

## **ASSESSING DEPARTURES FROM EQUILIBRIUM IN PROGRADE METAMORPHISM: THE KINETICS OF PORPHYROBLAST GROWTH IN THE BUSHVELD AUREOLE.**

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Although petrologists now have the tools to predict the equilibrium behaviour of many metamorphic systems, reaction processes take place away from equilibrium, and the extent of disequilibrium in prograde metamorphism is not well understood. This study uses a variety of microstructural observations, combined with numerical modelling, to quantify departures from equilibrium in hornblende-hornfels facies metapelites from the Bushveld aureole, South Africa. Modelling the interplay of kinetic rate laws for nucleation, interface- or diffusion-controlled crystal growth, and heat supply, suggests that the crystal size distribution (CSD) of a porphyroblastic index mineral is sensitive to three principal factors: the critical overstep at which nucleation begins, the rate constant for the limiting crystal growth mechanism, and the rate of heat supply. Thus, for a given mineral species and reaction process the CSD should be largely a function of heating rate. We measure the slope of the CSD in the larger size fractions, representing the acceleration of the nucleation rate in the earlier-formed crystals. This parameter shows a systematic variation with distance from the igneous contact, for both andalusite and garnet. Supplying values for heating rate (from conductive thermal modelling) and for crystal growth rate (from experimental studies) leads to the suggestion that the critical overstep for nucleation of andalusite is around 5 K. A closer investigation of the andalusite-forming reaction, comparing microstructural evidence with calculated equilibrium phase diagrams, further indicates that overstepping and chemical fractionation effects are of critical importance in determining the reaction sequence.