SECONDARY PHASES IN MANTLE ECLOGITES.

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Mantle-derived eclogite xenoliths contain a ubiquitous secondary assemblage located along grain boundaries of the primary phases. Textural and compositional characteristics of these secondary phases have been examined in approximately 60 eclogites from Bellsbank and Roberts Victor kimberlites, South Africa, ranging in composition from Fe- and Mg-rich bimineralic eclogites to grospydites. The major element chemistry of the primary phases of these samples have been previously described (Smyth and Caporuscio, 1984). The assemblage is much more abundant than, and significantly different from that observed in peridotites at these localities, whereas similar eclogites from different localities show similar secondary assemblages.

Mineralogically, the secondary assemblage appears to be systematically related to the bulk composition of the eclogite. Kyanite eclogites have spinel and secondary clinopyroxene as the dominant secondary phases plus minor Ba-feldspar, barite, and sulfides. In contrast, bimineralic eclogites contain abundant secondary phlogopite and amphibole, in addition to the above minerals, as the secondary assemblage. A few samples also contain rutile that may or may not be secondary. In both secondary phase assemblages, the major- and minor-element contents of these phases (Fe, Al, Mg, Ca, Mn, Ti, and Cr) correlate with the contents of these elements in the primary pyroxene. Analysis of secondary phases in a traverse across a single composite or banded eclogite nodule reveals a continous, systematic variation in composition (Fig.1). Corresponding major- and minor-element correlations occur amongst the secondary phases, as illustrated by the complete sample suite in Fig. 2. Correlation between secondary phase composition and primary garnet is largely lacking. In a few cases, the infiltration of kimberlite can be ruled out on the basis of trace element studies. However, minor secondary apatite and calcite are observed, particularly in the Cr-rich samples, and may indeed be related to the kimberlite.

Texturally, the assemblage appears to be locally controlled by chemical potential gradients surrounding the primary phases. The assemblage along garnet-pyroxene boundaries in bimineralic eclogites shows a distinct spatial sequence: primary garnet, amphibole + spinel, phlogopite, secondary clinopyroxene, primary pyroxene, such that amphibole always lies between phlogopite and primary garnet. Phlogopite commonly occurs as a necklace of oriented grains along garnet-pyroxene boundaries. Amphibole typically contains euhedral spinel inclusions, and is more common on garnet-garnet boundaries and in cracks in garnet than in association with primary pyroxene. Secondary clinopyroxene occurs along primary pyroxene-pyroxene and pyroxene-garnet boundaries and very seldom on garnet-garnet boundaries. It is typically epitaxial on the primary pyroxene. Spinels are generally small, euhedral grains of green hercynite-spinel solid solutions and occur as inclusions in amphibole in the bimineralic eclogites and as inclusions or symplectic intergrowths with secondary clinopyroxene in kyanite eclogites.

Compositionally, the phlogopites tend to be Al- and Fe-rich compared with micas reported from peridotites (e.g. Delaney et al., 1980; Erlank et al., 1988), although they cover a wide range of compositions. They contain variable amounts of minor elements such as Ba and Ti, with some phlogopites adjacent to rutile containing up to 4 wt% BaO and 9 wt% TiO_2. The amphibole is pargasite-ferrohastingsite, in contrast to the more Mg- or K-rich amphiboles observed in peridotites (e.g. Erlank et al., 1988). The secondary clinopyroxene is diopside- and Ca-Tschermaks-rich and strongly depleted in Na relative to the primary pyroxene. The spinel is typically low in Cr (< 7 wt% oxide) except in extremely Cr-rich eclogites where it occurs with up to 50 wt% Cr_2O_3.

The presence of phlogopite and spinel rather then feldspars indicates that the secondary assemblage is high-pressure, although lower pressure than the 30-60 kbar of the primary phase equilibrium.

As an alternative to a metasomatic origin, it is possible that the entire secondary assemblage in many samples may be derived from the primary phases plus minor accessory rutile and sulfides. It has long been noted that the pyroxenes in these rock may contain up to 0.4 wt% K_2O, and K_2O contents up to 1.5 wt% have been observed in pyroxene inclusions in diamonds. Having a slightly smaller radius than K, Ba is even more likely to substitute in clinopyroxene in these rocks. A few of the eclogites do contain exsolution lamellae of phlogopite or rutile in the primary pyroxene. Recently, we have observed up to 2000 ppm OH in these pyroxenes and textural evidence suggests that OH contents may have been higher than 5000ppm in the precursor pyroxenes (Smyth et al., 1991). Consistent with a mantle igneous origin for these rocks, exclusion of incompatible elements K, Ba and OH from the pyroxene would likely have occurred on cooling from the solidus temperatures (>1450°C) to the temperature of equilibration of the primary phases (1050 - 1250°C) at pressures of 3 to 6 GPa. The incompatible element-rich assemblage may then have undergone melting and recrystallization on incorporation into the kimberlite with variable amounts of infiltration of the kimberlite fluid.

We observe no conclusive evidence of alteration of the samples by a common metasomatic fluid than can be readily characterized.

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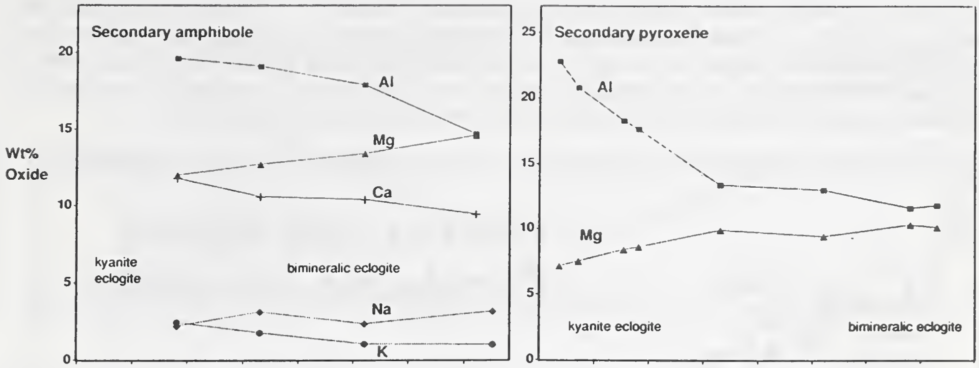

Figure 1. Variation in composition of secondary pyroxene and amphibole in a 30-mm traverse across a composite eclogite, HRV-17 (wt% oxide plotted against distance). No amphibole or phlogopite are observed in the kyanite-bearing region; secondary clinopyroxene and spinel occur throughout.

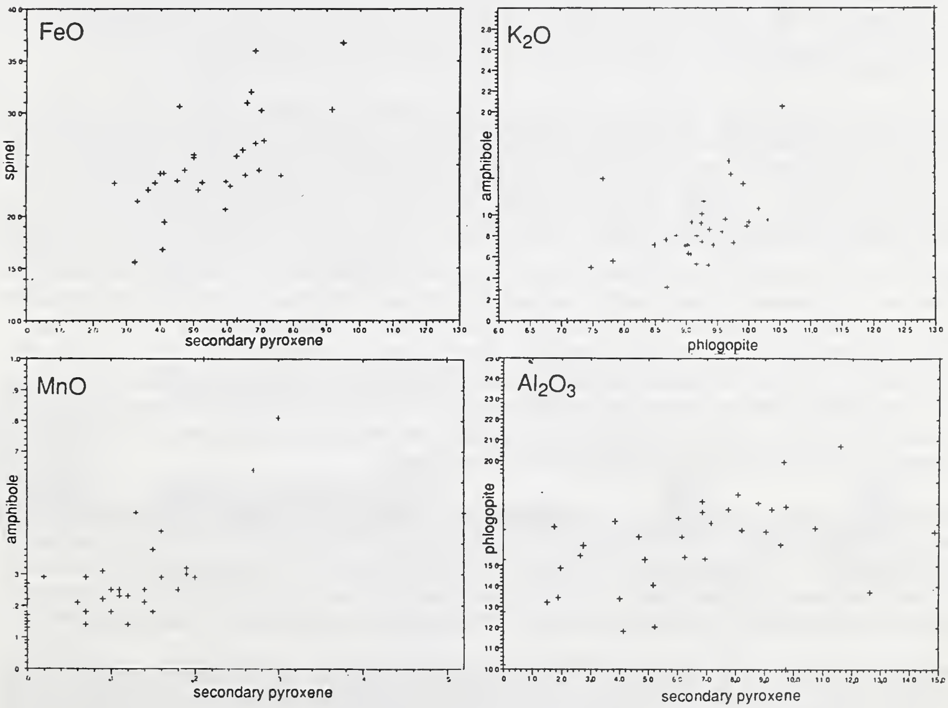

Figure 2. Composition correlation plots of selected major and minor elements amongst secondary phases in mantle eclogites.