Exsolution in orthopyroxene in the Archaean lithospheric mantle

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Archean cratons are underlain by extraordinarily thick, cold lithospheric mantle which extends to depths of 150-200km. The sub-cratonic lithospheric mantle is the residue of very high degree melting, which resulted in extreme depletion. The conditions under which melting took place continue to be debated, with proposed settings ranging from low pressure ocean ridges or arcs followed by thickening, to high pressure in a very hot plume. These scenarios make different predictions about the prevailing direction of movement of material within the evolving Archaean lithosphere.

Xenolithic minerals containing exsolution lamellae are known from the Kaapvaal and Siberian cratonic lithosphere. Such samples provide an opportunity to constrain, not only the conditions of subsolidus equilibration within the modern lithosphere, but also the formation conditions of the precursor phase. Recent work has focused on the compositions of enstatite containing exsolved lamellae of garnet. In addition, exsolution lamellae of spinel ± clinopyroxene are almost ubiquitous in bronzititic orthopyroxene. Here, we present geochemical data for exsolved orthopyroxenes that equilibrated across a broad range of pressures within the Kaapvaal cratonic lithosphere.

There is no major difference in the composition of pyroxene reconstructed from exsolved enstatite-garnet and bronzite-spinel. Both have humped REE patterns with a peak in the region of Ce. Thus, humped REE patterns are not limited to the garnet facies and extend well into the spinel stability field.

The exsolved orthopyroxenes last equilibrated at depths of 1-2GPa (spinel) and 3-5 GPa (garnet). Of greater interest is the formation conditions of the precursor pyroxenes which formed on the peridotite solidus during melting. The higher Al-contents of the reconstructed precursor pyroxenes indicate that they formed at significantly higher pressures than the conditions at which they equilibrated. This finding supports models of cratonic lithosphere formation during mantle upwelling.