American Mineralogist, Volume 96, pages 1354–1362, 2011

Garnet sector and oscillatory zoning linked with changes in crystal morphology during rapid growth, North Cascades, Washington

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Abstract

Metamorphic garnet with sector zoning in the cores and oscillatory zoning in the rims grew during rapid heating of pelitic rocks in the Chiwaukum Schist. These types of compositional zoning are exemplified by sharp, but low amplitude, boundaries between broad petal-shaped sectors and between narrow concentric zones, respectively. Zoning is most obvious in calcium, which is inversely correlated with iron and magnesium content. Garnet habit inferred from the oscillatory calcium zoning and external morphology indicates a growth transition from early crystal forms with both trapezohedral and dodecahedral forms to later crystal forms dominated by trapezohedral faces. This transition is accompanied by changes in compositional sector zoning and may reflect the roles of local growth dynamics and external forcing mechanisms affecting growth of garnet. Subsequent modification of these textures produced patchy zoning in calcium. Electron backscatter diffraction confirms the inferred crystal growth habits and that compositional zoning occurs within single garnet crystals.

Exchange thermobarometry and the peak mineral assemblages indicate that metamorphic conditions reached 640–670 °C at 6.9 kbar. These temperatures are sufficient to allow significant volume diffusion; therefore, preservation of the finely banded compositional zoning in garnet requires rapid heating and cooling. Garnet Sm-Nd ages and indistinguishable zircon U-Pb ages from adjacent orthogneiss bodies confirm that garnet grew rapidly during localized and short-lived heating adjacent to sill-like intrusions of tonalite.

Keywords: Garnet, sector zoning, oscillatory zoning, crystal morphology, rapid growth