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Equilibrium and kinetics in metamorphism of pelites in the Nelson aureole, British Columbia

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The distribution of metapelitic mineral assemblages in the Nelson aureole, British Columbia, generally conforms to what is predicted from phase equilibria. However, in detail, the mineral textures, mineral compositions and zoning, and sequence and spacing of isograds do not. Two of the main disequilibrium features in the aureole are: (1) delay in the onset and progress of several reactions, ie, thermal overstepping; and (2) unreactivity of staurolite and especially garnet porphyroblasts when they are reactants in higher grade reactions. The thermal overstepping is ascribed primarily to difficulty of nucleation of the product porphyroblasts and sluggishness of dissolution of reactant porphyroblasts required for product mineral growth. The extent to which these barriers to nucleation and growth delay the onset of reaction is related to the reaction affinity of each reaction, which for thermally activated reactions is, in turn, related to the entropy change of the reaction. For a given overstep in temperature, reactions that release large quatities of H2O, such as chlorite-consuming reactions, have a high reaction affinity compared to those which release little or no H2O, such as the chlorite-free staurolite-consuming reaction. Thermal overstepping is consequently expected to be less for the former than for the latter, as was observed in the aureole where ca. 30 °C overstepping was required for garnet growth from a muscovite+chlorite-bearing precursor and ca. 70 °C overstepping was required for growth of Al2SiO5 from a staurolite-bearing, chlorite-free precursor. In all cases reaction progress was strongly influenced by presence or absence of fluid, with fluid presence dramatically lowering kinetic barriers to nucleation and growth, and therefore thermal overstepping. Textural features of rocks from the nearly coincident garnet, staurolite and andalusite isograds are suggestive of a fluid-catalyzed ‘cascade effect’ in which reaction took place rapidly and several competing muscovite+chlorite-consuming reactions, some metastable, appear to have occurred in parallel. Metamorphic reaction, fluid release and possibly fluid presence in general in the aureole was episodic rather than continuous, and in several cases well removed from equilibrium conditions. The extent to which these findings apply to regional metamorphism depends on several factors, a major one being deformation, which is expected to lower kinetic barriers to nucleation and growth.