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Constraining the timing and character of crustal melting in the Adirondack Mountains using multi-scale compositional mapping and in-situ monazite geochronology

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ABSTRACT

Migmatites are common in the hinterland of orogenic belts. The timing and mechanism (in situ vs. external, *P*-*T* conditions, reactions, etc.) of melting are important for understanding crustal rheology, tectonic history, and orogenic processes. The Adirondack Highlands has been used as an analog for mid/deep crustal continental collisional tectonism. Migmatites are abundant, and previous workers have interpreted melting during several different events, but questions remain about the timing, tectonic setting, and even the number of melting events. We use multiscale compositional mapping combined with in situ geochronology and geochemistry of monazite to constrain the nature, timing, and character of melting reaction(s) in one locality from the eastern Adirondack Highlands. Three gray migmatitic gneisses, studied here, come from close proximity and are very similar in microscopic and macroscopic (outcrop) appearance. Each of the rocks is interpreted to have undergone biotite dehydration melting (i.e., Bt + Pl + Als + Qz = Grt + Kfs + melt). Full-section compositional maps show the location of reactants and products of the melting reaction, especially prograde and retrograde biotite, peritectic K-feldspar, and leucosome, in addition to all monazite and zircon in context. In addition, the maps provide constraints on kinematics during melting and a context for interpretation of accessory phase composition and geochronology. More so than zircon, monazite serves as a monitor of melting and melt loss. The growth of garnet during melting leaves monazite depleted in Y and HREEs while melt loss from the system leaves monazite depleted in U. Results show that in all three localities, partial melting occurred during at ca. 1160–1150 Ma (Shawinigan orogeny), but the samples show high variability in the location and degree of removal of the melt phase, from near complete to segregated into layers to dispersed. All three localities experienced a second high-*T* event at ca. 1050 Ma, but only the third (non-segregated) sample experienced further melting. Thus, in addition to bulk composition, the fertility for melting is an important function of the previous history and the degree of mobility of earlier melt and fluids. Monazite is also a sensitive monitor of retrogression; garnet breakdown leads to increased Y and HREE in monazite. Results here suggest that all three samples remained at depth between the two melting events but were rapidly exhumed after the second event.

Keywords: Monazite petrochronology, migmatite, polymetamorphism, Adirondack Highlands