

Geothermometry of Mn-Fe Exchange Between Garnet and Ilmenite Inclusions In Pelitic Rocks

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Estimating the temperature at which garnet starts to grow in pelitic rocks is an ongoing problem. Recent experimental studies and additions to thermodynamic databases suggest the possibility of using Mn-Fe exchange between garnet and ilmenite inclusions to estimate these temperatures (Feenstra and Engi 1998; Berman 2007). The exchange equilibrium is, $1/3 \text{ almandine} + \text{pyrophanite} = 1/3 \text{ spessartine} + \text{ilmenite}$ ($1/3 \text{ Fe}_3\text{Al}_2\text{Si}_3\text{O}_{12} + \text{MnTiO}_3 = 1/3 \text{ Mn}_3\text{Al}_2\text{Si}_3\text{O}_{12} + \text{FeTiO}_3$). Late Precambrian pelitic rocks in southeastern British Columbia are used in the present study. Garnet and staurolite zone garnets typically have bell-shaped zoning patterns for Mn. Ilmenite inclusions in these garnets were chosen for study. The working hypothesis is that at these temperatures the composition of these minerals will be little disturbed by diffusion. Available data suggest that garnet is the slower diffusing phase for Mn-Fe and that the closure temperature for diffusion will be $\approx 600^\circ\text{C}$. Thermodynamic data indicate that Mn-Fe exchange between garnet and ilmenite is not very sensitive to pressure ($\Delta V \approx 0.025 \text{ J/bar}$). Temperatures are commonly in the range $500\text{-}550^\circ\text{C}$. There is no significant difference between garnet zone and staurolite zone samples. Using ilmenite crystals in the matrix yield a wide range of temperatures suggesting non-equilibrium. Ilmenite crystals included in apparently homogenized garnet also yield a wide variety of temperatures. Another method of estimating these temperatures is the application of isochemical phase diagram P-T sections (pseudosections). Using garnet in at pressures of 7-8 kbar for three samples suggest temperatures in the $500\text{-}550^\circ\text{C}$ range. These results suggest that garnet in the garnet and staurolite zones in this area begin to grow at similar temperatures. Mn-Fe exchange between garnet and ilmenite inclusions in garnet amphibolites will be the subject of a future study.

References

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