DIAMOND- AND GRAPHITE-PERIDOTITE XENOLITHS FROM THE ROBERTS VICTOR MINE.

Viljoen, K.S.; Robinson, D.N and Swash, P.M.

Anglo American Research Labs., Kimberlite Res. and Serv. Lab., PO Box 106, Crown Lines, 2025, South Africa.

INTRODUCTION

The Roberts Victor kimberlite is situated in the Orange Free State, South Africa. This is within the central part of the Kaapvaal craton. It is a Group 2 kimberlite which has been dated at 128 My.

It is well known for the high proportion of eclogite xenoliths present, particularly in relation to the more usual dominance of peridotite xenoliths at most other kimberlites. MacGregor and Carter (1970) estimated that eclogites constituted over 95% of the xenolith population, and Hatton (1978) found that 98% of 700 nodules examined were of eclogitic, rather than peridotitic affinity. Recently, an attempt was made to characterise the peridotite suite more fully. A one day visit to the mine resulted in the collection of 20 specimens. Each xenolith was first sawn in two with a boron nitride impregnated saw. One half was carefully cleaned of adhering kimberlite matrix, crushed and digested in hydrofluoric acid. Examination of the acid residue proved that six of the xenoliths contain diamond, two contain both diamond and graphite while another four contain only graphite.

PETROGRAPHY

The peridotites are rounded and range in size from 10 cm to 30 cm in diameter. They are all extremely altered to serpentine, calcite and quartz. Olivine and orthopyroxene have been completely destroyed, clinopyroxenes are partially altered and garnets and spinels are fresh. All the xenoliths show coarse (undeformed) relict textures.

MINERAL CHEMISTRY

Olivine and orthopyroxene are too altered to analyse. The clinopyroxenes are calcic diopsides. They have moderate to high Cr_2O_3 (0.57% to 4.9%) and low Al_2O_3 (1.3% to 2.8%) and Na_2O (0.87% to 2.11%). Garnets are represented by both calcium saturated (lherzolitic) and low-calcium (harzburgitic) varieties. TiO_2 concentrations are all low (generally < 0.2%). Using the garnet chemistry as a guide, the six diamond-bearing xenoliths are represented by three lherzolites and three harzburgites (figure 1). One of the two graphite/diamond peridotites is a harzburgite while the other is a lherzolite. Of the four graphite peridotites one is a lherzolite while the rest (3) are harzburgites. Primary spinel was found in thirteen xenoliths. They are chromites (Cr/Cr+Al >.75) with low TiO_2 (<1%).

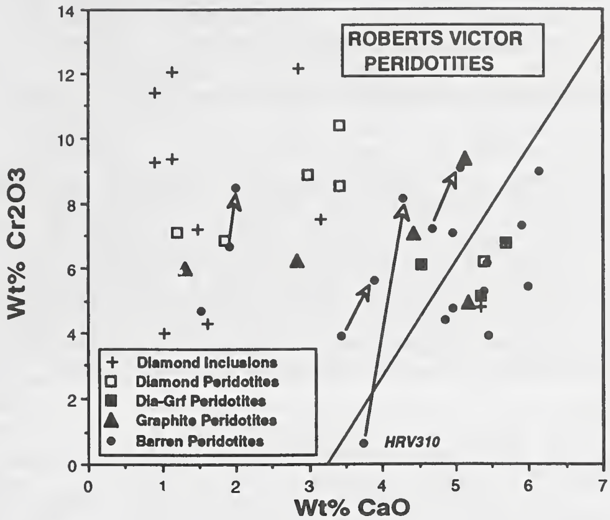

Fig. 1. CaO-Cr_2O_3 trends in garnets from peridotites (this study; Hatton 1978) and diamond inclusions (Gurney et al, 1984). Arrows indicate the range found in garnet compositions for each xenolith. Sample HRV310 is a peridotite with a websterite vein (Hatton, 1978).

GEOTHERMOBAROMETRY

The altered nature of the xenoliths makes it impossible to apply any geobarometer, or to obtain any temperature estimate for clinopyroxene-free xenoliths. Temperature estimates for clinopyroxene-bearing lherzolites can be obtained from the garnet-clinopyroxene thermometer. Calculation at 50kbr shows that the diamond peridotites (2 samples) equilibrated at approximately 1000 °C. Barren lherzolites define a temperature range from 1050 °C to 1200 °C. This equilibration temperature for the two diamondiferous lherzolites is similar to the range found in most diamondiferous eclogites (1000 to 1100 °C) from Roberts Victor (Gurney et al, 1984), suggesting that eclogitic diamonds and lherzolitic diamonds at this locality might have formed in the same region of the mantle.

DIAMONDS

The numbers of diamond crystals recovered from individual xenoliths range up to 19. Two xenoliths produced substantially greater numbers of diamond which, however, are bounded largely by breakage surfaces and must represent pieces of one or a small number of crystals. Diamond crystal sizes range from 0.3 to 0.5mm in four of the xenoliths, between 1 and 1.5mm in one case and from 2.5 to 3mm in another. The pieces mentioned in two other xenoliths range up to 2mm in diameter. Octahedral crystals predominate. These range from sharp-edged individuals with no or few trigonal etch pits to examples with partly bevelled edges and relatively numerous and large trigonal pits. In most cases, the bevelling at octahedral edges is by surfaces that are approximately dodecahedral, rather than tetrahexahedroids for most diamonds in the mine production. Graphite commonly veneers the bevelled portions as well as octahedral areas where flat-bottomed, trigonal pits have coallesced to leave residual, serrate laminae. Breakage surfaces to the fragmental grains in two of the xenoliths are either frosted or exhibit trigonal etch pits. These features indicate that the breakage is due to natural causes. The relatively small diamonds in four of the xenoliths are virtually colourless. In another case, brown diamonds occur together with yellow diamonds in the same xenolith. In two other xenoliths the diamonds are grey to black on account of microscopic inclusions, presumably graphite.

The abundances and masses of diamonds in the xenoliths are thousands of times those in the host kimberlite. Therefore, it is possible for at least most of the diamonds in the kimberlite to be accounted for by the disaggregation of xenoliths such as those described. The predominantly octahedral morphology amongst the xenolith diamonds, versus tetrahexahedroid morphology for the kimberlite diamonds, can be explained by the much more limited exposure of the xenolith diamonds to oxidising, kimberlitic magmatic fluids. The occurrence of brown with yellow diamonds in a single xenolith suggests that at least one of the diamond colours is secondary in origin.

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