ECLOGITE AND PERIDOTITE XENOLITHS FROM KAALVALLEI, KAAPVAAL CRATON: IMPLICATIONS FOR THE FORMATION OF SUBCONTINENTAL LITHOSPHERE

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The Kaalvallei kimberlite (Kaapvaal Craton) contains abundant eclogitic and lherzolitic mantle xenoliths. Garnet-lherzolites equilibrated at 35 - 75 kbar and follow a 40 mW/m^2 geotherm. They can be divided into three discrete groups: a high-temperature relatively fertile group (FP), an intermediate temperature depleted group (DP), and a low-temperature ultra-depleted group (UDP) that also contains spinel. A similar division can be made for the eclogites, in which fertile (FE) and depleted eclogites (DE) correspond to Group I and Group II eclogites, respectively. As both eclogites and peridotites show similar depletion trends with depth, the mantle sampled by the Kaalvallei kimberlite appears to be layered. The mantle down to 140 km is ultradepleted, depleted between 140 and 170 km, and fertile at deeper levels.

Depletion patterns are illustrated by trace-element patterns of clinopyroxenes, which show remarkable similarities between depleted peridotites and Group II eclogites, and between fertile peridotites and Group I eclogites.

Low abundances of Ti and Y in the DP and UDP suites (<0.1 and <0.01 relative to primitive mantle) suggest that these rocks are the residues of large amounts of near-fractional melting in the garnet stability field - possibly in a plume setting - resulting in a harzburgitic rock. The presence of clinopyroxene and garnet is therefore surprising and suggests that these minerals were formed by modal metasomatism or exsolved from orthopyroxene during depressurization. Sinusoidal REE patterns in garnets point to an important role for metasomatism, with an LREE-rich metasomatic agent and incomplete equilibration between rock and melt or fluid.

Depleted eclogites show similar Ti and Y depletions, and comparable LREE, U, Th enrichments, as the DP suite. The low Y content indicates that DE cannot be melt residues, hence their signature is of different origin from the DP suite. Most likely they represent crystallized siliceous melts that were significantly modified by interaction with the peridotites.

The FP suite shows signs of moderate melt extraction, as the more incompatible elements are increasingly depleted, whereas Ti and Y are close to primitive mantle values. Major elements point to melt extraction at much lower pressures than the pressure of subsolidus equilibration. The FE suite is thought to be derived from basaltic ocean floor with some admixed sediments, which is consistent with its trace-element signature. This suggests that both FP and FE are derived from subduction - the FP suite representing former oceanic lithospheric mantle - and were stacked at the bottom of the cratonic root.