and sillimanite grade (711A). Mean garnet radii for these specimens are 0.16, 0.08, and 0.19 (in order of increasing grade). Statistical analysis shows that the garnets in each rock crystallized in a diffusion-controlled nucleation and growth regime.

Pseudosections for Metasomatized Rocks

A Monte Carlo method for recovering original bulk compositions from metasomatized rocks allowed the creation of T-X(CO_2) pseudosections for each rock, which provides estimates of the critical temperature for garnet growth: 481, 477, and 485 °C (all ± ~10°C), suggesting that critical termperature was not a primary determinant of crystal size.

Results

Numerical simulations of thermally accelerated diffusion-controlled nucleation and growth for the three samples, which differ primarily in their heating rates, estimates of the initial density of nucleation sites and temperature dependence of the nucleation rate, closely match measured crystal size distributions.

This result supports earlier inferences [3] that post-crystallization annealing (Ostwald ripening) plays a negligible role in determining crystal size distributions; instead, variations in crystal size and crystal number density are primarily linked to variations in heating rate and nucleation kinetic parameters, with a subordinate role for the critical nucleation temperature, in contrast to earlier conclusions [2].

[1] Cashman, K. V. & Ferry, J. M. (1988) *Cont. Min. Pet.* **99**, 401-415. [2] Hirsch, D. M. & Carlson, W. D. (2001) Goldschmidt Conf. Vol. **11** abst# 3203. [3] Carlson, W. D. (1999) *Can. Mineral.* **37**, 403-413.

H/C ratios and Earth's deep volatile cycles. A role for reduced carbon?

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The H/C mass ratio of the exosphere (atmosphere, oceans, + crust) is equal to 2.1, substantially larger than in chondritic meteorites ($\leq$0.6) and dust from Haley's comet (~0.2) and larger than ratios observed from undegassed MORB and OIB (0.1-0.8), which may represent ratios of mantle source regions. Preferential extraction of C from deeper mantle by carbonatite partial melting can diminish the H/C ratio of MORB relative to their source, but the same is probably not true for OIB. Because volatile loss to space cannot raise the H/C ratio of the exosphere and sequestration of C in the core cannot explain the difference in H/C between the exosphere and the mantle, the high H/C ratio of the exosphere must either be owing to preferential mantle outgassing of H_2O relative to C during Earth history or to preferential subduction of C. If the latter, mantle carbon must be dominantly recycled. During partial melting of the mantle, oxidized carbon is less compatible than H_2O, and so partial melting should produce mantle residues with large H/C ratios and create an exosphere with small H/C. However, reduced carbon behaves more compatibly than H_2O and is increasingly compatible with diminishing oxygen fugacity. In this talk I will present thermodynamic calculations to explore the hypothesis that reduced carbon may have been retained preferentially in the mantle, perhaps owing to diamond precipitation during magma ocean solidification.