# Spinel-facies Peridotites from the Kaapvaal Root

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Spinel-facies peridotites are of particular interest because they are believed to form the uppermost part of the craton lithosphere and might in principle differ in age and origin from the underlying garnet peridotites. This report is based on bulk and mineral analyses for 21 large specimens, some with isotopic and trace element determinations, from Premier, Kimberley, Letseng-la-terai, and Frank Smith/Weltevreden. Similar rocks have been found at Liqhobong (Boyd and Nixon, 1975), Pipe 200 (Carswell et al., 1979) and Ngopetsoeu (Carswell et al., 1984). Their widespread occurrence within the craton is evidence that they may form a layer between the Moho and the underlying garnet peridotites and this conjecture is supported by experimental studies of the spinel- to garnet-facies transition (e.g. Harley and Carswell, 1990).

The most distinguishing characteristic of the spinel-facies peridotites, aside from the absence of garnet, is that the $Al_2O_3$ contents of their enstatites are markedly higher than are those of enstatites that have equilibrated with garnet at temperatures below 1100-1200°C. Enstatites in spinel-facies peridotites from the Kaapvaal craton contain 1.5-4.5 wt. % $Al_2O_3$ in contrast with enstatites in the low-temperature garnet peridotites that commonly contain only 0.6-0.8 wt. % $Al_2O_3$ (Fig. 1). Other characteristics of the Kaapvaal spinel peridotites include the occurrence of aluminous spinels, commonly in symplectite intergrowths with a variety of silicate phases and the presence of fine exsolution lamellae in enstatite crystals.

Low-temperature garnet peridotites from the Kaapvaal craton have high Mg numbers (91.5 - 93.5 for olivine) combined with a wide range in the proportions of olivine and orthopyroxene (10-45 wt. % opx). In these respects they differ markedly from oceanic peridotites (Boyd, 1989). However, there is virtually complete overlap in Mg number and modal proportions of orthopyroxene for the Kaapvaal spinel- and garnet-facies peridotites (Fig. 2). The compositional differences between oceanic and cratonic peridotites are pronounced, independent of facies. The Kaapvaal spinel and garnet peridotites have overlapping ranges of bulk CaO, $Al_2O_3$ and Cr number although the average Cr number for the spinel-facies rocks (0.202) is a little larger than that for the garnet peridotites (0.154). Inhomogeneities in mineral composition are more pronounced in the spinel-facies peridotites, most likely reflecting lower ambient equilibration temperatures.

REE patterns (obtained by SIMS) of diopsides from Kaapvaal spinel facies peridotites (Fig. 3) show marked variations in overall abundances and shapes of chondrite-normalized patterns. REE patterns are not as steep as those for diopsides from low-T garnet facies peridotites (Shimizu,

1975) because there is no preferential partitioning of HREE into co-existing garnet. Sample 914 shows relatively high levels of LREE enrichment, with a peak concentration at La, compared to diopsides in garnet-facies rocks which commonly peak at Nd. Despite the fact that diopside probably equilibrates faster with metasomatic melts, the varying, complex patterns are an integration of the multiple processes and varying degrees of equilibration experienced by these rocks (Shimizu et al, 1997). The sharply concave nature of the REE pattern of FRB 1425, with a marked gradient from Dy to Yb, may reflect the imposition of a metasomatic signature on an extremely LREE depleted protolith.

Densities for Kaapvaal peridotites have been calculated using mineral densities determined by Boyd and McCallister (1976). Data for PHN 1569 were used for the spinel-facies and low-temperature garnet peridotites and those for PHN 1611 for the high-temperature peridotites. A plot of these densities against temperature and depth has a positive trend (Fig. 4) analogous to the isopycnic trend of Jordan (1988) although most of the spinel and low-temperature garnet peridotites are more buoyant than his estimates. Temperatures for the spinel peridotites were calculated with the Tbkn thermometer of Brey and Köhler (1990) with an assumed pressure of 20 kb. The depth scale in Fig. 4 was taken from a T/P plot for the low-temperature garnet peridotites.

Caveats are, nevertheless, in order in regard to the plot shown in Fig. 4. The high-temperature peridotites are metasomatic rocks in poorly-known degree and their densities may not be representative of the mantle in the depth range from which they are derived. Moreover, there is a pronounced overlap in density and temperature between the spinel peridotites and the lowest-temperature garnet-facies rocks. This implies a failure of equilibration and possible errors in thermobarometry.

The spinel peridotites have Os model ages ranging to 3 Ga (Carlson et al., this volume) and are thus similar in age as well as in composition to the low-temperature garnet peridotites. There is thus no reason to suppose that their origin differs from the underlying garnet peridotites.

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