Indicator minerals in kimberlites and their respective stream sediments, Gibeon Kimberlite Province, Namibia

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This study deals with macrocrystic kimberlite indicator minerals from Anis Kubub, Berseba Reserve (Ovas), Diamantkop, Hanaus 2, Mukorob, Lichtenfels, Louwrensia and Achterfontein kimberlite suite from the off-craton Gibeon Kimberlite Province of Southern Namibia. The aim was to study the composition and distribution of kimberlite indicator minerals in the pipes and dykes as well as sediments from streams draining the kimberlite area. Altogether 15 pipes and dykes and 37 stream sediments were sampled. Streams samples were mainly taken from trap sites where maximum amounts of heavy minerals were accumulated and from weathered surfaces of kimberlite pipes and dykes. Indicator minerals were hand-picked from 0.5-1.0 mm and 1.0-2.0 mm fractions of the concentrates. The minerals included purple, red, reddish-brown and orange garnets, black ilmenite, pale and emerald green chrome diopside and black chromite. A representative number of each indicator mineral was analyzed by electron microprobe in the EPMA-laboratory of Geological Survey of Finland (GSF).

Ilmenite tends to be the most abundant indicator mineral in the study area but its abundance varies considerably (from < 1% to 95%, generally >50%). Garnets show a similar variation, with the proportion usually less than 45%. The remainder consists mostly of chrome diopside (generally <2%, maximum about 30%), rare chromite and chrome-spinel.

Compositionally , most of the garnets fall in the garnet lherzolite field, a few plot in the wehlite field and only 9 in the harzburgite+dunite field (Fig. 1). Cr_2O_3 contents of the garnet macrocrysts range from ~0 wt% to ~9 wt%. The ilmenites have a fairly restricted composition with TiO_2 48 wt% $\pm$ 2 (1 s.d.), MgO between 6.1-15.0 wt% and Cr_2O_3 1.62 wt% (average) $\pm$ 0.03 (1 s.d.). Cr-diopside has relatively constant MgO of (16.5 wt% $\pm$ 0.4 (1 s.d.), but Cr_2O_3 varies between 0.2-2.5 wt%. The spinel varies in composition from chrome spinel to low-Cr chromite (average=42 wt% Cr_2O_3).

In terms of relative proportion of garnets, TiO_2-poor garnet (<0.45 wt% TiO_2) predominates both in the pipes (69%) and in the stream sediments (82%). In contrast, titanium-garnet (0.45 to 0. 87 wt% TiO_2) is much lower abundance in the stream sediments and rare further away from the source. High Ti-garnet (>0.87 wt% TiO_2) proportions do not show much variation from pipe to stream sediments (Fig. 2. a,b.).

Heavy mineral studies show that the general trend with increasing distance from the source is a drastic and rapid increase in the proportion of ilmenite. Approximately 5 km from the source ilmenite proportions both in coarse and fine fractions exceed 80%. Importantly, the original indicator mineral proportions of the pipes do not affect this trend significantly. Considering garnets, low Ti-Cr pyrope is the most resistant. Due to its preferential cleavage, Cr-diopside disintegrates more easily and therefore disappears rapidly from the coarse fraction of stream sediments and may temporarily increase in the fine fraction proximal to the source.

Presence of an additional kimberlite source contributing to a stream sediment can be first detected in an increase in the abundance of garnets in the coarser fraction, and also in the finer fraction. Other facts supporting an additional source include the appearance of less durable garnets and often Cr-diopside, occasional appearance of ilmenites with characteristic surface alteration, garnet with kelyphitic rims and intergrowths of either ilmenite, garnet or Cr-diopside.

Figure 3 shows indicator minerals abundance patterns calculated from samples of Lichtenfels area (east of the Fish River. It can be seen that another source starts to contribute already before 1.3 km from the known pipe (0 km). This is confirmed at 2.2 km distance by a sharp increase in the proportion of garnets. The 4.8 km site exhibits the normal ilmenite increase without any indication of new sources. The sample from 5.6 km distance was taken just after the confluence with another stream, here again, contribution from another source is clear. In a successful exploration of diamonds, the understanding of the behaviour of the indicator mineral species during the river transport is vital for the correct interpretation of the calculated abundance patterns derived from stream sediment, especially in the case of complicated drainage pattern and multiple sources.

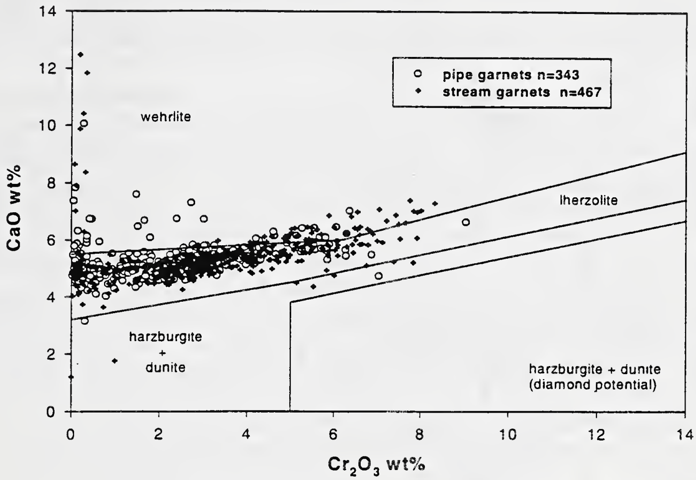

Fig.1.CaO vs Cr_2O_3 plot for macrocryst garnets from the off craton Gibeon kimberlites.
(n= number of grains)

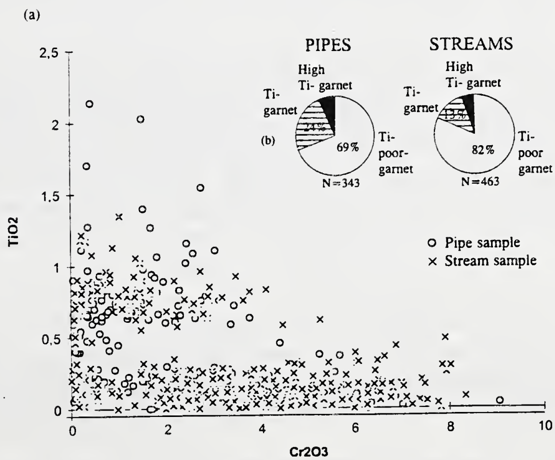

Fig.2.(a) TiO_2 vs Cr_2O_3 plot (same samples in Fig.1.), (b) diagram showing the proportions of garnet in the pipes and in the stream sediments

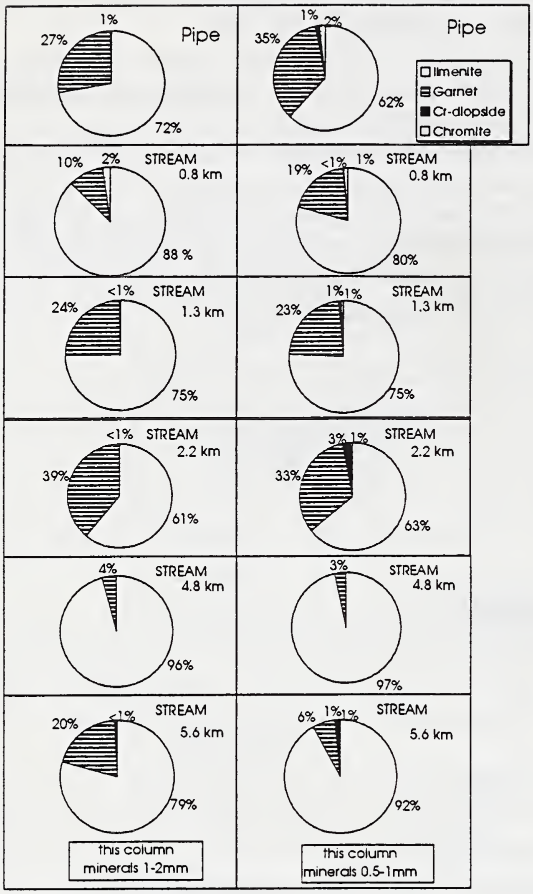

Fig.3. The distribution pattern of indicator minerals in stream sediment and a known kimberlite pipe.
The patterns indicate draining from multiple sources (Lichetenfels, east of the Fish River).

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