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An alternate mechanism for the production of garnet zoning: a case study from the contact aureole of the Western Adamello Tonalite

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The metamorphic rock record preserves primary evidence for the conditions (pressure {P}, temperature {T}, composition {x}, and timing {t}) and rates of geological processes occurring during geodynamic processes such as orogenic cycles. Garnet is an important metamorphic mineral in this regard as it can record both the equilibrium conditions (P, T, x, and t) and non-equilibrium processes in compositional zoning. Correct geological interpretation of garnet compositional zoning, however, relies on recognizing correctly the mechanisms responsible for producing the zonation. Two generations of garnet are observed in the Western Adamello Tonalite contact aureole, northern Italy. The first, Variscan metamorphic generation of garnet predates the intrusion while the second is associated with Tertiary contact metamorphism. We show how the second generation of garnet forms via partial replacement of the first generation of garnet through dissolution-reprecipitation. An important observation here is that samples that experienced similar thermal histories but have different bulk rock compositions exhibit different replacement front characteristics and different length-scales of compositional zoning associated with replacement. While compositional zoning profiles in each sample individually could be mistaken for diffusional relaxation of an initially sharp epitaxial overgrowth, strongly contrasting timescales produced by multicomponent diffusion modelling for each of the samples illustrates that this is not the case. Differences in compositional zoning are instead attributed to the effects of host rock and/or fluid composition during dissolution-reprecipitation. This suggests that replacement fronts in garnet may preserve information on the composition of metamorphic fluids. Further, we argue that this is a common process in metamorphic rocks and so the recognition of the characteristic textures of this process are important for accurate inversion of timescales of metamorphic processes from compositional profiles in garnet.