SODIUM IN GARNET AND POTASSIUM IN CLINOPYROXENE: CRITERIA FOR CLASSIFYING MANTLE ECLOGITES

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MacGregor and Carter (1970) recognized two groups of eclogites at Roberts Victor, based largely on textural differences. Group I eclogites have large, cloudy, subhedral to rounded garnets set in a matrix of clinopyroxene. Some garnets may be poikilitically enclosed in clinopyroxene, and some clinopyroxene may contain exsolution lamellae. Group II eclogites have an interlocking texture of anhedral garnet and clinopyroxene, and the minerals are less altered than in group I eclogites. Chemically, it was noted that group II clinopyroxenes were lower in K_2O than those in group I eclogites, a feature also noted by Erlank (1970). Garnets also tend to have higher Na_2O content in group I eclogites.

Hatton (1978), in an extensive study of 700 Roberts Victor eclogites, continued to apply the MacGregor and Carter (1970) scheme. He found that although 75% of the eclogites could be regarded as group I, many could not be placed in either category based on texture alone. He relied heavily on the fresh appearance of minerals as a distinguishing criteria, and included eclogites with fresh, unaltered grains in the group II category, though their textures varied.

Several workers have found that eclogitic inclusions in diamond contain potassium-enriched clinopyroxene and sodium-enriched garnet (Sobolev, 1977; Gurney et al., 1979; Tsai et al., 1979; Moore and Gurney, 1985). Similar enrichment occurs in the garnet and clinopyroxene of diamondiferous eclogites, (Reid et al., 1976), and Robinson et al., (1984) suggested that this may be used to classify eclogites.

This investigation returns to the eclogites of Roberts Victor, to demonstrate that sodium in garnet and potassium in clinopyroxene are useful criteria for discriminating two groups of mantle eclogites. Diamondiferous eclogites from several localities are also examined in the light of this new scheme.

A total of 564 garnet and pyroxene microprobe analyses were obtained from polished thin sections of group I, group II, and diamondiferous eclogites. The group I and II eclogites are taken from the suite previously studied by Hatton (1978), and include megacryst-bearing, chrome-rich, and inhomogeneous varieties. The diamondiferous eclogites are from the Roberts Victor, Orapa, Star, Jagersfontein, Newlands, Ardo (Excelsior), Mitchemanskraal, and Sloan 2 kimberlites, with some containing both diamond and graphite. Sixty second counting times were taken for sodium in garnet and potassium in clinopyroxene, to ensure a 0.01% lower limit of detection, with 0.01% 2 sigma.

Based on the original classification of Hatton (1978) the results show that sodium in garnet (Na_2Ogt) and potassium in clinopyroxene (K_2Ocpx) are significantly enriched in group I eclogites, and depleted in group II eclogites. Sodium in group I garnets averages $0.10 \pm 0.02\%$ Na_2O. In contrast, group II garnets have an average sodium content of $0.05 \pm 0.03\%$ Na_2O (Fig. 1a). Group I clinopyroxenes have an average potassium content of $0.12 \pm 0.03\%$ K_2O), while group II clinopyroxenes average $0.04 \pm 0.05\%$ K_2O (Fig. 1b).

It can be seen from Figs. 1a and 1b that the oxide ranges overlap for the two eclogite groups. For the group I eclogites, low values of Na_2Ogt and K_2Ocpx are present only in metasomatized nodules (recognized by the presence of abundant secondary phlogopite in the rock; Hatton, 1978). It is possible that sodium has been removed from the garnet during metasomatism or other alteration processes. Potassium depletion in eclogitic clinopyroxene from metasomatism or decompression melting has been reported elsewhere (Switzer and Melson, 1969; Mysen and Griffin, 1973; Reid et al., 1976; McCandless and Collins, this volume). It has also been noted that measured K_2O in clinopyroxene can vary with crystallographic orientation (McCandless and Collins, this volume). The high K_2Ocpx and Na_2Ogt values in group II eclogites are largely from kyanite-bearing eclogites. These eclogites were classified as group II based on their fresh appearance (Hatton, 1978), while MacGregor and Carter (1970) found that all kyanite-bearing eclogites were group I. On the basis of our proposed criteria, we agree with the latter. The problems inherent in using texture alone as a criteria for classifying eclogites thus become apparent.

Even with these samples included in their original groups defined by Hatton (1978) however, it is found that 81% of the garnets from group I eclogites have 0.09% or more Na_2O, while 89% of the group II garnets are below this value. For K_2O in clinopyroxene, 94% of the group I clinopyroxenes are at or above 0.08% K_2O, with 76% of the group II clinopyroxenes below this value. When the metasomatized group I and kyanite-bearing group II eclogites are excluded, 91% of the group I garnets have 0.09% or greater Na_2O in garnet, and 96% of garnets in group II eclogites have less than 0.09% Na_2O. For the group I clinopyroxenes, 99% are at or above 0.08% K_2O, and 86% of the group II clinopyroxenes are below 0.08% K_2O.

It is proposed that values of 0.08% K_2O in clinopyroxene and 0.09% Na_2O in garnet can be used as criteria for classifying mantle eclogites. Eclogites with average contents of $K_2Ocpx \geq 0.08\%$ or $Na_2Ogt \geq 0.09\%$ are considered as group I, and eclogites below these values are group II. For reasons previously discussed, both values may not be high in a group I eclogite, in which case the presence of either enriched garnet or clinopyroxene is considered significant. By applying these quidelines to the eclogites of at Roberts Victor, 90-100% are correctly placed into a group I or II category. This is a highly successsful result. It remains to be shown how widely applicable these criteria will prove to be.

It has been noted that diamondiferous eclogites have K_2O-enriched clinopyroxene and Na_2O-enriched garnet (Robinson et al., 1984; Reid et al., 1976). The average values of these oxides in diamondiferous eclogites are nearly identical to those for group I eclogites. Sodium in garnet is $0.11 \pm 0.02\%$ Na_2O, and potassium in clinopyroxene is $0.10 \pm 0.04\%$ K_2O. Low contents of K_2O present in clinopyroxene are believed to be due to those processes similarly attributed to low values in Rovic group I clinopyroxenes. Thus, based on K_2Ocpx alone, only 65% of the the diamondiferous eclogites would be classified as group I. In considering Na_2Ogt, however, all of the diamondiferous eclogites are group I, using the cut off limits expressed above. It is believed that all of the diamondiferous eclogites of this study are group I eclogites, based on these results. Conversely, this suggests that group I eclogites formed under conditions similar to those required for diamond genesis.

The application of peridotitic garnet chemistry to evaluate the presence of diamond in kimberlites has been proven (Gurney, 1984). An increasing number of kimberlites are now recognized as having eclogitic diamonds, based on associated mineral inclusions (Otter and Gurney, this volume; Moore and Gurney, 1985, this volume; Rickard et al., this volume) The similar enrichment patterns of K_2O in clinopyroxene and Na_2O in garnet for group I and diamondiferous eclogites has been shown. Group I eclogites, and the garnets and clinopyroxenes derived from them, may therefore be useful tools in the prospecting and evaluation of kimberlites, where the eclogitic diamond paragenesis is important.

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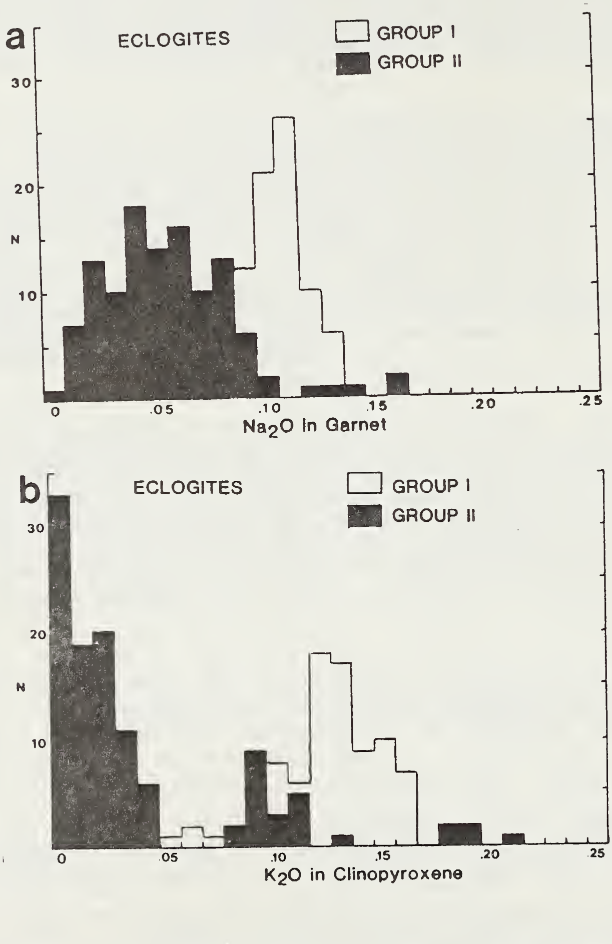

Figure 1. Histograms of (a) Na_2O in garnets and (b) K_2O in clinopyroxenes from Roberts Victor group I and group II eclogites. Values in weight percent.