Upwelling of the SE Australian lithosphere: Thermo-tectonic evolution of garnet pyroxenite xenoliths from Western Victoria

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Garnet exsolution in clinopyroxene megacrysts in basalts can be used to reconstruct the thermal history of the lithosphere. Multiple stages of exsolution and recrystallization have been preserved in garnet pyroxenite xenoliths in Cenozoic basalts from western Victoria, and provide new insights into the evolution of the active continental lithosphere of SE Australia. The exsolved and equilibrated assemblages include dominant clinopyroxene, garnet, orthopyroxene and spinel ± ilmenite ± plagioclase, suggesting that the xenoliths originally were clinopyroxene-dominated cumulates with minor associated garnet, orthopyroxene or spinel.

Geothermobarometry of the exsolved, host and reconstructed original mineral assemblages suggests that the garnet pyroxenites first crystallized at 1300-1500 °C and pressures of 16-30 kb. They then underwent extensive exsolution, recrystallization and reaction during cooling and finally stabilized at ~950-1094 °C and 12-18 kb before entrainment in the basalts. Variation of REE contents in the garnets and their equilibrium clinopyroxene preserves evidence of an intermediate stage (1032°C and 21 kb). This process implies that the protoliths of the garnet pyroxenites crystallized from basaltic magmas over a range of depths of ~50-100 km; during or shortly after cooling, they were tectonically emplaced to higher levels, close to the crust-mantle transition zone (~40-60 km; i.e. an uplift of at least 10~20 km). This uplift is reflected in aspects of the crustal history of the region, and may have been connected with lithosphere-scale thrusting or rifting-extension.