Cr GARNET - DIAMOND RELATIONSHIPS IN VENEZUELA KIMBERLITES.

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A swarm of NNW-trending kimberlite dykes and sills in the Guaniamo area of Bolivar Province occupy the NW portion of the Guyana Craton. They are the oldest kimberlites so far recorded (ca. 1.9 Ga) and have petrographic features and chemistry (taking into account tropical weathering) of Group 1 macrocrystic olivine monticellite kimberlite. Overlying alluvials contain diamonds derived wholly or in part from these kimberlites and not from the Roraima sedimentary Group as previously believed.

Heavy mineral concentrates contain high proportions of coarse octahedral spinel (up to 66.6% Cr_2O_3) and a few show alteration to yimengite, $K(Cr, Ti, Fe, Mg, Al)_{12}O_9$ (second recorded occurrence) attributed to metasomatism within harzburgitic rocks near the base of the lithosphere. No peridotite xenoliths were found other than small aggregates of Cr pyrope and serpentinised olivine.

Chromium garnets (red, purple, green) are abundant and include harzburgitic, lherzolitic and wehrlitic varieties (CaO = < 2-24 wt %; Cr_2O_3 up to 14 wt %, Fig 1) i.e. an extremely wide range from only a few kimberlite specimens. Model Sm/Nd isotope ages determined on two single grains of subcalcic (harzburgitic) pyrope are ca. 2.6 Ga. These grains show chondrite normalised humped REE patterns with peaks at Nd (6 x chondrite) which are similar to those reported by Shimizu and Richardson (1987) for subcalcic garnet inclusions in South African diamonds. The subcalcic nature of the garnet implies formation in a harzburgite that had suffered a large degree of melt extraction. The REE enrichment and 2.6 Ga Nd model age record an ancient trace element enrichment event that preceded or accompanied diamond formation. In contrast, two calcic (lherzolitic) garnets show smooth LREE depleted patterns signifying a different involvement in the evolutionary events of the craton notwithstanding a similar model Sm/Nd isotope age (2.6 Ga).

A single diamond inclusion was notable in being a calcic pyrope (CaO = 5.17; Cr_2O_3 = 5.18 wt %). Two others (courtesy of H.O.A. Meyer) from unspecified Venezuela localities are normal subcalcic (G10) varieties. Application of Ni thermometry to all three grains gave temperatures of c. 1300°C which are considerably above those of concentrate garnets (maximum 1050°, Fig 2).

The twin peaks shown in Figure 2 represent a group of low temperature (750-900°C) i.e., shallow, predominantly low Cr calcic lherzolitic garnets and a group of higher temperature (900-1050°C) high Cr lower Ca lherzolite-harzburgite garnets. Within the latter group there is some evidence that lherzolites may be interspersed with more depleted harzbugites within the lithosphere (cf. Boyd and Nixon, 1988), a situation reflected by the limited diamond inclusion data above. Four subcalcic garnets close to G10 composition fall within the temperature range 900-1000°C compared with the normal South African range of 1000-1150°C.

Assuming a Kaapvaal-type geotherm, the proportion of garnets derived from the basal lithosphere diamond zone (950-1250°C range) is low considering the observed high diamond grades. One possibility is that the ambient geothermal gradient in this part of the Guyana Craton was shallower (cooler) at the time of kimberlite eruption compared with that in the Kaapvaal Craton.

The difference in temperatures indicated by the garnet inclusions in diamond (closed system) and those from the concentrates (open system harzburgites, lherzolites etc) could represent the degree of cooling between the time of diamond formation (garnet encapsulation) at 2.6 Ga and eruption at ca. 1.9 Ga.

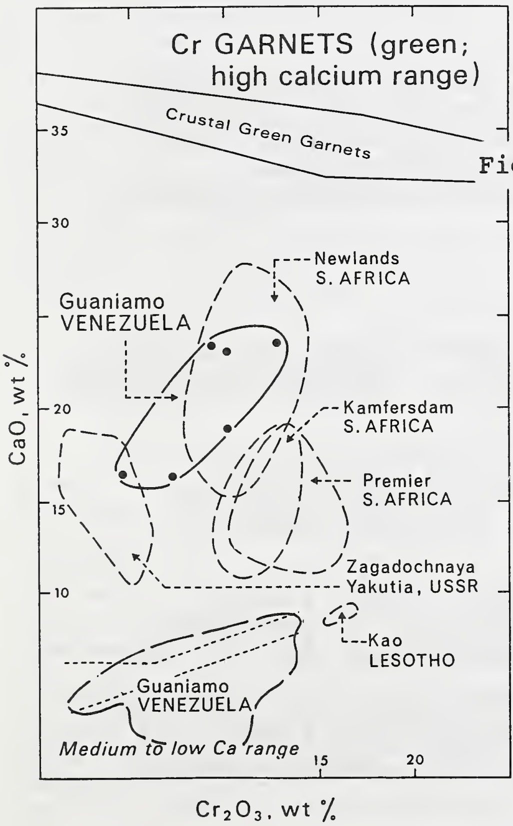

Figure 1 CaO-Cr_2O_3 composition fields of chromium garnets in Guaniamo kimberlites, Venezuela. The medium to low Ca field is represented by 123 garnet analyses. Traversing this field the sloping dotted lines embrace the field of lherzolite garnets, with that of wehrlites above and dunite-harzburgites below (Sobolev et al. 1973). Non Venezuela data after Schulze, 1989 .

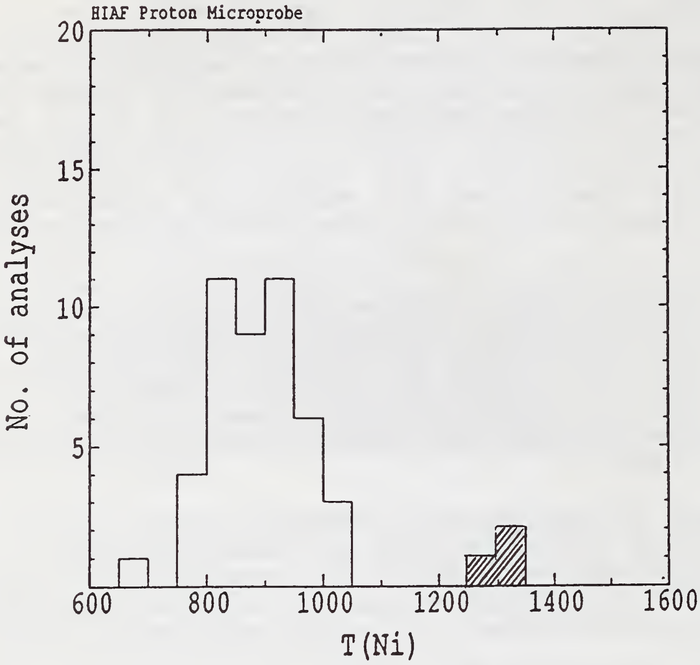

Figure 2 Composite histogram of T_{Ni} for 48 Cr pyropes from Guaniamo kimberlites. The "twin peaks" represent lherzolitic and lherzolitic + harzburgitic type garnets (low and higher temperature ranges respectively); the three high temperature garnets are diamond inclusions.

References

Boyd, F.R. and Nixon, P.H. (1988). Low-Ca garnet harzburgites: origin and role in craton structure. Carnegie Institution of Washington. Ann. Report, 8-13.

Schulze, D.J. (1989). Green garnets from South African kimberlites and their relationship to wehrlites and crustal uvarovites. Geol. Soc. Australia. Spec. Publication. No. 14, 820-826.

Shimizu, N. and Richardson, S.H. (1987). Trace element abundance patterns of garnet inclusions in peridotite-suite diamonds. Geochim. Cosmochim. Acta. 51, 755-758.

Sobolev, N.V., Lavrent'yev, Yu.G., Pokhilenko, N.P. and Usova, L.V. (1973). Chrome-rich garnets from the kimberlites of Yakutia and their paragenesis. Contr. Mineral. Petrol., 40, 39-52.