CLINOPYROXENE-RICH SHEETS IN GARNET-PERIDOTITE: XENOLITH SPECIMENS FROM THE MATSOKU KIMBERLITE PIPE, LESOTHO

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Introduction:

Examination of xenoliths collected from the Matsoku kimberlite pipe in 1973 has shown the existence of clinopyroxene-rich garnet-lherzolite sheets or dikes occurring within a peridotite host rock. The contacts of the sheets are extremely sharp and roughly planar, whilst the host rock is garnet-lherzolite of the type poor in clinopyroxene and garnet and referred to as common peridotite (CP) by Cox et al. (1973). The clinopyroxene-rich sheets range in thickness from approximately 3.5 to 16 cms. In some cases clinopyroxene is only abundant (35 to 45 modal %) in the marginal zones (1.2 to 3.5 cms thick) of the sheets, whilst their interiors are largely of orthopyroxene and olivine whose relative modal proportions vary considerably. In other cases clinopyroxene is abundant throughout the sheets, though some modal layering roughly parallel to the sheet margins may be present on scales varying from 0.2 to 0.5 cms.

Petrography of clinopyroxene-rich sheets:

In addition to olivine, orthopyroxene, clinopyroxene and garnet, the clinopyroxene-rich sheets may contain primary-metasomatic minerals (Harte and Gurney, 1975), especially ilmenite (locally exceeding 10 modal %). For the most part the olivine and pyroxenes form clear and relatively small grains (0.5 to 1.0 mm) with a mixture of moderately granoblastic-polygonal and rational grain boundaries. Clinopyroxene and more commonly orthopyroxene also occur in cloudy grains showing fine lamellae of included silicate and ilmenite which appear to be exsolution products. These cloudy grains often show irregular grain boundaries and a partly interstitial habit. In the relatively clinopyroxene-poor interiors of some sheets, large orthopyroxenes may occur showing clear cores surrounded by cloudy zones and sometimes with a clear outer selvedge. The silicate lamellae in the cloudy orthopyroxenes are of clinopyroxene. Large orthopyroxenes are often accompanied by large olivine crystals with irregular grain boundaries.

The amount of garnet in the sheets is widely variable. A partial selvedge (around 0.2 cms thick) of garnet is quite common at the contact of the sheets with the host CP, and a broader zone (up to 2.0 cms) of relatively high (up to 25%) modal garnet occurs at the margins of some sheets. In the clinopyroxene-poor interior of some sheets garnet forms $<$ 5.0 modal %, whilst in other cases 0.2 cm wide seams or stringers contain $>$ 50 modal % garnet. The garnet occurs principally in distinctive poikiloblastic grains, but also in "pools" (Cox et al. 1973) which might represent droplets of magmatic liquid.

Mineral and bulk-rock chemical compositions:

Pertinent aspects of these data are summarised in Figs. 1 and 2 and below:

(a) Olivine and orthopyroxene compositions are closely similar throughout any sheet and the adjacent host CP. This feature includes the orthopyroxene host of the cloudy orthopyroxenes, but not the bulk composition of such crystals which are enriched in clinopyroxene and ilmenite molecules.

(b) Clinopyroxene is often of nearly constant composition in the sheets and the adjacent host rock but a sharp change in Cr/Al ratio occurs across the contact in some xenoliths (Fig. 1a).

(c) Within the sheets garnet in both poikiloblastic and "pool" forms is of similar composition, but the host CP garnet varies in Cr/Al ratio and there is usually an abrupt change in this ratio across the contact (Fig. 1b).

(d) Compared with xenoliths of CP alone, the CP host of the sheets is enriched in Fe (Figs. 1 and 2) and all sheets and host CP have Mg/Fe ratios intermediate between those of CP xenoliths interpreted as depleted mantle and xenoliths interpreted as cumulates (Gurney et al. 1975).

(e) The compositions of homogenous pyroxenes indicate a common T and P similar to that of other Matsoku xenoliths (quoted as near 1050°C and 50 kbar by Gurney et al., 1975).

Discussion:

The structural and textural features of the sheets indicate a magmatic origin. The cloudy pyroxenes are related to this high temperature event, subsequent to which the minerals re-equilibrated to a common T. and P. Transfer of Fe and Mg between the sheets and their host rocks has occurred, but the movement of other elements, especially Cr, appears to have been restricted.

It is proposed that the large olivine and orthopyroxene crystals (rimmed by cloudy orthopyroxene) in the interiors of sheets represent residual crystals of a partial melt, whose progressive crystallisation formed the clinopyroxene-rich margins of sheets and eventually the garnet found concentrated near contacts and in thin seams. Such a sequence conforms with a crystallisation path along the clinopyroxene cotectic surface to the pseudoinvariant point where garnet commences crystallisation (O'Hara, 1970). The closely similar Cr/Al of garnet and clinopyroxene near the margin of all sheets supports this mode of evolution.

The high bulk CaO/Al_2O_3 of some clinopyroxene-rich margins (Fig. 2) have a cumulative aspect and some of the low melting fraction liquid may have been lost from the sheets. This is supported by the occurrence of garnet of the same composition as that of the sheets (Fig. 1b) in a garnet-rich vein in an orthopyroxenite (LBM 40). The mode of this vein as well as that of "pools" (Cox et al. 1970) suggest that the low melting fraction liquid may be very low in normative clinopyroxene.

The close association of primary-metasomatic minerals with some sheets, may indicate that this metasomatism is related to the magmatic event responsible for the clinopyroxene-rich sheets.

References:

Cox, K.G., Gurney, J.J. and Harte, B., 1973; in 'Lesotho Kimberlites' (ed. P.H. Nixon) p. 76-100.
Gurney, J.J., Harte, B. and Cox, K.G., 1975; Physics Chem. Earth, 9, p. 507-523.
Harte, B. and Gurney, J.J., 1975; Carn. Inst. Wash. Yr. Bk. 75, p. 528-536.
O'Hara, M.J., 1970; Phys. Earth Planet Int., 3, p. 263-245.

Figure Captions:

Fig. 1 Atomic ratios Cr/(Cr+Al) and Mg/(Mg+Fe) in: (a) clinopyroxene (b) garnet.
Fig. 2 Bulk rock weight percentages of: FeO* (total Fe as FeO), CaO, Al_2O_3 and Cr_2O_3 plotted against MgO/(MgO + FeO*).

In both figures the symbols indicate the following rock types: ◇ garnet-lherzolites of common peridotite (CP) type - interpreted as depleted mantle. □ garnet-lherzolites and garnet-pyroxenite - interpreted as cumulates. ▲ clinopyroxene-rich margins of clinopyroxene-rich sheets. ◆ common peridotites (CP) in contact with clinopyroxene-rich sheets. △ complete sections across clinopyroxene-rich sheets.

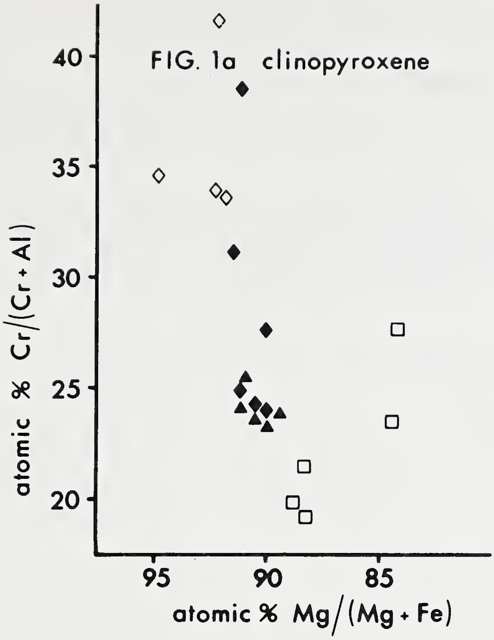


FIG. 1a clinopyroxene
atomic % Cr/(Cr + Al)
atomic % Mg/(Mg + Fe)
40
35
30
25
20
95
90
85

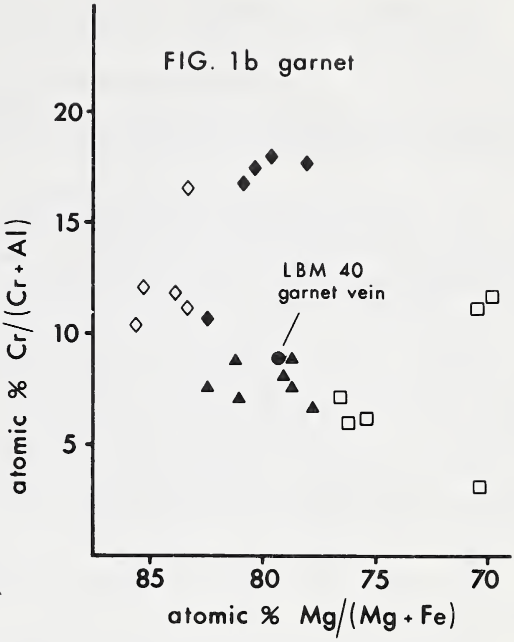
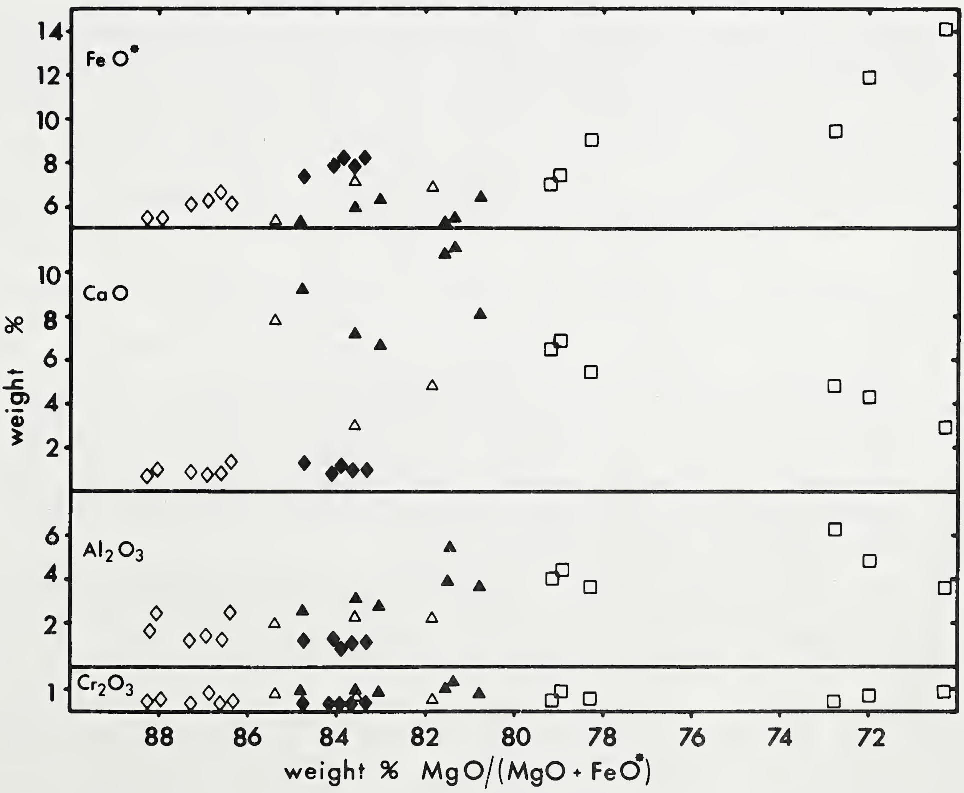


FIG. 1b garnet
LBM 40
garnet vein
atomic % Cr/(Cr + Al)
atomic % Mg/(Mg + Fe)
20
15
10
5
85
80
75
70

FIG. 2


FeO*
CaO
Al2O3
Cr2O3
weight %
weight % MgO/(MgO + FeO*)
88
86
84
82
80
78
76
74
72