

GARNET AND ILMENITE FROM SOME PREMIER KIMBERLITE INTRUSIVES

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Premier Mine is the largest kimberlite in a cluster of eleven kimberlite pipes situated in the centre of the Archaean Kaapvaal craton. The intrusion, which is 30km ENE of Pretoria, has been dated at 1180 ± 30 m.y. (Allsopp and Kramers 1977) and is a Group I kimberlite. It has been mined almost continuously since 1902.

The pipe consists of several intrusive phases described purely by their visual aspects and including Brown, Grey, Fawn, Green and Piebald varieties (Figure 1). It is thought that the Premier kimberlite body was emplaced in three main phases of intrusive activity: the Brown kimberlite represents the first phase of intrusion and is the richest in diamond. It was followed by the Grey (second intrusive phase) and Black kimberlites (third intrusive phase). The Grey kimberlite is volumetrically the most significant, whilst the Black kimberlite is present as a plug like body in the western part of the pipe. Other kimberlites are volumetrically minor. A carbonatite intrusion represents the final phase of intrusive activity at Premier and is spatially associated with the Black Kimberlite.

Three Premier kimberlite types were available for this study: Grey, Green and Black. The mantle macrocryst suite was extracted from each phase by heavy mineral separation techniques and the macrocryst minerals categorised by composition.

The low chrome garnets appear to be mainly derived from the megacryst suite on the basis of igneous trends and high Fe-Ti compositions. Very few eclogitic garnet compositions appear to be present (Figure 2). Chrome-bearing peridotitic garnets are much more common, and peridotitic diamond indicator minerals suggest that more peridotitic than eclogitic diamonds should be present (Figure 3). This contrasts with the results of a study of diamond inclusions from Premier Mine, where eclogitic diamonds are more abundant than peridotitic in the ratio 60/40 (Gurney et al. 1985).

Garnet compositions indicate that the diamond suite in the Black kimberlite has a higher eclogitic component than either the Grey or Green variety, and a lower peridotitic component. The mantle mineral suites of the Grey and Green kimberlites are statistically very similar, supporting the previously proposed hypothesis that the Green kimberlite is a metamorphosed variant of the Grey related to the intrusion of the Black kimberlite. This is supported in this study by both parametric (T-tests) and non-parametric (Kruskal Wallis tests) which indicate no significant differences between the mantle mineral suite compositions for the Green and Grey kimberlites at a confidence level of 95%.

Statistical analysis of the ilmenite dataset reports a high negative correlation of MgO and TiO₂ with calculated estimates of Fe₂O₃ / FeO_c (Table 1). This supports the idea that Mg and Ti may be approximate indicators of mantle oxygen fugacity, higher concentrations of both corresponding to more reduced mantle conditions. Ilmenite compositional data for the different kimberlite types imply very similar redox conditions in the deep upper mantle at the times of their respective emplacements.

TABLE 1: Correlation coefficients (ilmenites)

Oxide	Whole Group	Grey	Black	Green
TiO ₂ : MgO	0.93	0.94	0.92	0.95
TiO ₂ : FeO _C	-0.81	-0.82	-0.78	-0.85
TiO ₂ : Fe ₂ O _{3C}	-0.91	-0.88	-0.96	-0.96
MgO : FeO _C	-0.97	-0.96	-0.97	-0.97
MgO : Fe ₂ O _{3C}	-0.90	-0.91	-0.90	-0.92

* FeO_C and Fe₂O_{3C} are calculated.

This study demonstrates that significant differences in the mantle sample may exist in different kimberlite intrusive phases of the same diatreme. The finding that diamond inclusion composition peridotitic garnets outnumber Group I eclogite-derived garnet appears at variance with earlier work on diamond inclusions which reported paragenetic proportions 60:40 with respect to eclogitic:peridotitic diamonds. Possible reasons for this might include that the concentrate macrocrysts studied are not representative of the paragenetic proportions of the diamond population, that the eclogitic diamonds studied previously were predominantly sampled by another intrusive phase not studied here (such as the Brown kimberlite), or alternatively that diamond inclusions may not accurately represent the paragenetic proportions of the diamond suite.

REFERENCES

- Allsop H.L. and Kramers J.D. (1977) Rb-Sr and U-Pb age determinations on South African kimberlite pipes. Extended Abstracts 2nd International Kimberlite Conference Santa Fe, Unpaginated.
- Gurney J.J., Harris J.W., Rickard R.S. and Moore R.O. (1985) Inclusions in Premier Mine Diamonds. Transactions of the Geological Society of South Africa 88, 301-310

FIGURE 1: Generalised geological plan of Premier Mine (from De Beers internal report)

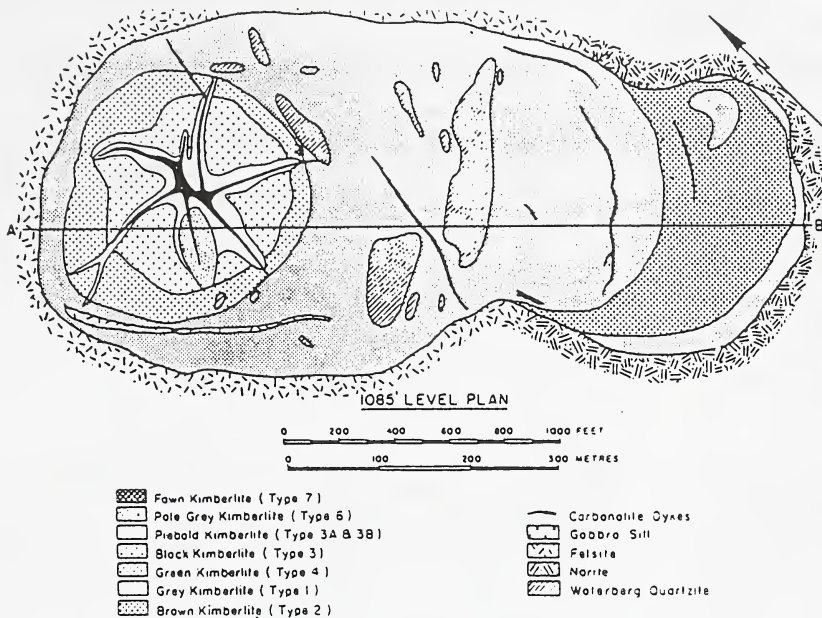


FIGURE 2: Low-Cr garnet macrocrysts

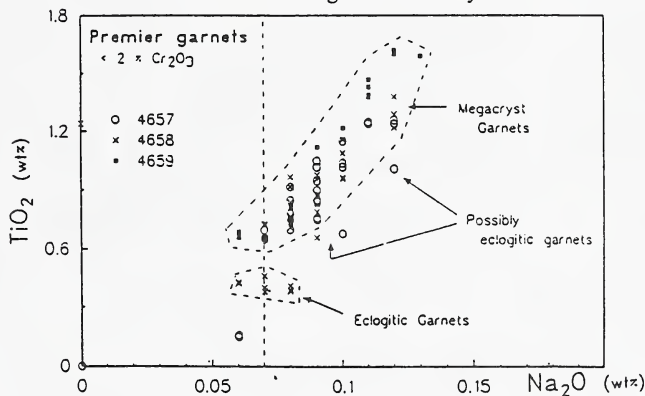


FIGURE 3: All garnet macrocrysts

