Partial disequilibrium within the garnet core of upper amphibolite facies rocks: limitations on the use of combined ion-exchange and net-transfer reaction thermobarometry

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The possibility of partial disequilibrium within the garnet core is examined, wherein Mg, Fe and Mn have homogenized at the thermal peak of metamorphism, while Ca preserves the earlier prograde growth zonation. Several authors (Loomis et al. 1985; Chakraborty and Ganguly 1991; Schwandt et al. 1996) have noted that diffusion of Ca in garnet is slower than diffusion of Mg, Fe and Mn. Given that diffusion is an exponential function of temperature, the length-scale of diffusional equilibration is strongly temperature dependent. As a result, there should exist a range of temperatures for a given period of time at which Mn, Fe and Mg have diffusionally homogenized within the garnet core, while Ca has not, resulting in partial disequilibrium. Zoning profiles of Fe, Mg, Mn and Ca across garnet porphyroblasts from within the sillimanite + K-feldspar zone of the Wolverine Metamorphic Complex in British Columbia, and calculations of the characteristic length scale of diffusion for each of these elements within garnet, suggests that due to its more sluggish diffusivity, Ca, unlike Fe, Mg and Mn, was unable to diffusionally homogenize into the core of garnet at the thermal peak. Variations in the flux of these elements during intragrain diffusion produces partial disequilibrium of Fe, Mg and Mn with Ca within the garnet core, and precludes the use of combined Fe-Mg exchange thermometry with Ca-bearing net-transfer reaction barometry for an estimate of peak P-T conditions. The problem is avoided at lower and higher grades, where diffusion is sufficiently slow and fast, respectively, such that growth zoning is preserved or entirely obliterated with respect to all elements.

References

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