CAUSES OF VARIATION IN PORPHYROBLASTIC TEXTURES ALONG A REGIONAL METAMORPHIC FIELD GRADIENT. D. M. Hirsch¹ and W. D. Carlson², ¹Dept. of Geological Sciences, Univ. of Texas at Austin, Austin, TX 78712, dhirsch@mail.utexas.edu, ²Dept. of Geological Sciences, Univ. of Texas at Austin, Austin, TX 78712, wcarlson@mail.utexas.edu.

Quantitative analysis of textures in garnet-bearing schists from the Waterville Formation of south-central Maine¹ demonstrates that prograde differences in garnet crystal sizes and number densities are principally the consequence of different nucleation temperatures, rather than the result of post-crystallization annealing.

Three-dimensional sizes and locations for all garnet porphyroblasts were determined by ultra-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 (Fig. 1) shows that the garnets in each rock crystallized in a diffusion-controlled nucleation and growth regime. Comparison of crystal size distributions to previous data², obtained for the same samples using stereological methods, reveals significant differences in mode, mean, and shape of the distributions.

Garnet-biotite Fe-Mg exchange thermometry provides peak temperatures of 480, 515, and 650°C (all ± ~35°C); these values, combined with published pressure estimates, were used to constrain pressure-temperature paths in numerical simulations of garnet crystallization in these samples (Fig. 2). Numerical simulations of thermally accelerated diffusion-controlled nucleation and growth for the three samples, which differ only in their estimates of the initial density of nucleation sites and their estimates of the temperatures at the onset of nucleation, closely match measured crystal size distributions.

This result supports earlier inferences³ that post-crystallization annealing (Ostwald ripening) plays a negligible role in determining crystal size distributions; instead, an increase in crystal size and decrease in crystal number density are direct consequences of increasing nucleation temperature, either as a result of lower spessartine content of garnet, or along a metamorphic field gradient.

This study confirms previous hypotheses⁴ linking the ultimate crystal size distribution for garnet porphyroblasts to the temperature at which garnet begins to crystallize. Because nucleation is a function of the thermal overstepping whereas diffusion is a direct function of temperature, variation in the temperature of the garnet-forming reaction leads to an increase in porphyroblast size with metamorphic grade.

Acknowledgement: We note with gratitude that specimens for this study were graciously provided by Prof. John Ferry of Johns Hopkins University.