Thermodynamic Modeling and Geochemical Evidence for rapid neo-Acadian metamorphism in the Smith River Allochthon of southern Virginia

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Metamorphic rocks can encode a complex record of the physical conditions of their formation and can thus reveal the timing and duration of a variety of tectonic processes. This typically rests on the assumption that metamorphic rocks accurately record successive phases of chemical equilibrium, and that evidence for departures from equilibrium can be identified when experienced. Here, we utilize both equilibrium and disequilibrium features preserved at the thin section scale in metapelites to constrain a portion of the tectonic history of the Smith River Allochthon (SRA) in the southern Appalachians.

We interpret garnet porpyhroblasts in the metapelites as recording at least 3 stages of growth. Crystal cores (Grt 1) are partly inherited from Taconic regional metamorphism (*ca*. 460 Ma) and also record a granulite facies event associated with intrusion of the Rich Acres gabbro at 430 Ma. Peak *P-T* estimates for contact metamorphism of 850˚C and 0.5 GPa are constrained by Fe-Ti oxide thermometry on spinel inclusions in Grt1. Textural and chemical evidence suggests that Grt1 experienced a period of resorption following this thermal peak, consistent with reaction with melt that was retained in the the system during cooling. Some samples preserve a high-Ca garnet rim (Grt 2), itself partly overgrown by staurolite, that is preferentially developed on portions of garnet crystals within biotite-rich domains. The heterogeneous distribution of Grt2 highlights the role of melt loss and local refertilization at the hand sample scale, and limited length-scales of equilibrium at the grain scale.

Thermodynamic modeling of samples with Grt2 is consisent with a clockwise *P-T* path with peak conditions of 600˚C and 0.7 GPa. Retention of sharp chemical boundaries between Grt1 and Grt2 domains suggests that this *P-T* path occured rapidly enough to inhibit substantial diffusive equilibration. Major element diffusion modeling in garnet constrains the timescale near peak *T* to be less than 1 Ma.

The tectonic setting and absolute timing for this last metamorphic cycle are yet to be fully constrained, but may be related to the *ca.* 350 Ma neo-Acadian orogeny in the Southern Appalachians.

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