A COMPARISON OF TWO METHODS TO ASSESS DIAMOND POTENTIAL USING MAJOR AND TRACE ELEMENT ANALYSIS OF DIAMOND HEAVY MINERAL CONCENTRATE (PERIDOTITIC AND ECLOGITIC GARNETS)

by
G. R. LEAR
B.Sc - Sydney University

A thesis submitted as partial fulfilment of the requirements for the degree of Master of Economic Geology

University of Tasmania
Geology Department
Centre for Ore Deposit and Exploration Studies
July, 1993

This thesis contains no material that has previously formed part of another higher degree or graduate diploma in any tertiary institution, and to the best of the author's knowledge and belief, no material that has been written or published by another person, except where due reference is provided.

G.R. LEAR
16 July 1993

ABSTRACT

Thirty garnets from each of nine kimberlite pipes from southern Africa and Yakutia were analysed for major element as well as for trace element concentrations using electron and proton probes. The concentrates came from a mix of barren and diamondiferous kimberlites as well as from both on-craton and off-craton localities. The major element approach (using plots of CaO vs Cr_2O_3 and Na_2O vs TiO_2) was used to predict the diamond potential of the source(s) from which the garnets were derived. Histograms of TiO_2 were used to separate high and low temperature garnet populations. The major element method correctly predicted the diamond potential of the source of five out of nine (56%) of the concentrates from the geochemistry of the eclogitic garnets contained within them.

The same garnets were analysed for trace element levels of nickel and the nickel concentration in each garnet grain was used to calculate its temperature of crystalisation by use of the garnet-nickel geothermometer. This temperature was then related to diamond potential by interpreting it in terms of the graphite and diamond stability fields. The two sets of predictions were then compared.

The garnet-nickel geothermometer gave an accurate assessment of the diamond potential for six of eight pipes studied (75%). The two inaccurate predictions derived from the interpretative process not taking into consideration the shallowness of the lithosphere for one source (Nouzee) - giving a steeper than "ideal" geotherm- and to the presence of a low-temperature suite of concentrate garnets in the Roberts Victor sample.

The analyses failed to confirm the presence of a single G10 garnet in one hundred and twenty seven peridotitic garnets examined from eight of the heavy mineral concentrates, even though seven of these came from diamondiferous kimberlites, five of which were of economic grade. This indicates that, in those areas where soil sampling recovers quite small numbers of (peridotitic) garnets, it may not be possible to adequately assess diamond potential using the presence or absence of G10 garnets

CONTENTS

INTRODUCTION

This study examines garnets contained in the heavy mineral concentrate from nine kimberlite pipes from southern Africa and Yakutia and attempts to predict whether or not they were derived from barren or diamondiferous sources. A semi-quantitative estimate of grade is also made. The methods used to assess diamond potential will rely on the major element approach (Gurney & Moore,1991) using only kimberlitic garnets and the nickel geothermometer (Griffin et al;1989). The major element approach has been in use for about two decades. The nickel geothermometer is a much more recent development and has really only been used by industry for about four years. These methods have also been used to assess the diamond potential of lamproites (Griffin & Ryan;1992 B), with varying degrees of success. Reference will also be made to the geochemistry of ilmenite and chrome-spinel from the selected pipes but they are a minor component of this thesis. They were included more to acquaint the reader with some of the additional methods of assessing diamond potential, as well as to illustrate the way the original evaluation can be confirmed or otherwise. In order to explain the limitations inherent in these techniques which rely on indicator mineral geochemistry, a summary of diamond genesis, kimberlite genesis, mantle petrology, mantle sampling by kimberlite, and of diamond exploration - using heavy mineral concentrates is considered necessary.

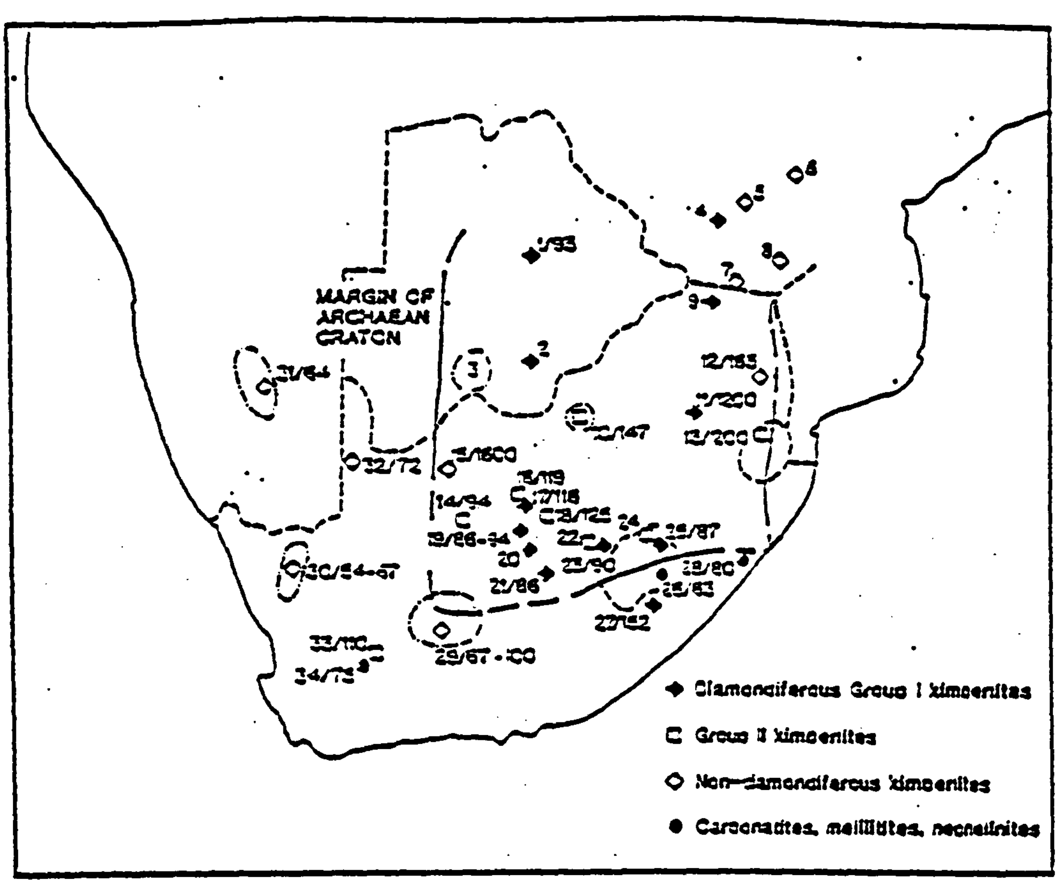
REVIEW OF DIAMOND AND KIMBERLITE GENESIS

Almost all (98%) of inclusion-bearing diamonds can be classified as either peridotitic (mainly harzburgitic) or eclogitic (Kirkley et al; 1991). Age dating of their inclusions has shown that they have formed throughout most of the earth's history and that diamonds of different ages within one pipe are possible; two dates for

Finsch in South Africa give ages of 1580 My for an eclogitic inclusion and approximately 3300 My for a peridotitic inclusion. The age of emplacement of kimberlite pipes, in many cases, gives dates of formation which are younger than the dates derived for the diamonds contained within them. (Kramers,1979, Richardson,1986, Richardson at al;1990, Kirkley, et al;1991). Kimberlite and diamond are therefore not considered to be genetically related to each other.

Histograms of the ratio of carbon-13 to carbon-12 (delta^{13}C) indicate that there appear to be two sources of carbon from which diamond has formed. Peridotitic diamonds have a restricted delta^{13}C range (-2 to -9 per mill) which supports the hypothesis that they are derived from a relatively homogeneous asthenoshere source or a convecting zone within the upper mantle. Eclogitic diamonds however, have a delta ^{13}C range (-34 to +3 per mill), which is more consistent with carbon which has been derived from a number of sources. This, together with the fact that eclogites have a bulk chemical composition (and trace element signature) which is similar to that of oceanic basalt, has lead to the belief that their carbon source is subducted ocean floor basalts and sediments. (Fipke et al;1989, Kirkley, et al;1991).

Diamondiferous kimberlites in southern Africa are restricted to within the boundaries of the Kalahari craton as the former USSR's are restricted to the Siberian craton (Figures 1, 2 & 3). Temperature and pressure calculations for crystallisation of peridotitic diamond inclusions place their source at a depth of from 150 km to 200 km with paleotemperatures of between 900ºC to 1300ºC (Figures 4 & 5). These estimates are close to those for the present-day cratonic geotherm (change in temperature with depth) and this, coupled with their old age (approx, 3,300 My) supports the hypothesis that the Archaean cratonic geotherm was similar to todays,

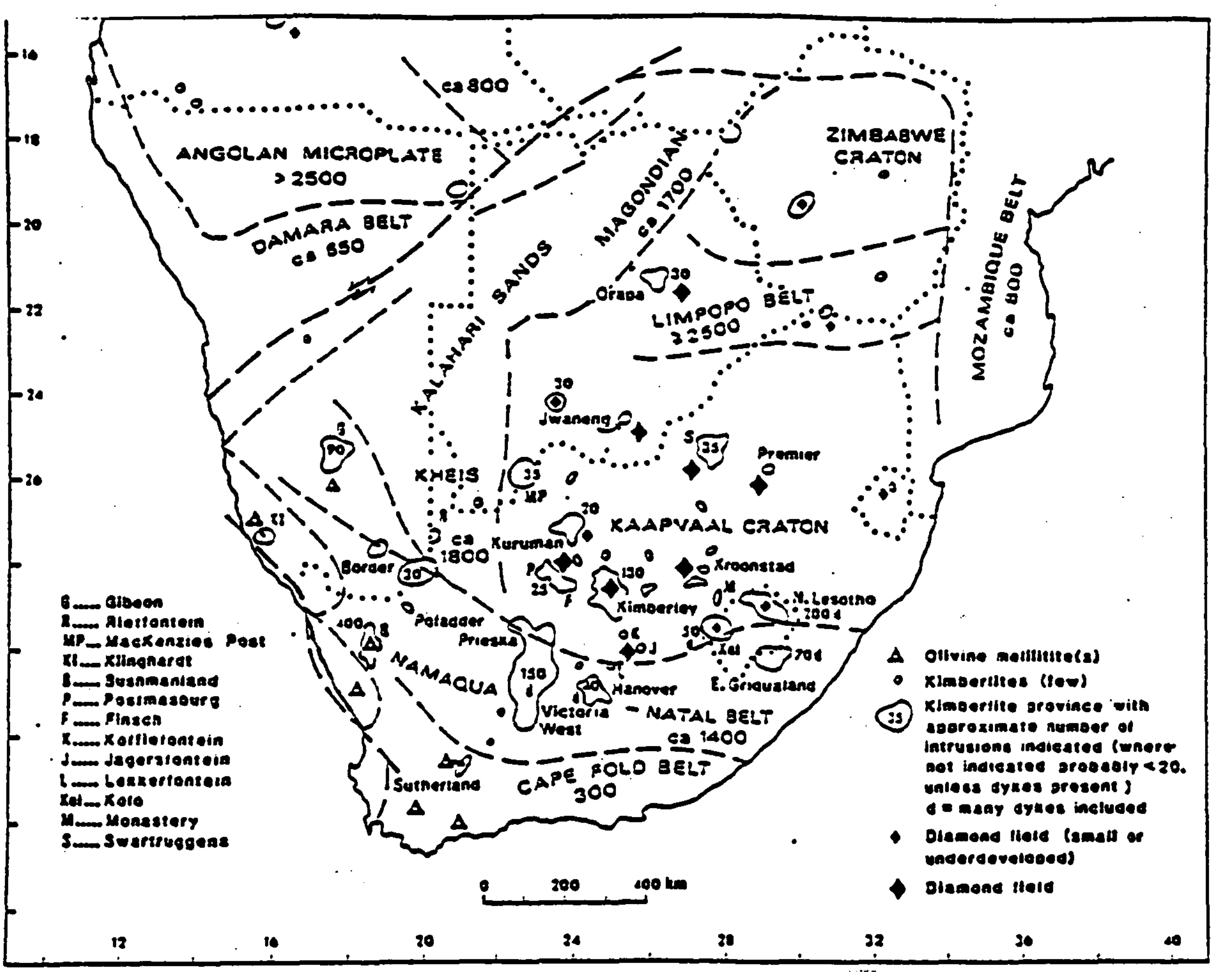


Distribution and ages of southern African kimberlites.
◆ major Group I kimberlites or kimberlite clusters; ◇ non-diamondiferous kimberlites; -·-· areas of non-diamondiferous kimberlite intrusion; ☐ Group II kimberlites; ● carbonatites, olivine melilitites and nephelinites. Numbers following strokes are ages of kimberlites, sometimes averaged for a cluster of intrusions.

1. Orapa; 2. Jwaneng; 3. S.W. Botswana; 4. Colossus and Wessels; 5. Clare; 6. Charter; 7. River Ranch; 8. Shingwize; 9. Venetia; 10. Swartruggens; 11. Premier; 12. Dullstroom (Elandskloof); 13. Dokolwayo; 14. Finsch; 15. Kuruman; 16. Bellsbank; 17. Barkly West (Newlands, Mayeng, Frank Smith); 18. Boshof area (New Elands, Roberts Victor, Blaauwbosch); 19. Kimberley area (Bultfontein, Dutoitspan, De Beers, Wesselton); 20. Koffiefontein; 21. Jagersfontein; 22. Winburg area (Star, Lion Hill); 23. Monastery; 24. Marakabei, Lesotho; 25. Mothae, Lesotho; 26. Melkfontein carbonatite; 27. Mzongwea; 28. Eshowe melilitites; 29. Victoria West (Lushof, Uintjes Berg); 30. Namaqualand (Platbakkies, Brakfontein); 31. Gibeon-Keetmanshoop area, Namibia (Deutsche Erde, Mukorob); 32. Rietfontein; 33. Eendekuil; 34. Sutherland melilitites

(From : Dawson, 1986)

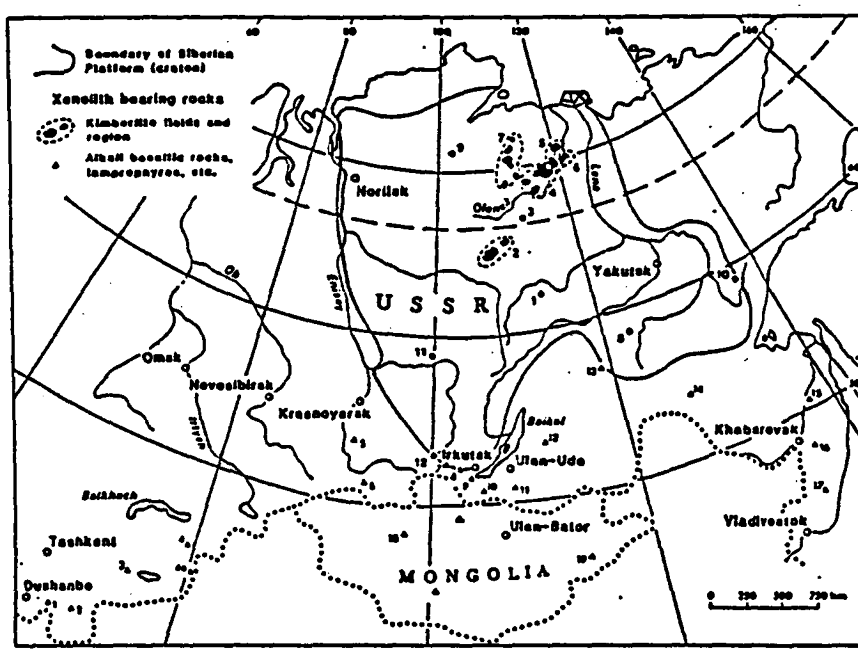
FIGURE 1



Distribution of kimberlites in southern Africa with approximate boundaries of the cratons shown.

(From : Nixon, 1987)

FIGURE 2



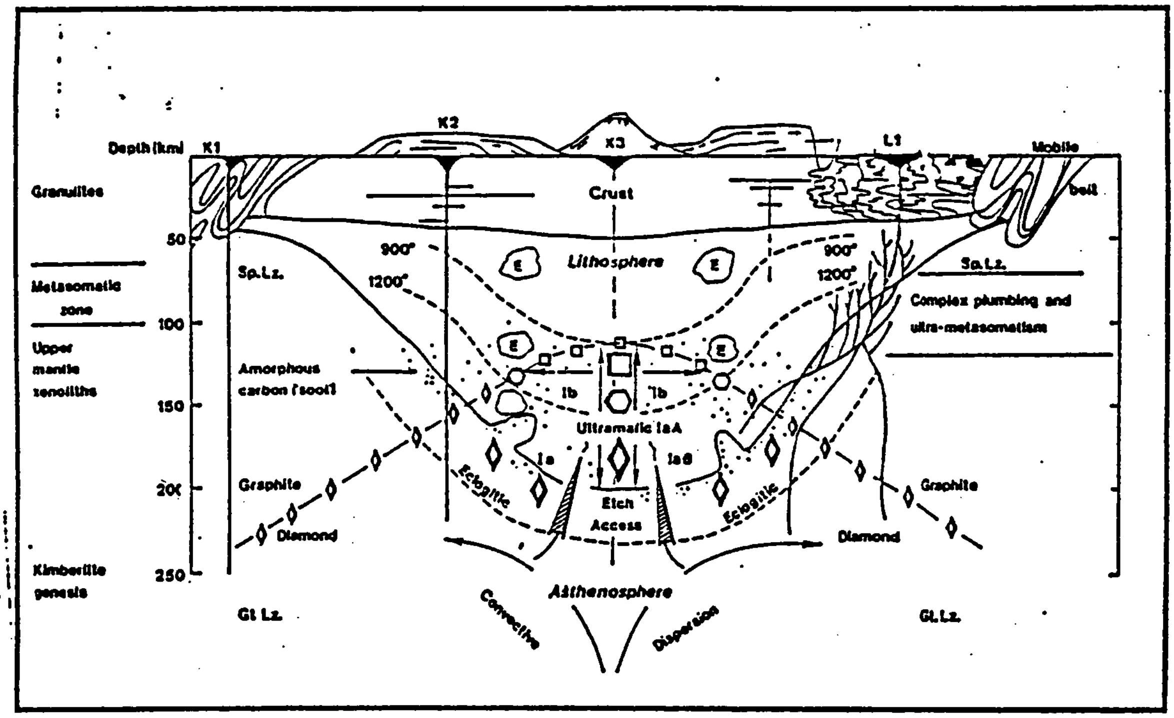
Xenolithic localities of USSR and Mongolia

(From :Sobolev. and Nixon, 1987)

Basaltic rocks
1. Hissar clusters
2. SE Pamir
3. Talas-Kirgaz
4. Dzhungaria
4a. Toyun
5. Minusinsk
6. Tanu Ola range
7–12. Baikal group
13. Udokan range
14. Tukuringra mts
15. Sindinsky volcano
16. Nadan'khada volcano
17. L. Khanka group
18. Tariat basin } Mongolia
19. Dariganga } Mongolia

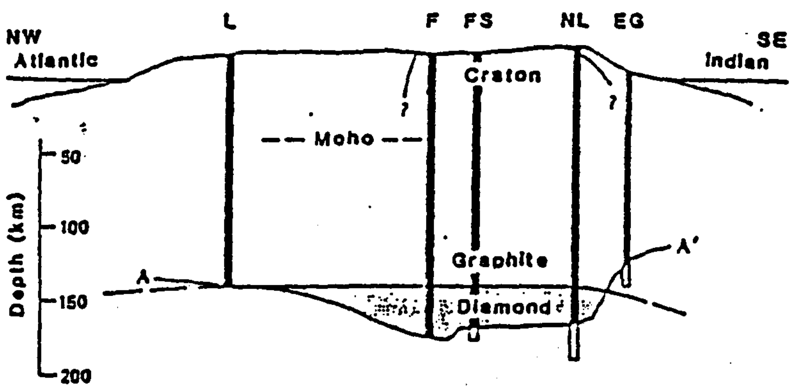
Kimberlite clusters
1. Malo-Botuobiya
2. Daldyn-Alakit
3. Muna
4. Middle Olenek
5. Lower Olenek
6. Near Lena
7. Kuonamka
8. Upper Aldan
9. Maimecha-Kotui
10. Ingily
11. Chadobets
12. Belozima (Oka)

FIGURE 3



Multiply constrained model for diamond genesis from Haggerty (1986). The subcratonic lithosphere has a crustal thickness of ~ 40 km and is bounded by mobile belts. The asthenosphere has a higher oxygen fugacity, density and temperature than the lithosphere. It is geochemically fertile and rheologically ductile in comparison. The lithosphere is dominated by harzburgite and subordinate dunite. The isotherms in the lithosphere are concave, the diamond stability field convex. Irregular eclogite pods in this model sink to the lithosphere asthenosphere contact. Infiltrating partial melts from the asthenosphere etch lithospheric diamonds. Micro diamonds are deposited on the cooler lithosphere. Types Ia and Ib form in locations as denoted in the figure. Vents K1, K2 and K3 are typical kimberlite sampling profiles. L1 is considered probable for Argyle and Ellendale (abridged from fig. 1, Haggerty 1986).

FIGURE 4



Model for the lithosphere beneath southern Africa based on geothermobarometry for xenolith suites. Ratio of depth scale to horizontal scale is 4:1 below sea level; the topography shown is greatly exaggerated. Vertical bars represent xenolith suites, and the maximum depths shown are for clusters of xenoliths of deepest origin in each suite. The line A–A' is approximately the locus of points of inflection in the xenolith geotherms, or the breaks between clusters of points for high- and low-temperature xenoliths (Fig. 5). The xenolith suites are L, Louwrencia; F, Finsch; FS, Frank Smith; NL, northern Lesotho; and EG, East Griqualand. The graphite-diamond transition is represented by a line drawn through the points of intersection of individual xenolith geotherms with the equilibrium boundary of Kennedy and Kennedy

(From : Kennedy and Kennedy, 1976)

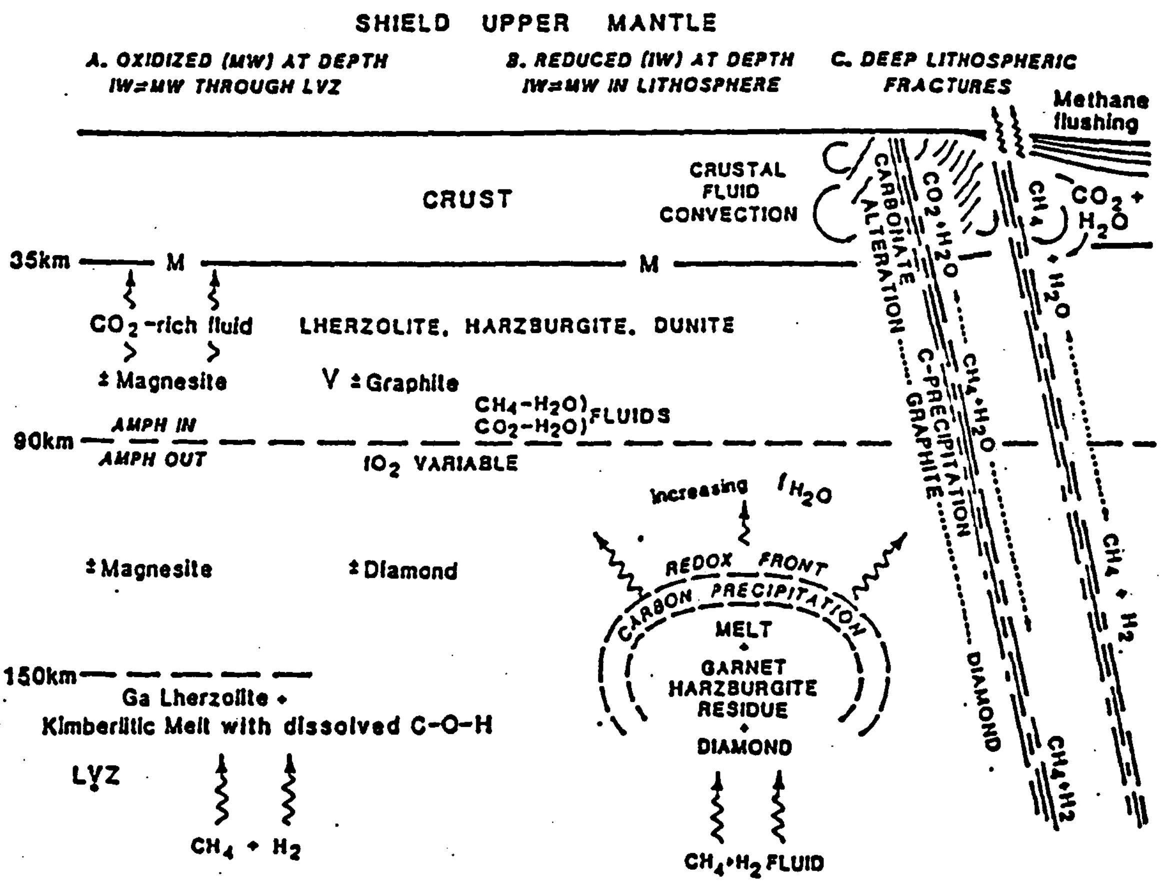
FIGURE 5

or about 40 mW/m^{-2} (Helmstaedt,1992; Boyd & Gurney,1986). Eclogitic inclusions in diamond tend to have higher temperatures (above 1100ºC) and depths of formation that may exceed 300 km (Moore & Gurney,1985; Haggerty,1986).

Diamondiferous eclogites are also restricted to on-craton areas and have an age span from the Archaean through most of the Proterozoic (Richardson,1989; Smith at al.,1989). The apparent restriction of diamondiferous kimberlite pipes to cratons is explained in terms of the depth of the continental lithosphere beneath them and the long term temperature and pressure requirements of diamond formation and preservation. Diamonds are stable at depths below about 150 to 200 km and temperatures generally not exceeding 1200ºC (Boyd et al.,1985) - conditions which appear to exist only beneath continental cratons, whose (relatively cool) Lithosphere roots may approximate 400 km in depth (Helmstaedt, 1992 ; Gurney & Moore,1992).

THE MANTLE AND KIMBERLITE

There are a number of theories regarding the origin of kimberlite. These can be grouped into several classes. The first has it sourced within the lithosphere (Gurney & Moore,1992; Harte,1983), while a second (Ringwood et al.,1992), believes that a boundary layer within the transition zone comprised of mixed domains of subducted former harzburgite and aesthenospheric "pyrolite" - an hypothetical primitive mantle source material (Nixon,1987, Ringwood et al.,1992), is the ultimate source region for both kimberlites and ocean island basalts, (Figure 6). This is based on rare earth fractionation, isotopic, trace element and geochemical similarities between



Schematic model illustrating redox interactions between reduced fluids and the subcontinental lithosphere beneath old shield regions. Different scenarios (A, B, C) illustrate alternative interactions between reduced fluids and oxidized lithosphere. (A) suggests a deep, thin asthenospheric layer (partial melt layer) in which the fO_2 change from mantle to lithosphere is accommodated within the melt. (B) illustrates 'redox melting' in which diamond-bearing refractory garnet harzburgite is left as a residue from oxidation of $CH_4 + H_2$ to $H_2O + C$ with extraction of a kimberlitic melt phase. (C) suggests a role for deep lithosphere fractures in localizing mantle fluid release and interaction of these fluids with oxidized crustal fluids at shallow depths.

(From :Taylor and Green., 1986)

FIGURE 6

kimberlite and ocean island basalts. Their analysis explains the variable composition of xenoliths which occur in kimberlite, such as eclogite and peridotite (lherzolite and/or harzburgite) which carry a similar geochemical signature to that of MORBs. They attribute this to fluid induced melting of lithosphere peridotite by hot plumes which have risen from the 600-700 km depth level. The kimberlite melt would segregate from a diapir and have elements of both mantle and subducted ocean slab. It could then cause metasomatism of eclogite ± harzburgite ± lherzolite and subsequently entrain diamonds contained within the lithosphere, transporting them to the surface via deep lithosphere fractures. Any peridotite (harzburgitic or lherzolitic) and/or eclogite inclusion(s) that the diamonds may contain is considered to be co-genetic with the diamonds and hence separate (although possibly distantly related in time and space) to similar material which may be contained within the mantle plumes or diapirs.

Others, (Taylor and Green, 1986) offer a detailed analysis which involves components of the first two but which explores the role of redox interaction between deep mantle degassing CH4 + H2-rich fluids and the peridotite or eclogite components of a subducted slab(s) and the way these fluids may in turn modify the melting relationships and oxygen activities in mantle peridotites. Haggerty (1986), Schulze (1986), and Rickard et al; (1986), believe that eclogite could be directly underplated during the Archaean "onto the base of cool, lithospheric, metasomatised, thick, sub-cratonic, upper mantle peridotite." by a shallowly subducted oceanic crust.

DIAMOND CONCENTRATE

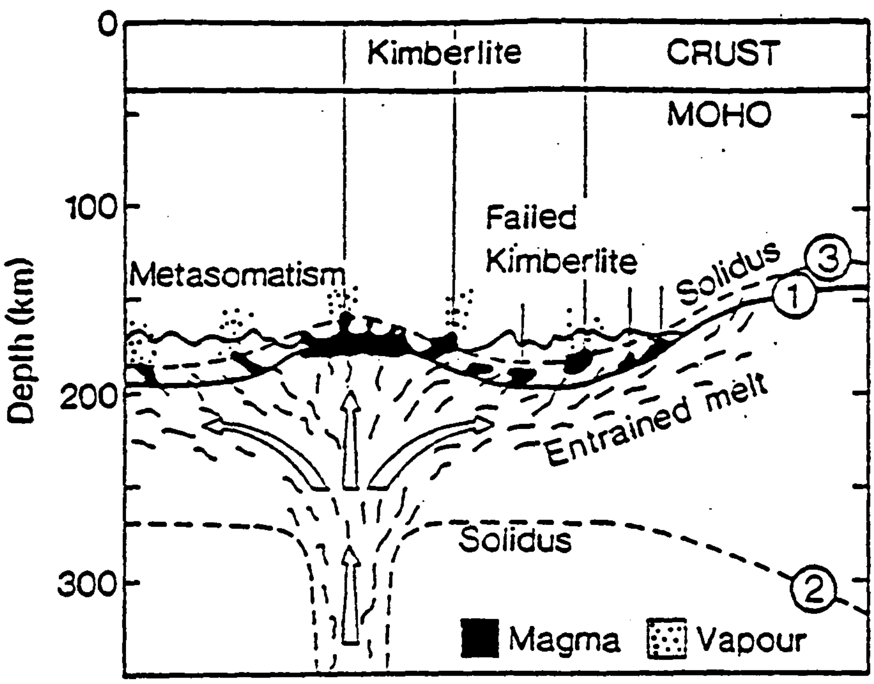
The use of various minerals to locate diamond deposits within Southern Africa, is recorded as being in common use for more than one hundred years (Gurney et al., 1991; Gurney & Moore, 1991). Early prospectors and geologists in that continent used the association of indicator minerals known to occur with diamond in their efforts to locate additional deposits. "Gravel there was in abundance, containing all the so-called 'indications' - agates, jasper, chalcedony, banded ironstones --- bandtoms of the digger". (Cornell,1920). These "indicators" were unrelated in their genesis to that of diamond and represented the fragmented components of the country rock through which kimberlite had intruded. It was not until the discovery of Koffiefontein and Jagersfontein in 1870 (Gurney et al., 1991) that it was realized that kimberlite pipes were the primary source of diamonds.

The development of sophisticated geochemical micro-analytical technology, capable of detecting elements within the parts per million range or better on extremely small samples, has enabled the more recent exploration techniques to evolve, again, using "indicator minerals". These minerals, principally chrome-rich picro-ilmenite, chrome-spinel, chrome-pyrope (peridotitic) garnet and almandine-chrome-poor pyrope (eclogitic) garnet are believed to be disagreggated mineral grains from mantle equilibrated peridotites and eclogites (Gurney & Moore,1991) which have been sampled and transported to the surface by an intrusive event(s) - either a kimberlite or lamproite (Fipke, et al.,1989).

The effect of diatreme dynamics (both pre- and post-erosional) on concentrate generation can be considerable. Many pipes have experienced multiple intrusive events, with both barren and diamondiferous intrusions occuring in the same pipe (Haggerty, 1986). The average grade may differ markedly for each intrusion, with both barren and diamondiferous intrusions occuring together (Haggerty, 1986) - De Beers mine has grades which range from 3 c 100 t^{-1} up to 60 c 100 t^{-1} (Gurney, 1986; Hatton & Gurney, 1979). It is also quite common for pipes to contain both eclogitic and peridotitic diamond inclusions and garnets and for there to be two populations of high and low temperature peridotites (Griffin et al., 1992 A). It is therefore possible/probable that an erosional dispersal train(s) from a single pipe will have mixtures of both low and high grade heavy mineral concentrate and for this dispersal train to be extensive or restricted depending on the position of the pipe in relation to topographic highs or lows (where it will be subjected to either erosional and/or depositional processes). Of the three minerals discussed in this study the order of resistance to weathering (from most resistant to least resistant) is: chrome spinel, ilmenite and garnet. Climate plays a considerable part in this with cold climates tending to slow the rate of break-down (Atkinson, 1986). In the Canadian near-arctic environment chrome diopside is reported as generally destroyed within 50 km of the source and pyrope-garnet within 150 km (The Northern Miner). In warmer and humid tropical climates rates of destruction would be accelerated and hence dispersal distances could be expected to diminish considerably. In the Kalahari of southern Africa during an exploration program some years ago, the author noted that ilmenite was the most common heavy mineral concentrate, followed by garnet and lastly by chrome spinel. These later two in quite small numbers. Presumably, the variations in ilmenite, garnet and chrome spinel reflect primary variations in the kimberlite rather than selective weathering of chrome spinel in the Kalahari (Taylor, W; pers, comm).The relative abundance of primary concentrate minerals may also change depending on the kimberlite e.g, Group 2 kimberlites and lamproites do not have ilmenite.

Kimberlites are grouped into two classes. Group 1 kimberlites have an essentially aesthenosheric MORB/OIB source -undifferentiated to slightly depleted in terms of Sr and Nd isotope systematics. Group 2 kimberlites and lamproites are derived from an essentially old metasomatically enriched lithosphere source with low Sm/Nd (Smith, 1983; Fraser et al., 1985, Helmsteadt, 1992).

Kimberlites are believed to be sourced ultimately from within the mantle, possibly the lithosphere, aesthenosphere and/or the transition zone. They may rise as hot plumes and interact with the lower lithosphere where they incorporate components of that region into their melt - including fragments of peridotite wall-rock which disaggregate to form garnet xenocrysts (Griffin et al., 1992 A). They may also sample diamonds contained in the lithospheric keel beneath a craton which are either eclogitic or peridotitic or both. Kimberlites and diamond are therefore not genetically related. Estimates are that about one percent of kimberlites carry economic grades of diamond. Many are barren and have sampled portions of the lithosphere which do not contain diamonds, e.g, they may have sampled parts of the lithosphere which fell within the graphite stability field (Figure 7). Alternatively, they may have sampled diamonds which were subsequently destroyed en-route to the surface or the kimberlite may have failed to reach the surface as it travelled upward along deep crustal fractures. The fractures are believed to be generated by a



Model for kimberlite genesis. Asthenospheric derived melts enriched in volatiles rise to the contact with the cool keel of the lithosphere. As the plume diverges laterally the melt becomes concentrated in the lithosphere and promotes lithospheric thinning. The evolution of vapour from lateral magma chambers propagates cracks through the lithosphere and the eruption of kimberlite magmas

(From : Wyllie, 1986)

FIGURE 7

combination of the (relatively low density) hot kimberlitic magma at the base of the lithosphere (which is ductile) acting to cause fracture nucleation in that region; fracture generation within the upper lithosphere (which is brittle - Black & Liegeois, 1993), developed in response to a tensile stress which exists parallel to the surface (Anderson, 1979). Although early fracture growth might be slow, once movement of the magma toward the surface has taken it out of the diamond stability field, ascent rates would need to increase appreciably to enable preservation of diamond to occur (Eggler, 1989). At a distance of about three to four kilometres from the surface, overburden loads are considered insufficient to contain a highly gaseous (CO_2, H_2O) intrusive such as a kimberlite and explosive eruption would occur.

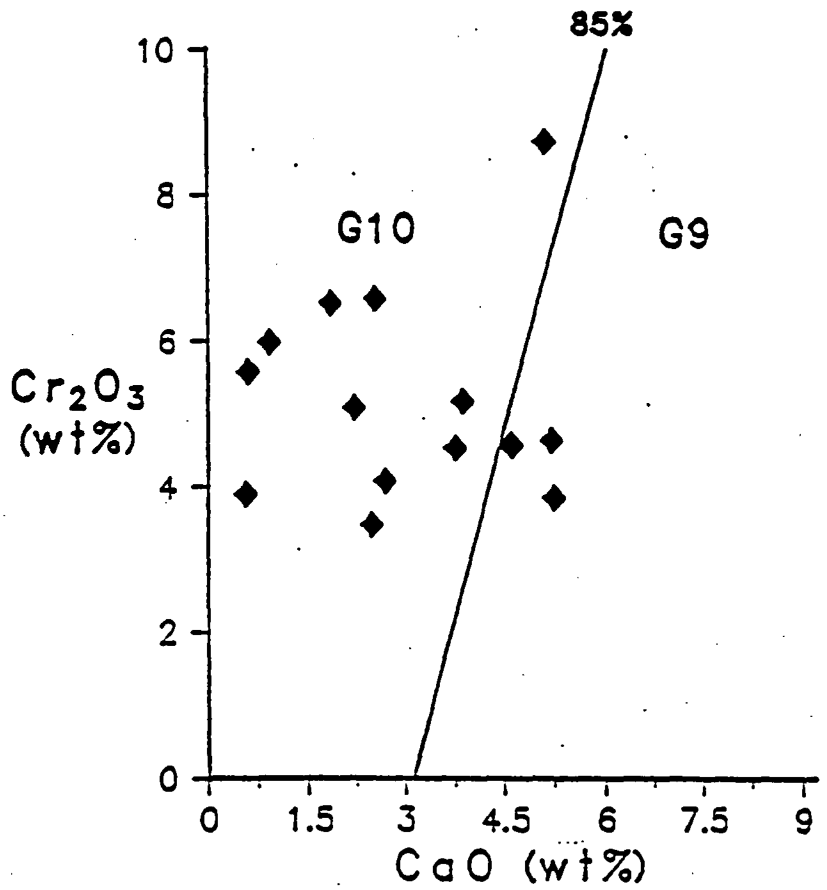
If this model is correct, it would follow that diamond is most vulnerable to destruction by oxidation (to produce CO_2) during the early stages of lower lithosphere melt accumulation and fracture nucleation. Metasomatism in the mantle may be coupled with oxidation (Ballhaus et al., 1991; Ionov & Wood, 1992) with variable oxygen states existing in any environment, including the subcontinental lithosphere (Ionov & Wood, 1992; Taylor & Green, 1986).

It is believed that diamondiferous harzburgites are preferentially disaggregated on sampling and transport to the surface due to the presence of a carbonate phase which dissociates in response to the reduced pressure whilst temperatures remain fairly high. Primary harzburgite minerals constitute a small portion of the secondary heavy mineral dispersal train, mixed up with numerous other components (Boyd & Gurney, 1982).

This reduction in the amount of expected harzburgite garnets may also be caused by conversion of harzburgite to lherzolite following introduction of Ca, Ti, Zr, Y, etc., during a metasomatic event (Griffin et al., 1992 A). Many peridotite garnets show compositional zonation which has in part been attributed to melt infiltration during a metasomatic event and to disequilibrium adjustments during changes in temperature and pressure. The most common pattern is for Cr and Ca to decrease from core to rim and for Ni, Zr, Y and Ti to become progressively enriched towards the rim. (Smith & Boyd, 1992; Smith et al., 1991) Separate grains from within the same xenolith may display Cr gradients which move in opposite directions to each other (core to rim and vice- versa). This has been attributed to mechanical intermixing of different lithologies in shear zones (Boullier & Nicolas,1973).

I have attempted to minimise any zonation which may exist by taking all analyses as near as possible to the centre of each grain and by avoiding taking analyses near fractures within grains (Soey Sie; pers, comm). It is possible that some of my analyses were on rim segments of grains rather than whole (intact) grains. I have attempted to discriminate against this by comparing their Zr/Y ratios. Those with values > 3 have been considered as affected by melt infiltration (Griffin et al., 1989; O'Reilly et al., 1991)).

By far the most common crystalline mantle material present in kimberlites are dispersed mineral grains. The proportion of grains to coherent xenoliths (in most kimberlite pipes) exceeds a ratio of >100:1. They are generally 1 to 2 mm in diameter and are believed to have crystallized in rocks, probably in association with olivine, enstatite, chromite and diamond. (Boyd & Gurney, 1986). These mineral



The CaO vs Cr_2O_3 contents of fourteen peridotitic garnet diamond inclusions from Koffiefontein. The 85% line is designed to separate calcium saturated from calcium undersaturated garnets (Gurney 1985). Diamonds on either side of the line approximate to G10 (subcalcic n = 11) and G9 (calcic n = 3) garnets after Dawson and Stephens (1975). (From : Boyd and Gurney, 1986)

FIGURE 8

grains, when eroded from a kimberlite, are the heavy minerals which hopefully, are sampled by the exploration team in search of diamonds.

Methods of Assessing Concentrate Garnets (with reference to chrome spinels and ilmenites)

A. MAJOR ELEMENT APPROACH

The major element approach of Gurney and Moore (1992) assesses the diamond potential of peridotites and eclogites in the following way. They consider that garnet harzburgite is the major diamond bearing rock type of the lithosphere followed by chromite harzburgite and then garnet lherzolite. This evaluation follows from their studies into diamond mineral inclusions and the relative proportions of each type of peridotitic and eclogitic inclusions found in diamonds.

GARNETS (Peridotitic)

Concentrations of CaO Vs Cr_2O_3 (both wt %) are plotted as has been done for diamond inclusion garnets (Figure 8). Those garnets which have values of Cr_2O_3 of < 2 wt% are considered eclogitic and those that have Cr_2O_3 values > 2 wt% are considered to be peridotitic. The diagonal line separates "G10" harzburgitic garnets to the left of the line and "G9" lherzolitic garnets to the right of the line. In general, the trend to lower Ca and higher Cr in the G10 garnets is interpreted as reflecting progressive major element depletion (extraction of low melting temperature components) and the development of harzburgites and dunites as residua from primary lherzolitic compositions through either single stage or multiple melt extraction depending on the amount of chrome in the garnets (Griffin et al., 1992 A;

Canil & Kejian, 1992). Low Ca garnets with > 4 wt% Cr_2O_3 coexisting with spinel in diamond inclusions may have been derived from an extremely Cr & Mg-rich protolith such as a very depleted harzburgite (or its hydrated equivalent-serpentinite) or dunite (Canil & Kejian, 1992). Gurney (1986) states that " there may be no genetic basis for the association between the garnets and diamonds ", being based entirely on empirical observation. The method of evaluation is semi-quantative; diamond grade is considered to be high if most of the garnets plot within the garnet harzburgite (G10) field. The fewer the garnets that plot in this field, the lower the grade.

GARNETS (Eclogitic)

To the above evaluation must be added the grade as assessed for the eclogitic component. Any eclogitic garnet that contains ≥ 0.07 wt% Na_2O (or ≥ 0.09 wt% Na_2O in Group 1 eclogites) is considered to be "significant" in diamond exploration. This is because elevated levels of Na_2O and TiO_2 are characteristic of eclogitic garnet diamond inclusions world-wide (Gurney and Moore, 1992). Therefore, the more of these there are the higher the grade. A plot is made of Na_2O Vs TiO_2 (Figure 9). The irregularly shaped field has been developed by plotting the results of analyses of eclogite which were found as inclusions for diamonds from world-wide localities. Elevated levels of TiO_2 are also considered significant in diamond exploration.

CLINOPYROXENE (Eclogitic)

Clinopyroxenes derived from diamondiferous Group 1 Eclogites (MacGregor and Carter, 1970) are expected to have an average K_2O content ≥ 0.08 wt% (McCandless & Gurney, 1986). They were not included in this study.

A plot of TiO_2 versus Na_2O for eclogitic diamond inclusion garnets from world-wide localities. Note that the elevated levels of both these elements is characteristic of eclogitic garnets associated with diamonds. In prospecting samples, garnets with $Na_2O > 0.07$ wt% are considered significant. Symbols o = southern Africa; x = Australia; * = North America; + = USSR. (From : Fipke et al., 1989)

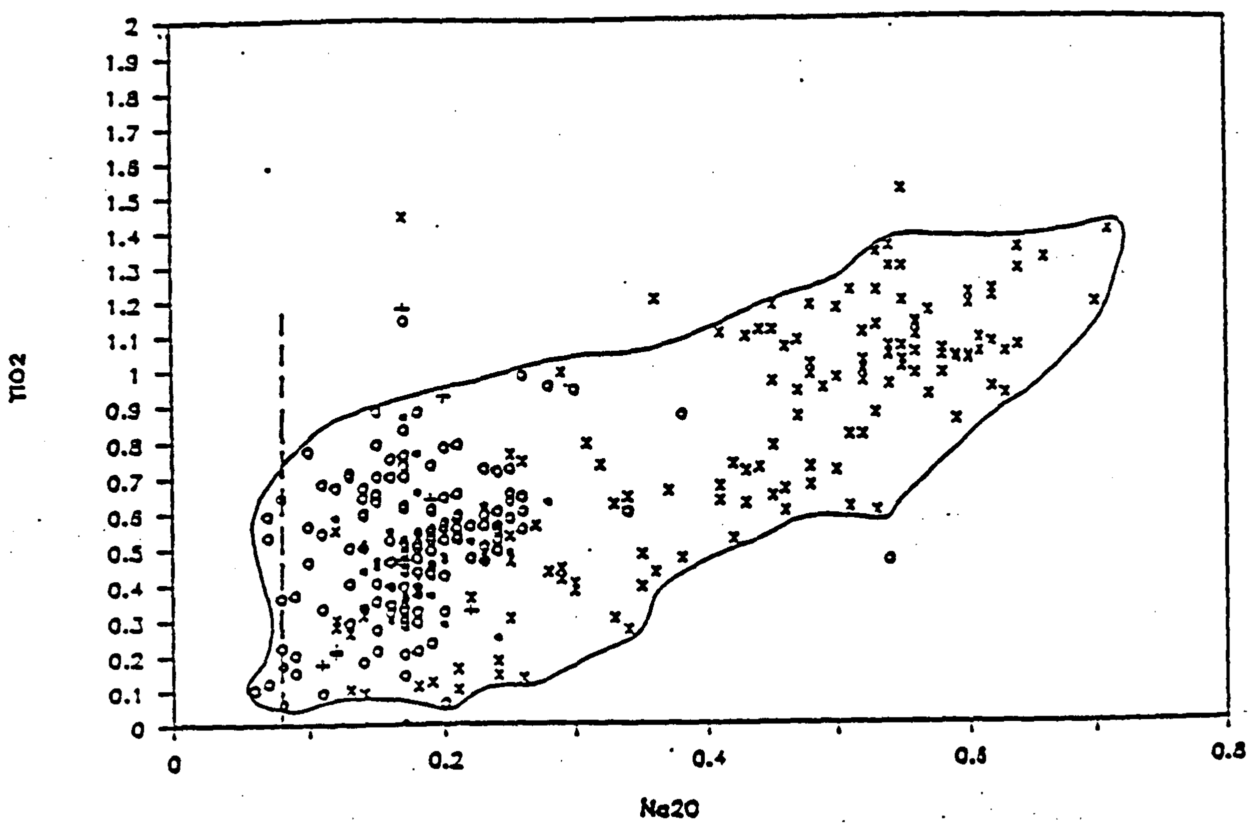


FIGURE 9

A plot of MgO Vs Cr_2O_3 for chromite diamond incusions from world-wide localities. Note the highly restricted chrome-rich character of the inclusions The preferred compositional field for exploration applications which incudes >90% of the data points is indicated. (From : Gurney and Moore, 1991)

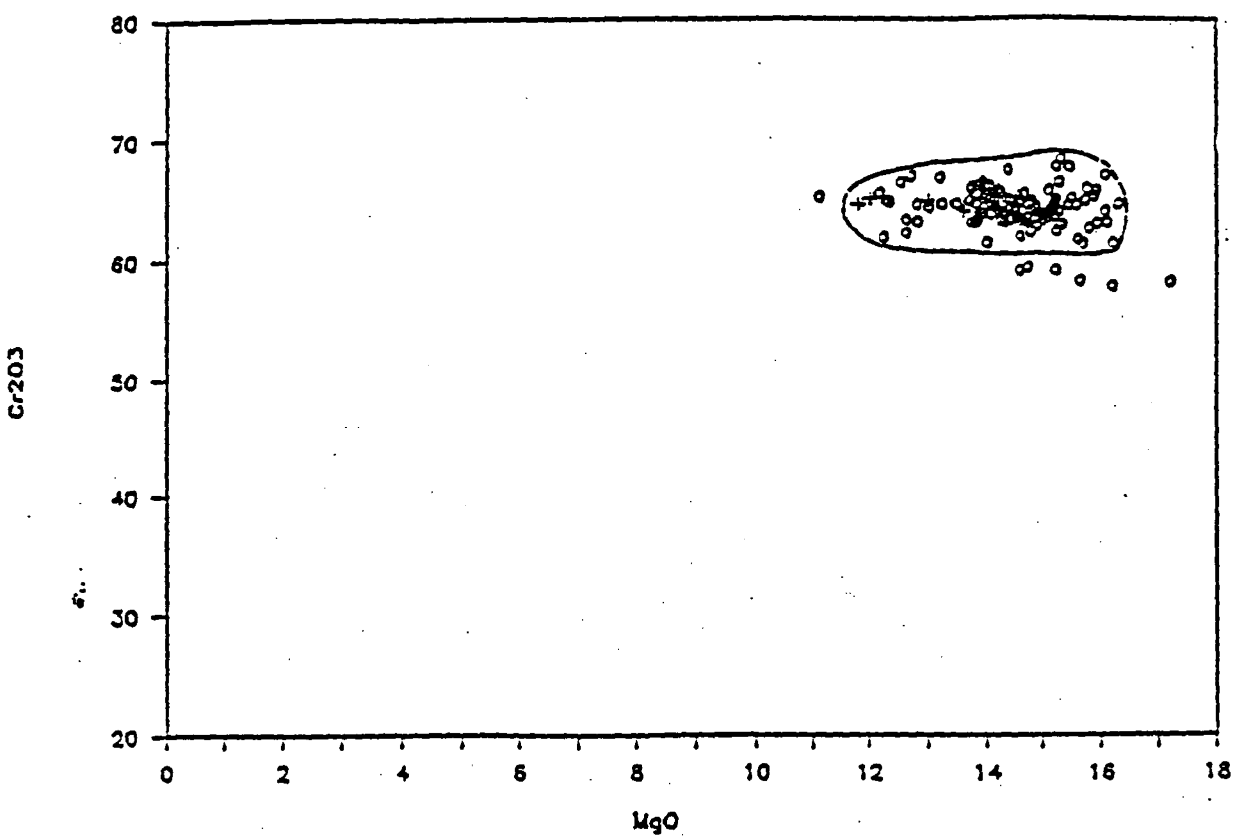


FIGURE 10

CHROMITES (Peridotitic)

A plot of MgO Vs Cr_2O_3 (Figure 10) is made for chromites derived from disaggregated chromite harzburgite. The small circular field indicates where analyses for 85% of chromite inclusions found in diamonds plot. Any concentrate with chromite that plots in this field would be considered to have good potential to have been derived from the diamond stability field. The more that plot within the field, the higher the grade.

GARNETS (Megacryst)

These are derived from coarse single crystals/discrete nodules, which may have differentiated from a magma possibly related to the host kimberlite (Schulze, 1987). In southern Africa megacryst minerals are almost always present in Group 1 kimberlites but are rare in Group 2 rocks (Hops et al., 1986). In this study I have discriminated against megacryst garnets initially, by selecting only garnet grains which appeared unbroken, did not contain fractures and which were less than 2 mm in size (all of the concentrate was ≤ 2mm in size). Most megacryst suites show a negative correlation between temperature and Cr_2O_3 (Shulze, 1987) and I have made plots of these two variables based on their Cameca analyses and their temperature as determined by the nickel geothermometer - $T_{(Ni)}$. Although garnets in high temperature megacryst nodules from Jagersfontein have Mg#s of 81-86 and those from the Cr-poor megacryst suite have Mg#s of 75-82 (J.J. Hops et al.,), elsewhere (Schulze, 1987, Eggler et al., 1979) it has been observed that significant differences in megacryst composition may occur between pipes with the more general features applying world-wide. A determination of which garnet grains, if any, from these nine kimberlite concentrates, are megacrystal in origin would require a separate study in order to more fully discriminate for their (possible) effects. Their mg#s are included in the table provided.

ILMENITE

These may provide an indication of the redox state that existed at their point(s) of incorporation into the kimberlite. Ilmenites with low Fe^{3+}/Fe^{2+} ratios and relatively high Cr and Mg from southern Africa are associated with higher diamond content (Gurney, 1989; Gurney & Moore, 1992; Nixon & Condliffe, 1986).

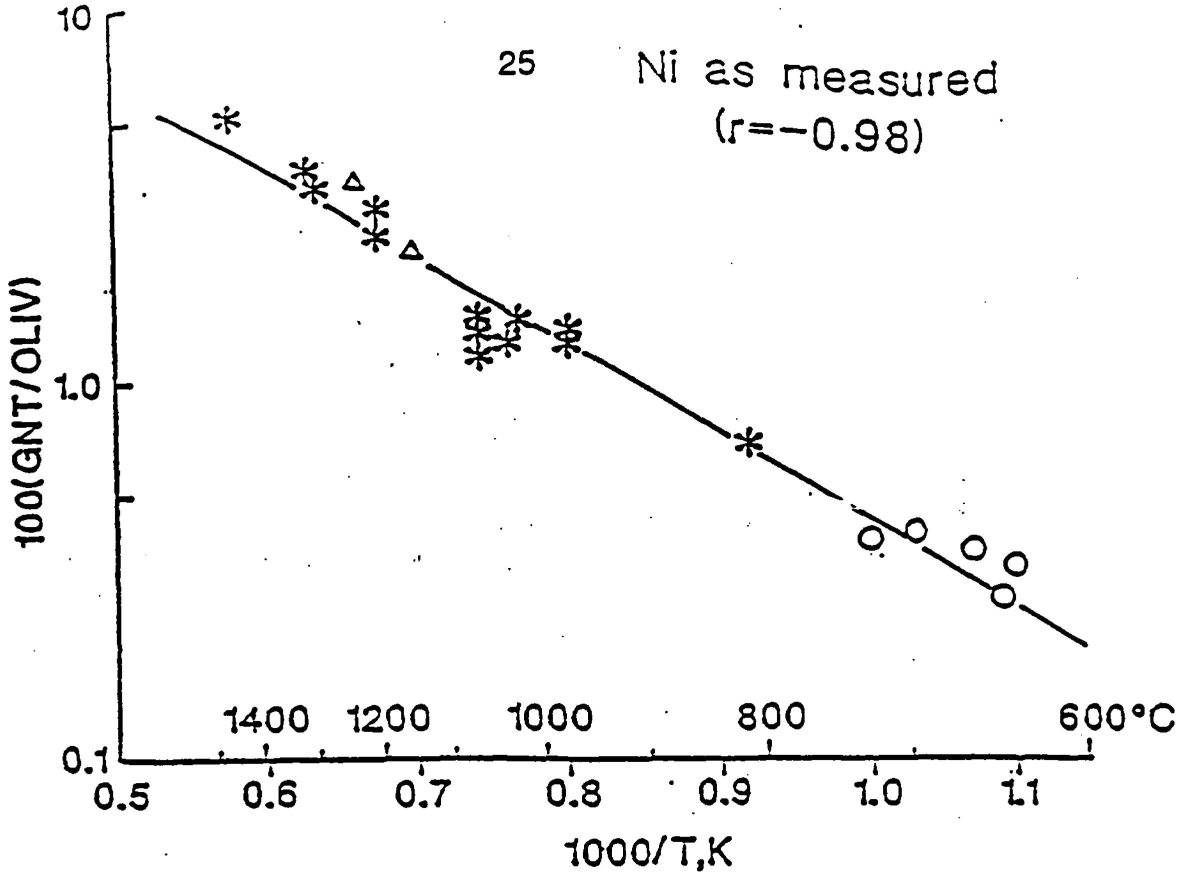
B. THE NICKEL GEOTHERMOMETER (Summarised from Griffin et al., 1989)

Examination of garnet-peridotite xenoliths from kimberlites by proton microprobe analysis shows that partitioning of nickel between chrome pyrope garnet and olivine is strongly temperature dependent. In terms of its nickel content, olivine has a small range (in ppm) and is considered to have a reasonably fixed composition relative to the garnet, which increases its nickel content as temperature increases. This relationship is linear (Figure 11) and the equation of the regression line obtained from plotting (ppm Ni in garnet/ppm Ni in olivine) Vs Temperature is used to directly calculate the temperature of equilibration of a garnet grain once the concentration of nickel within it is determined. The equation is :

$$T, ^{\circ}C = \{1000/[-.435 \log_{10}(Ni_{gnt}/30) + 0.83]\} - 273$$

The main assumptions made in the use of the nickel geothermometer are:

• That the chrome pyrope garnet is in equilibrium with olivine and is not derived from pyroxenites of the chrome diopside peridotite suite (and thus equilibrated with clino ± orthopyroxene rather than with olivine). If this is correct then the linear relationship should hold.



Plot illustrating the linear relationship which suggests that Ni partitioning between garnet and olivine should be mainly temperature dependent. (From : Griffin et al., 1989)

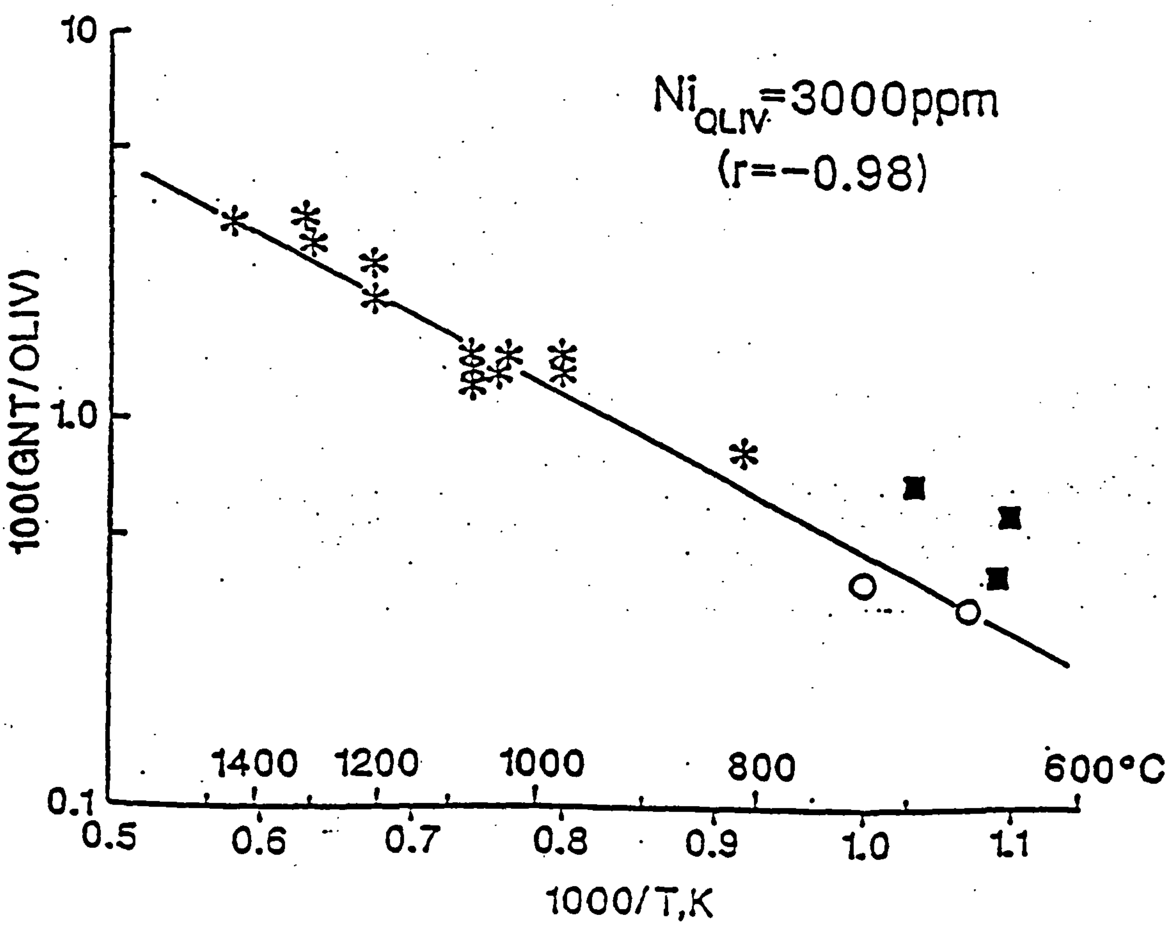


FIGURE 11

• Although it appears to be insensitive to large variations in the Ca, Al and Cr contents of the garnets, it is possible that variations in Fe/Mg may introduce an error of ≤10% in the temperature estimate, this is relevant where Fe-rich peridotites are concerned.

• That the estimate used for the paleogeotherm for the location being studied is accurate.

Provided these assumptions and conditions are met the method of Griffin et al., give estimates for the temperature of crystallisation of chrome pyrope garnets (predominantly "G9"s in their studies) which are within about ± 50ºC of expected values. In common with the major element approach (Gurney and Moore,1992) any assessment of diamond potential is a semi-quantative one. Histogram plots of temperature Vs Number of samples (in this case individual chrome pyrope garnet grains) are made and a vertical line is drawn through the 1000ºC position (Figure 12). This represents the approximate intersection of the graphite-diamond reaction curve in an area with a cratonic geotherm. A high proportion of garnets from diamondiferous pipes give nickel temperatures of 950 to 1250 ºC, (Griffin et al.,1990) consistent with the temperatures estimated for diamond formation and preservation. These temperatures are representative of those that existed at the time of the garnets ± diamonds entrainment in the rising plume/diapir. The temperatures obtained for the concentrate peridotitic garnets could be expected to extend over a larger range than that determined for equivalent diamond inclusion garnets (Griffin et al., 1992 A; Daniels & Gurney, 1991) - also Figure 12 -. The lower temperatures may be attributed to those garnets which have equilibrated in the graphite stability field while the higher temperatures may be related to metasomatism. Histograms of garnet T_{Ni} often display two (or more) peaks;

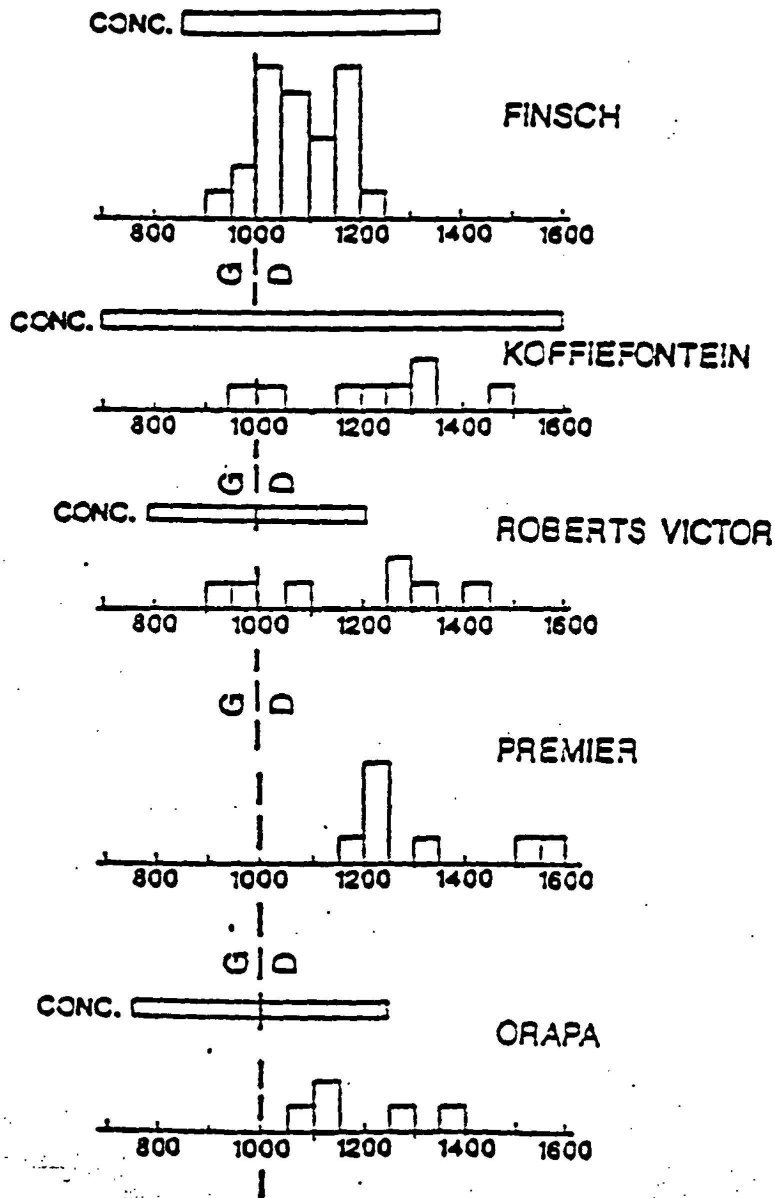


Fig. 6. Distribution of Ni temperatures (assumed Ni in olivine = 3000 ppm) for DI garnets and concentrate garnets from individual pipes. *G*, graphite; *D*, diamond. All temperatures in °C

(From : Griffin et al., 1992.A)

FIGURE 12

recording different thermal histories for concentrate garnets as well as for populations of garnets from multiple sampling/intrusive events. Generally, the temperatures obtained for diamond inclusion garnets will be higher than those obtained for concentrate garnets from the same pipe. This is believed to be due to cooling of the peridotitic mantle following formation of the diamonds (Griffin et al., 1992 A). High temperature garnets, with T > approximately 1300ºC, may indicate a heating event in the mantle which could have destroyed any diamonds before sampling (Taylor pers, comm.).

The nickel geothermometer cannot be used on eclogitic garnets because eclogitic garnets would not have equilibrated with olivine.

THE MANTLE SAMPLE

Both methods attempt to ascertain whether or not a given concentrate was derived from within the diamond stability field. This is then related to potential diamond grade assuming diamonds have in fact been sampled. (Gurney & Moore, 1992). Very little is known about the distribution or grade of diamonds that exist in the lithosphere, except that which has been provided from the study of known kimberlites and lamproites. In areal extent they represent a very small percentage of the total upper mantle region. In general, eclogite appears to source higher diamond grades than peridotite, this is believed to be related to their greater depth of origin (Helmsteadt, 1992). As peridotite type diamond inclusions are believed to outnumber eclogitic diamond inclusions by about 3:1 (Kirkley et al., 1992) it has been assumed that this is the relative proportions of diamonds to be found in these rock types world-wide.

SAMPLES

Thirty garnets were selected from each of nine heavy mineral concentrates. A table is provided in the appendix giving the location of each pipe, its known diamond grade (e.g. high, medium, low or zero), whether off-craton or on-craton, and whether economic or non-economic. The concentrates were from southern Africa (Roberts Victor, Koffiefontein, Rietfontein, Mothae, Nouzee, Orapa) and Yakutia (Leningradskaya, Zarnitsa, Udachnaya). They were not pre-picked to remove G10's etc. (Gurney; pers, comm). This amount was selected for analysis because it exceeds (in number of grains) the amount of concentrate which may be encountered during the earlier stages of an exploration program (Gent, 1992,). As pointed out previously, there is often less.

The garnets were selected on the basis of their colour, being a mix of mainly purple and orange with some browns, except in the case of Orapa where all garnets chosen were eclogitic (orange) and Roberts Victor (predominantly eclogitic garnets) for which I selected peridotitic (purple) garnets in order to obtain adequate proton probe data. I also expected to find the most G10's in this sample and wanted to see how many of my selection would plot into the G10 field (using CaO wt% vs Cr_2O_3 wt%).

The grain samples were in the 1-2mm size range except for the Yakutian samples which were generally about 1 mm in diameter. Identification of garnet type on the basis of colour can be difficult. Eclogitic and peridotitic populations are reasonably easy to separate but further division into harzburgitic vs lherzolitic is not as straight-forward. Identification by major element analysis using the electron probe is necessary.

All sample grains were mounted in epoxy resin and polished and polished in the lapidary section the Geology Department. A coating of carbon was then placed onto the surface of the mount. This was carried out by staff at the Central Scientific Laboratory.

ANALYTICAL TECHNIQUES

A. CAMECA (SX-50)

Major element chemistry was determined by analysis on the Cameca SX-50 microanalyser using natural mineral standards with a GARNET label and an accelerating voltage setting of 15kV, a beam current of 20 nA and a beam size of 20 µm diameter. The average analytical time per sample was 2 minutes and 40 seconds. All elements were analysed for twenty seconds at the peak position and for ten seconds each side of the peak i.e, ten seconds for the background count. The counting times and detection limits for each element are provided in appendix 4. Ferric ion in garnet was calculated assuming perfect stoichiometry with eight cations to twelve anions. The iron oxide analyses were recalculated based on the cation total and the results are presented in the Garnet Data (Cameca SX-50) table.

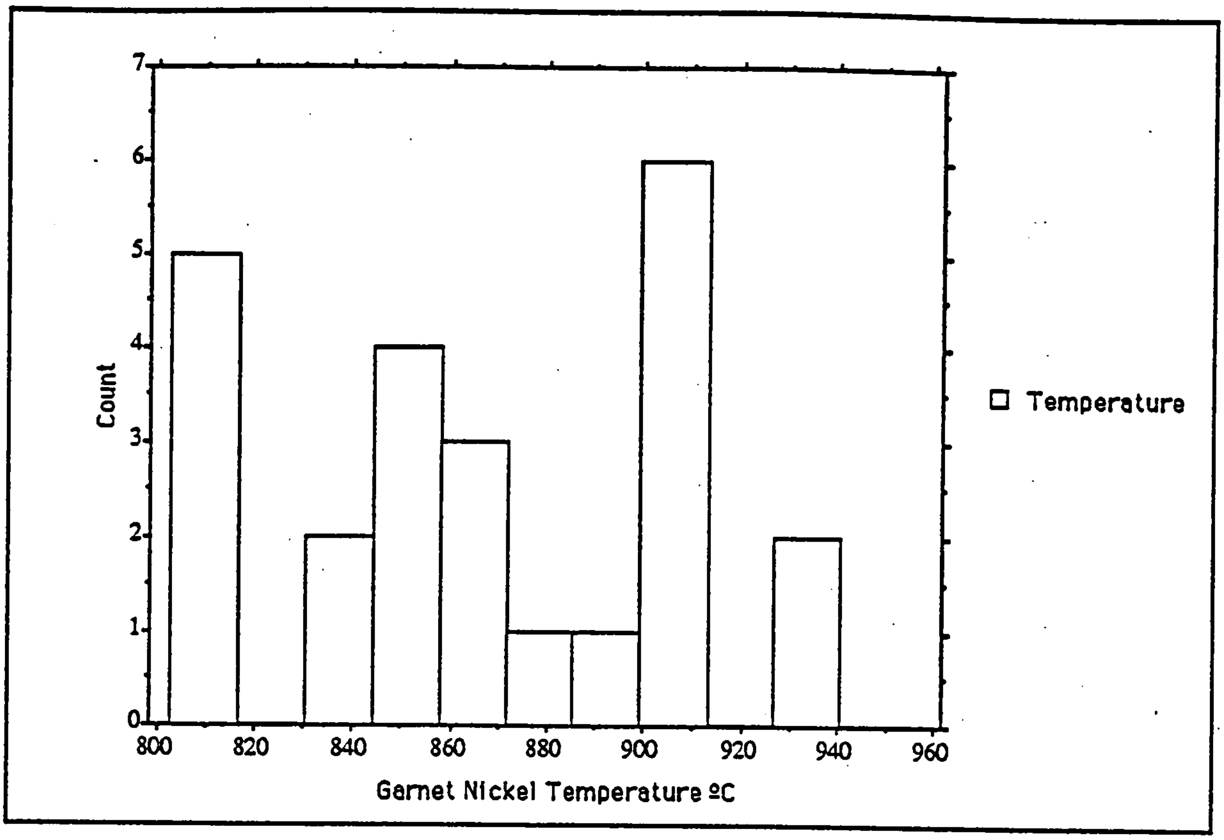
B. PROTON PROBE (PIXIE)

The proton microprobe at the CSIRO's Heavy Ion Analytical Facility in Sydney offers analytical capabilities approximately two orders of magnitude or better than that obtainable by the electron microprobe (Sie et al., 1990). The current is generated by a model 1430 Tandetron linear accelerator operating at up to 3 MV. The microbeam developed is passed through a (magnetic) beam bender and through an electrostatic "Russian" quadrupole lens where it is focused down to a diameter of 15μm at 6nA. This was the beam size used in these analyses. The proton beam penetrates the garnet samples between 50 and 60 μm. Several samples were too thin and the analyses were discarded. The beam was unable to be focused on several samples because they had been positioned too near to the edge of their mount. The positioning of grains on a sample mount is critical due to this restriction of lateral focusing of the proton beam. These restrictions do not apply to the Cameca SX-50. The analytical time of the proton microprobe averaged about three minutes. All analyses were run using detector #17. Due to temporary limitations on the stabilization of the beam current, it was necessary to normalise the trace element data against the FeO (total) analyses determined on the Cameca SX-50. Adjustments were then made to the nickel values (all in ppm) as determined by the proton probe. Recalculated Ni values were then used according to the method of Griffin et. al., (1989) to calculate the temperature of equilibration of the peridotitic garnets. Generally there was good agreement between the Cameca SX-50 and the HIAF proton probe data sets. Where there was significant disagreement (± 30% variation) the proton probe analyses were rejected and the data thus obtained was not used in this study.

RESULTS

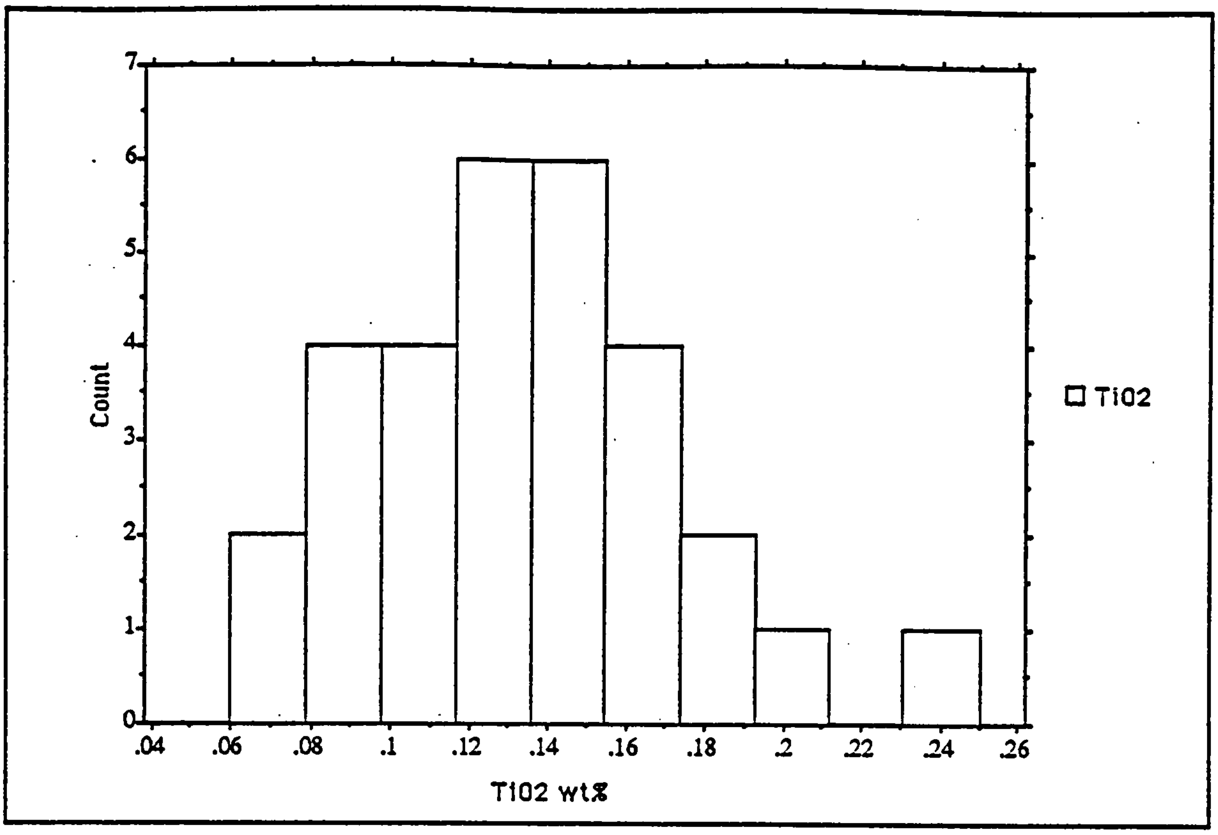
ROBERTS VICTOR

The histogram of T_{Ni} for garnets from Roberts Victor (Figure 13) has three main peaks at 810ºC, 860ºC and 915ºC with eight out of 24 being ≥ 900ºC. (but all are less than the 1000ºC cut-off for diamond stability on a cratonic paleo-geotherm as used by Griffin et .al., 1989). with no garnet having a T_{Ni} ≥ 940ºC. The majority (19 out of 24) were much less than the T_{Ni} found for most diamond inclusion garnets from Roberts Victor which averaged 1300ºC (Griffin et al, 1992 A), however there is good agreement with the RV41A diamond inclusion garnet from Griffin et al.,'s study which has a T_{Ni} of 941ºC. The Histogram (Figure 14) for TiO_2 (wt%) supports this as it indicates that 28 out of the thirty garnets were derived from low temperature peridotites, i.e, they have ≤0.2 wt% TiO_2. Low temperature peridotite suites have a maximum temperature of equilibration of 1100 ºC. Major element analyses for CaO Vs Cr_2O_3 (Figure 15) show that these are all lherzolitic "G9" garnets. The plot of Cr_2O_3 Vs temperature, (Schulze, 1987 and Figure 16) suggests that this concentrate sample did not include components of a megacryst garnet suite. Twenty six out of thirty garnets had Zr/Y ratios of 1-3 which indicates that they were substantially unaffected by metasomatism. Roberts Victor has an average grade of 42c per 100 tonnes. An evaluation based only on the presence or absence of G10 garnets would assess this as being derived from an uneconomic prospect. An evaluation based solely on the information provided by the garnet-nickel geothermometer would also have reached the same conclusion due to the lack of garnets which had a T_{Ni} of 1000ºC or greater.



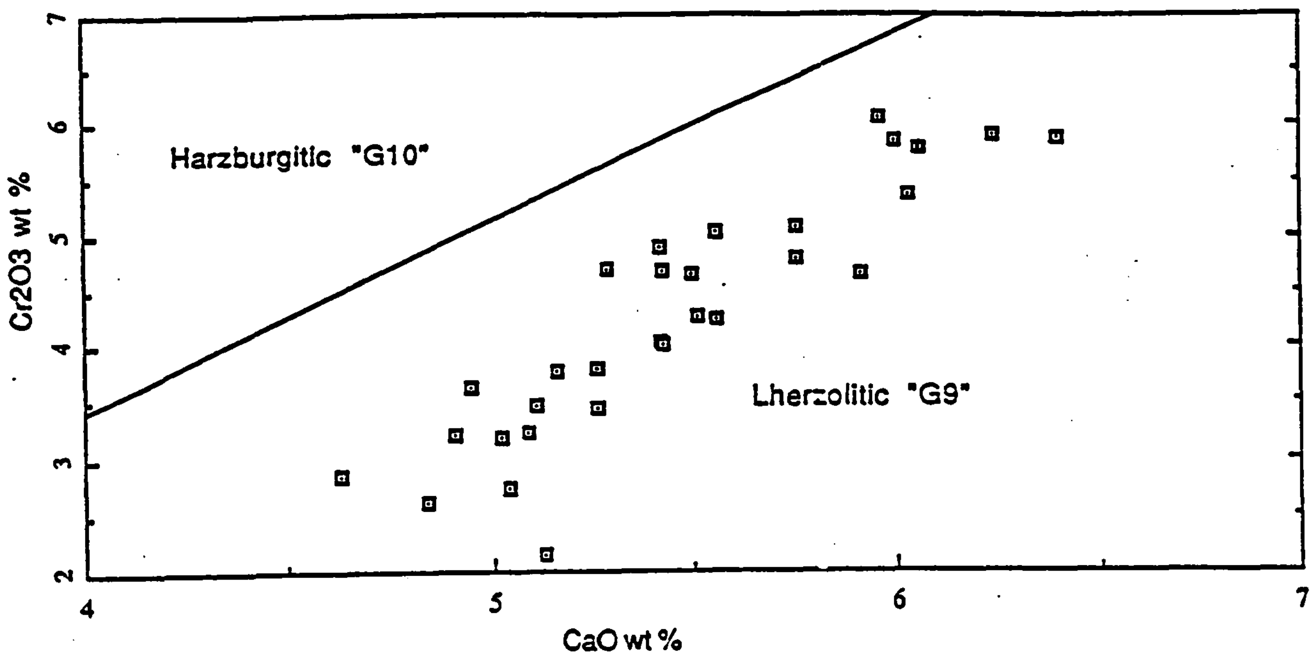
Histogram of garnet-nickel temperatures for concentrate garnets from Roberts Victor. All garnets are low temperature (≤ 1000ºC) and are considered to have been too cool to have been derived from within the diamond stability field. (see Griffin et al, 1992 A)

FIGURE 13



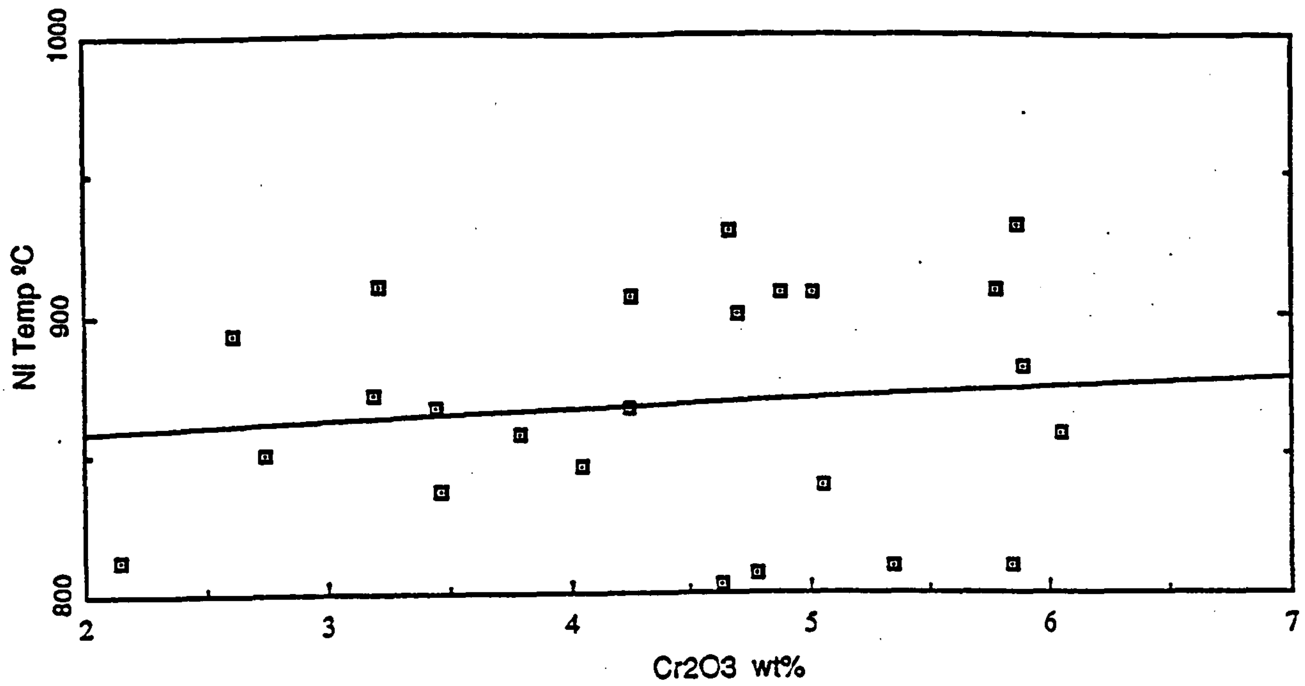
Histogram of TiO_2 wt% for Roberts Victor. Twenty eight of the thirty garnets have ≤ 0.2 wt% TiO_2 and are therefore classified as being derived from a low temperature peridotite. This interpretation is supported by the garnet-nickel temperatures determined for the same garnets. (see Boyd. F.R, 1987 and Griffin et al, 1989)

FIGURE 14



Plot of CaO Vs Cr2O3 (both wt%) for concentrate garnets from Roberts Victor.All garnets (n=30) are peridotitic and plot within the lherzolitic 'G9' field. The diagonal line separates harzburgitic 'G10' garnets from lherzolitic 'G9' garnets. A horizontal line is normally drawn at 2 wt% Cr2O3 (which in this case is the lower margin of the border for the plot) and this is used to separate peridotitic G10 and G9 garnets from the (low Cr2O3) eclogitic garnets. (See Gurney and Moore, 1991).

FIGURE 15

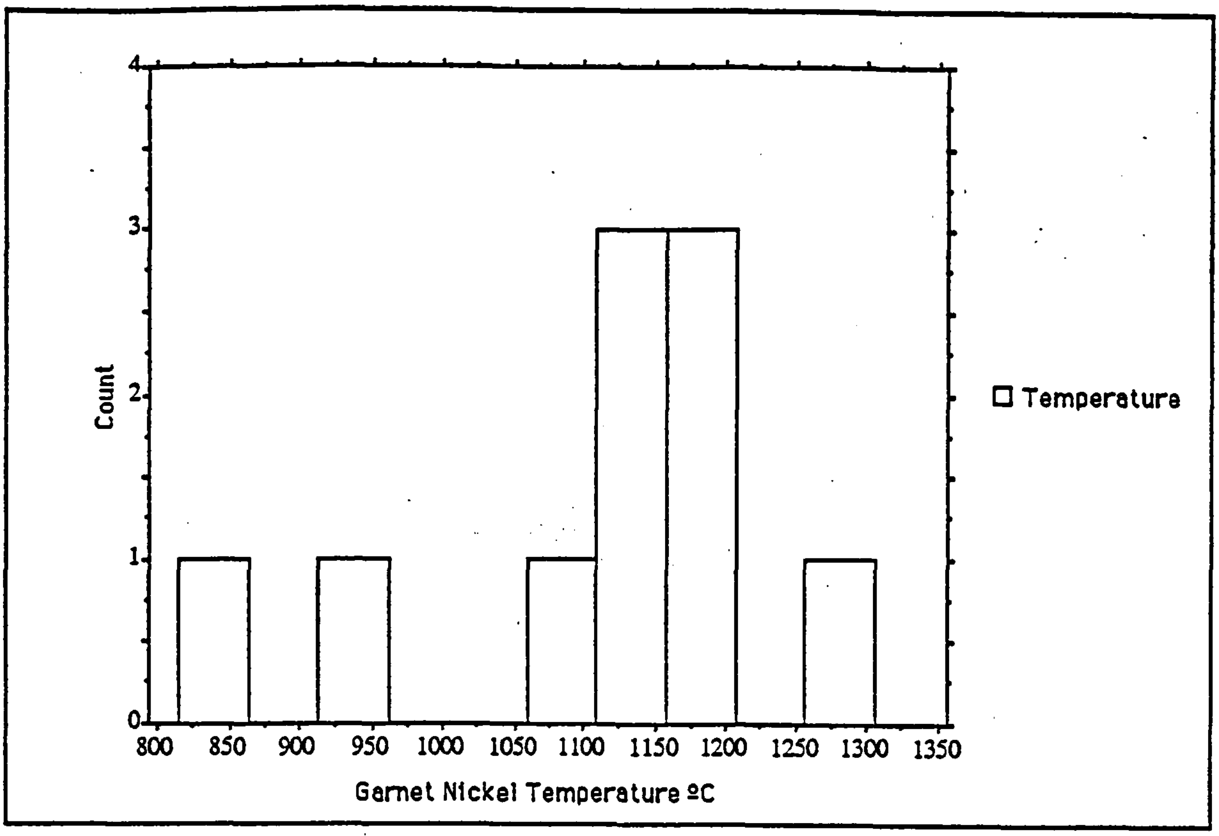


Plot of Cr2O3 Vs garnet equilibration temperature (as determined by the garnet nickel geothermometer for Roberts Victor garnet concentrate. This type of plot is used to determine whether the garnets are megacrystal in origin. The horizontal line is the line-of-best-fit (regression line). A negative correlation of Cr2O3 with increasing temperature would indicate that some or all of the garnets may have been derived from a megacryst(s). (See Schulze, 1987).

FIGURE 16

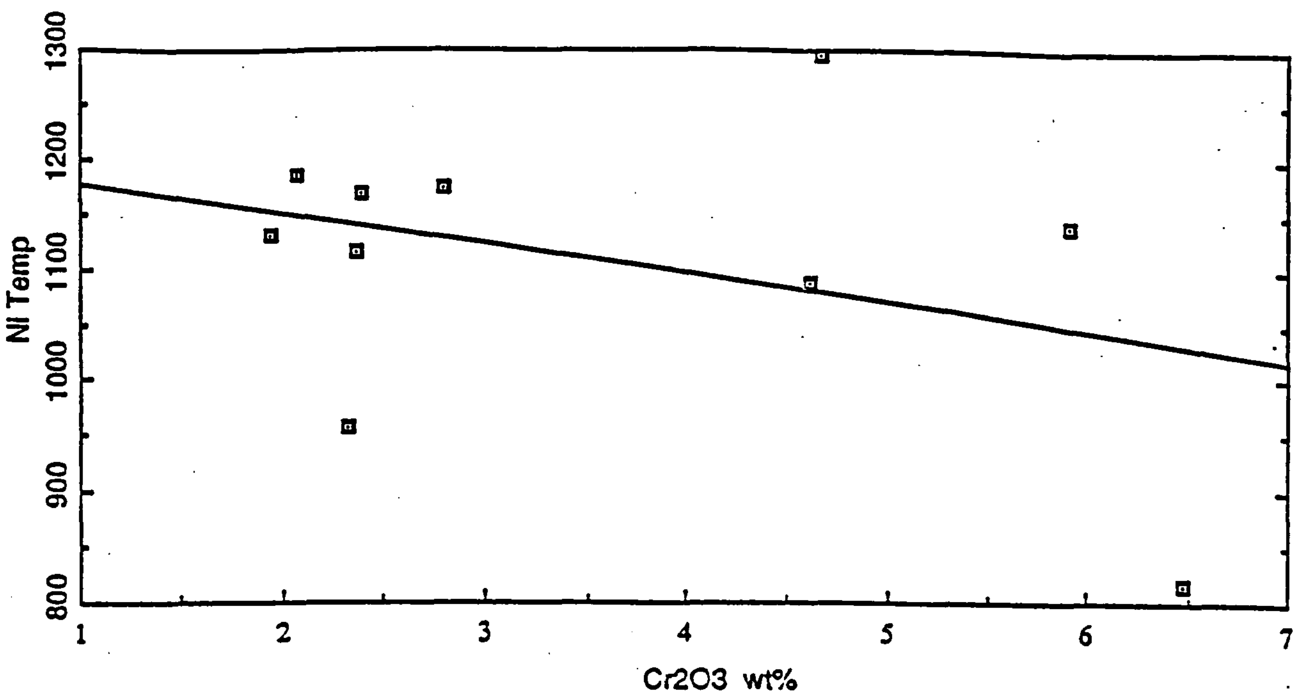
KOFFIEFONTEIN

The histogram for T_{Ni} for garnets from this concentrate (Figure 17) shows a single strong peak at 1150ºC. The average temperature (T_{Ni}) for these garnets was 1107ºC (n=10) which is in good agreement with those obtained by studies of diamond inclusion garnets (Griffin et al., 1992 A) for this kimberlite and which ranged from 967ºC to 1295ºC. The TiO_2 histogram (Figure 21) classifies nine of the ten peridotitic garnets as being derived from a high temperature peridotite. Zr/Y values were mostly between 3.5 & 4.5 indicating that they may have undergone some metasomatism. A plot of $T_{(Ni)}$ Vs Cr_2O_3 (Figure 18), gave a moderately negative correlation. Examination of the plot showed that this regression line was being produced by the two lower temperature garnet grains (816ºC and 957ºC). With such a small database (n=10), a small deviation from the norm can produce significant line-of best- fit errors. The agreement of the $T_{Ni's}$ for these garnets with those found independently (Griffin et al., 1992 A) would support the tentative conclusion that the garnets had not (substantially) been derived from a megacryst suite. Of the eleven eclogitic garnets in this concentrate (Figure 19) eight had ≥ 0.07 wt% Na_2O (73%) - see and would also plot within the world-wide eclogitic diamond inclusion field (Figure 20 and Figure 9) which would be considered significant in terms of diamond potential. Together, the major element analyses and the garnet-nickel geothermometer indicate that these garnets may have been derived from a potentially diamondiferous kimberlite which was sourced from within the diamond stability field.



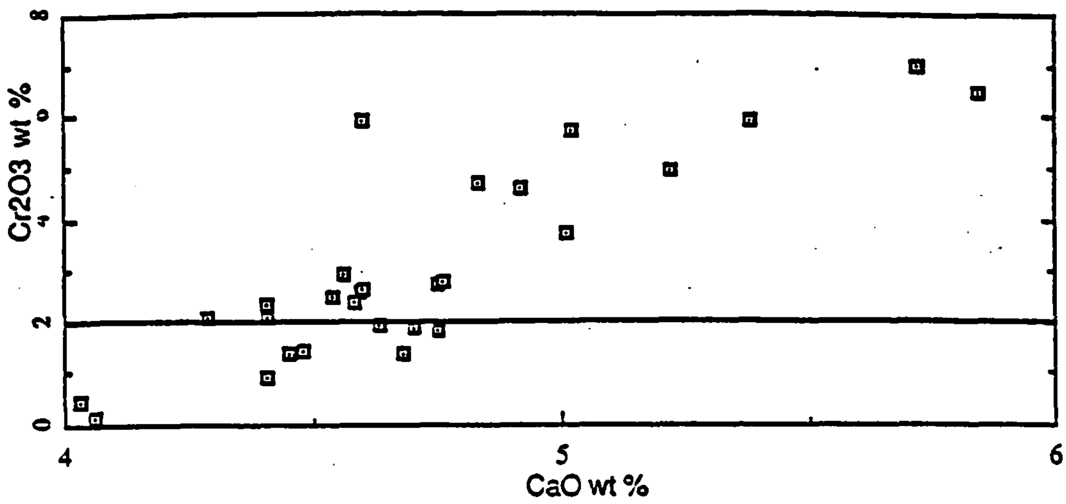
Histogram of garnet-nickel temperatures for concentrate garnets from Koffiefontein. The main peak at about 1150ºC is consistent with an interpretation for these garnets having been derived from a moderate to high grade diamondiferous kimberlite. (see Griffin et al, 1992 A)

FIGURE 17



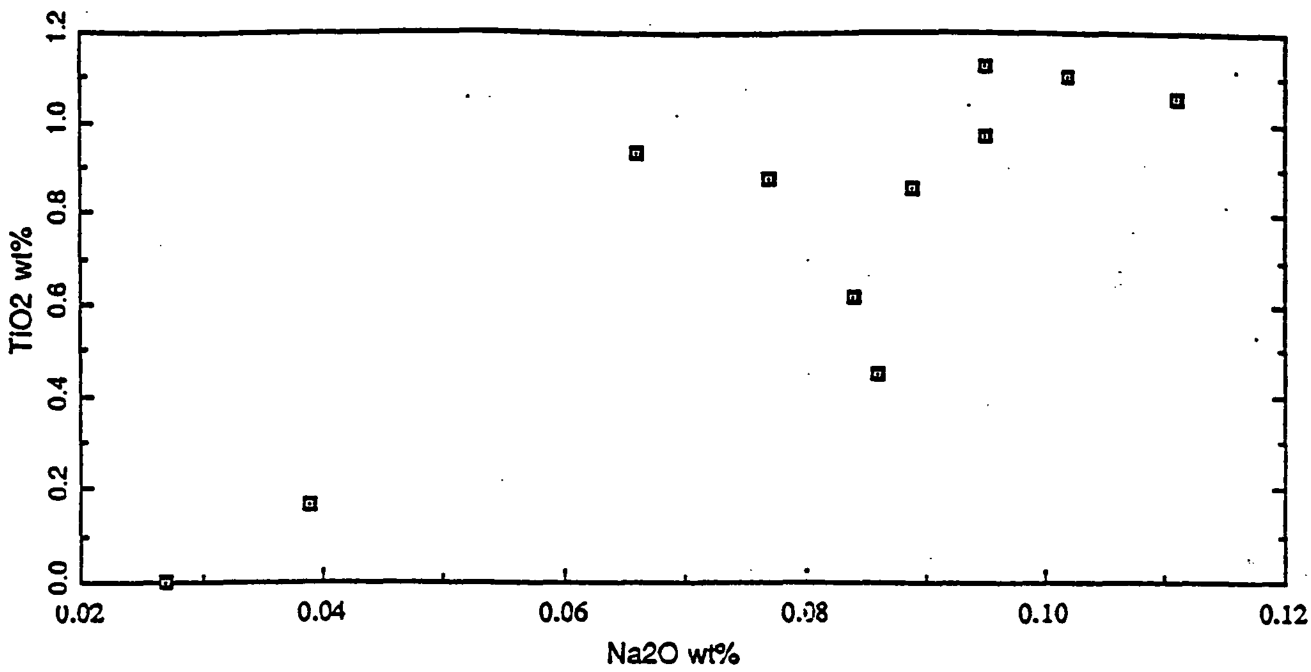
Plot of Cr2O3 Vs garnet equilibration temperature (as determined by the garnet nickel geothermometer for Koffiefontein. Cr2O3 displays a negative correlation against temperature (see the diagonal line-of-best-fit) indicating a possible megacrystal component exists in this sample. The small data base (n=10) used however, makes this statistically uncertain. For example, if the lower two temperature garnets were removed the plot would exhibit a positive correlation for Cr2O3 against temperature. (See Schulze, 1987).

FIGURE 18



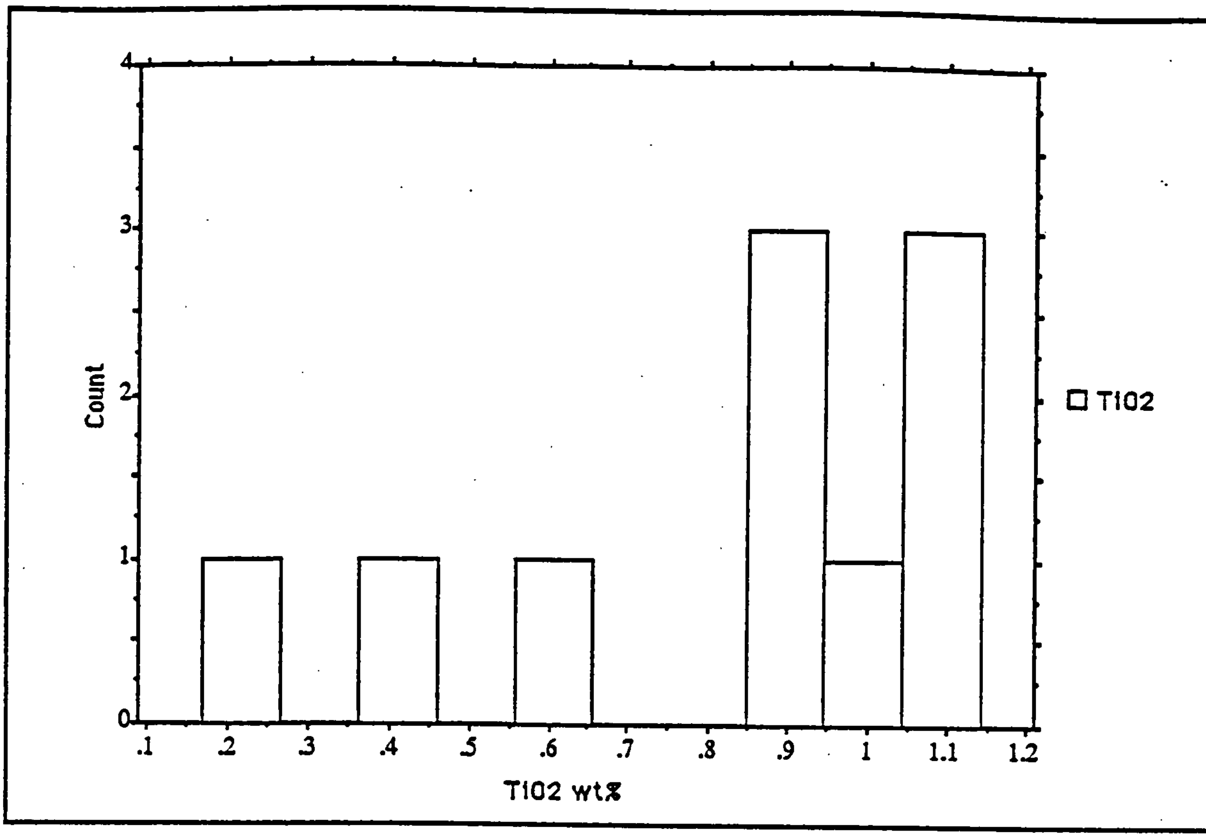
Plot of CaO Vs Cr_2O_3 for concentrate garnets from Koffiefontein. Those plotting below the horizontal line are classified as eclogitic. Those plotting above the horizontal line are all classified as lherzolitic 'G9's'. There are no G10 garnets in this sample.(See Gurney and Moore, 1991).

FIGURE 19



Plot of Na_2O Vs TiO_2 for eclogitic concentrate garnets from Koffiefontein. Five of the garnets plot within the significant field (see Figure 9) for diamond inclusion eclogitic garnets from world-wide localities. (See Gurney and Moore, 1991).

FIGURE 20

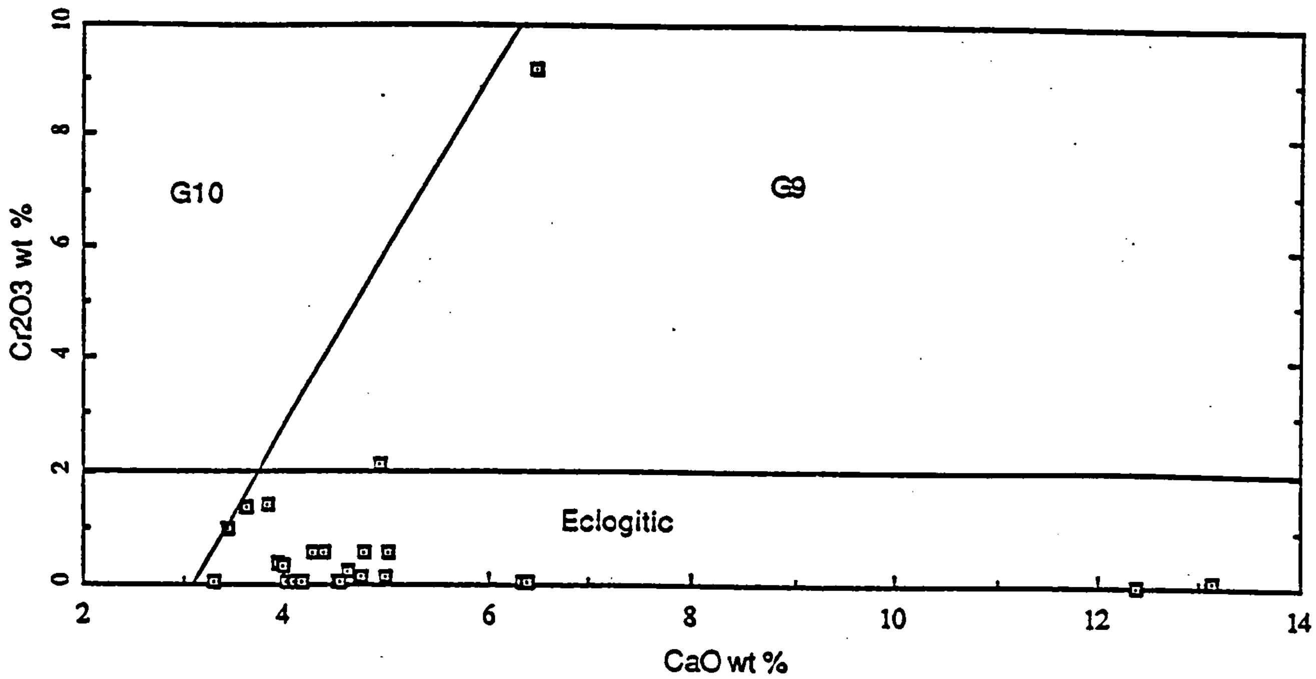


Histogram of TiO_2 wt% for Koffiefontein. Nine of the ten garnets are classified as being derived from a high temperature peridotite. (see Boyd. F.R, 1987)

FIGURE 21

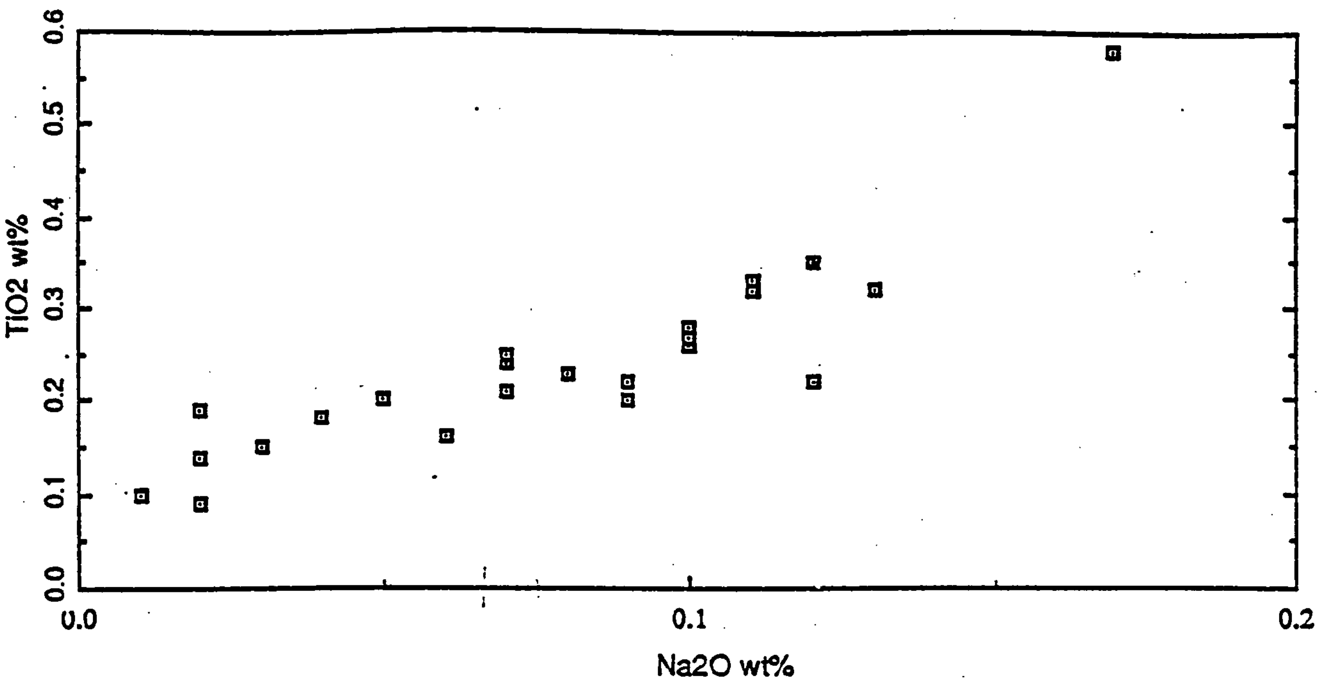
RIETFONTEIN

Only two of the twenty five garnets selected from this concentrate two (#3 & #7) were not eclogitic. (Figure 22) They were both lherzolitic G9's and have T_{Ni}'s of 826ºC and 870ºC and mg#'s of 84.2 & 84.8 respectively. The temperatures are below that expected for garnet concentrates from a diamondiferous kimberlite (≥1000ºC) as well as below that expected from a high temperature megacryst (>1100ºC - Hops et al., 1986) This is not supported by the TiO_2 contents of the garnets (O.35 & 0.7 wt% respectively- table 1) which indicates that they were both derived from a high temperature peridotite. This data is therefore considered suspect. A total of 12 out of 24 eclogitic garnets were classified as being Group 1 eclogites having ≥.0.09 wt% Na_2O, and eleven were Group 2 eclogites (≤ 0.9wt% Na_2O). Fourteen out of twenty three garnets (61%) had Na_2O in them which would have been considered significant in terms of positive diamond potential. They would also plot within the significant field on Figure 9 (see also Figure 23). The major element approach using only eclogitic garnets indicates that Rietfontein is a potentially diamondiferous kimberlite in contrast to the (tentative/suspect) evaluation of it being barren based on the nickel geothermometer and peridotitic garnets.



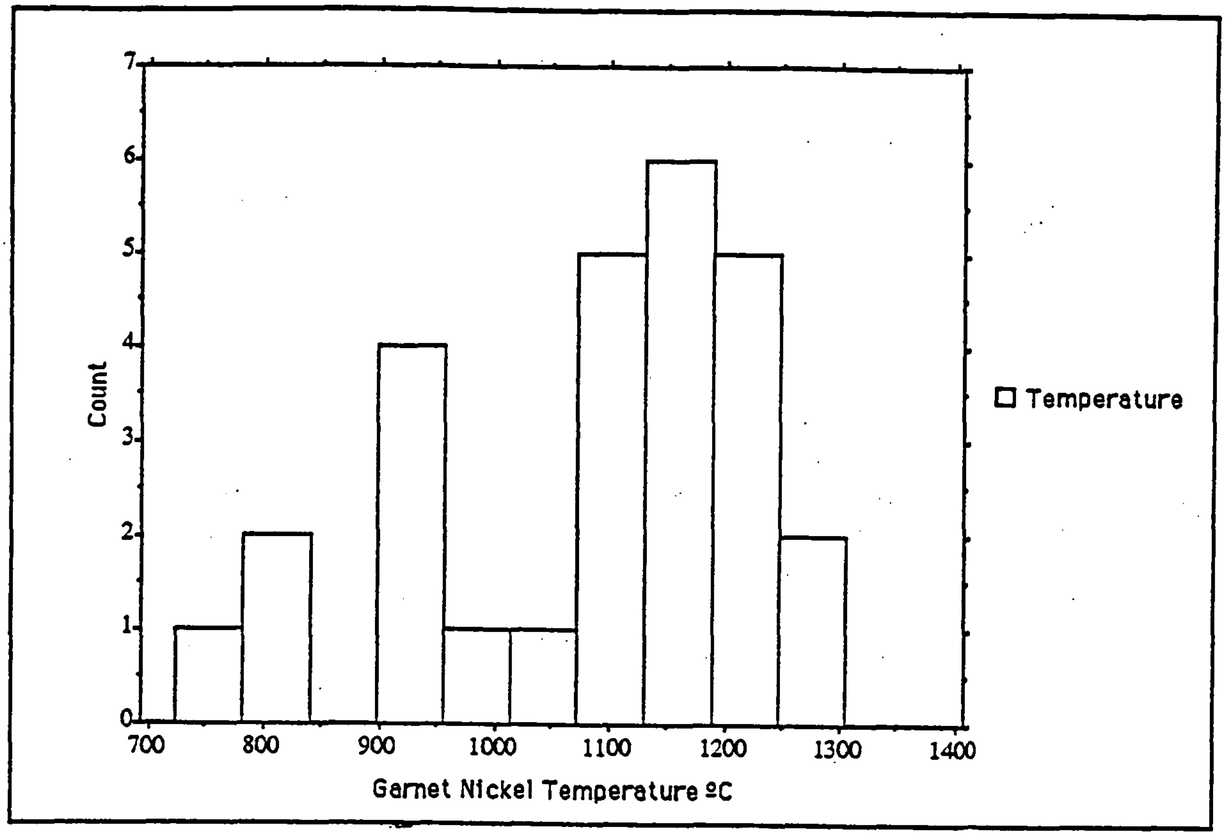
Plot of CaO Vs Cr2O3 for concentrate garnets from Rietfontein. The garnets are predominantly (n=23) eclogitic with only one plotting within the garnet lherzolite (G9) field. (See Gurney and Moore, 1991).

FIGURE 22



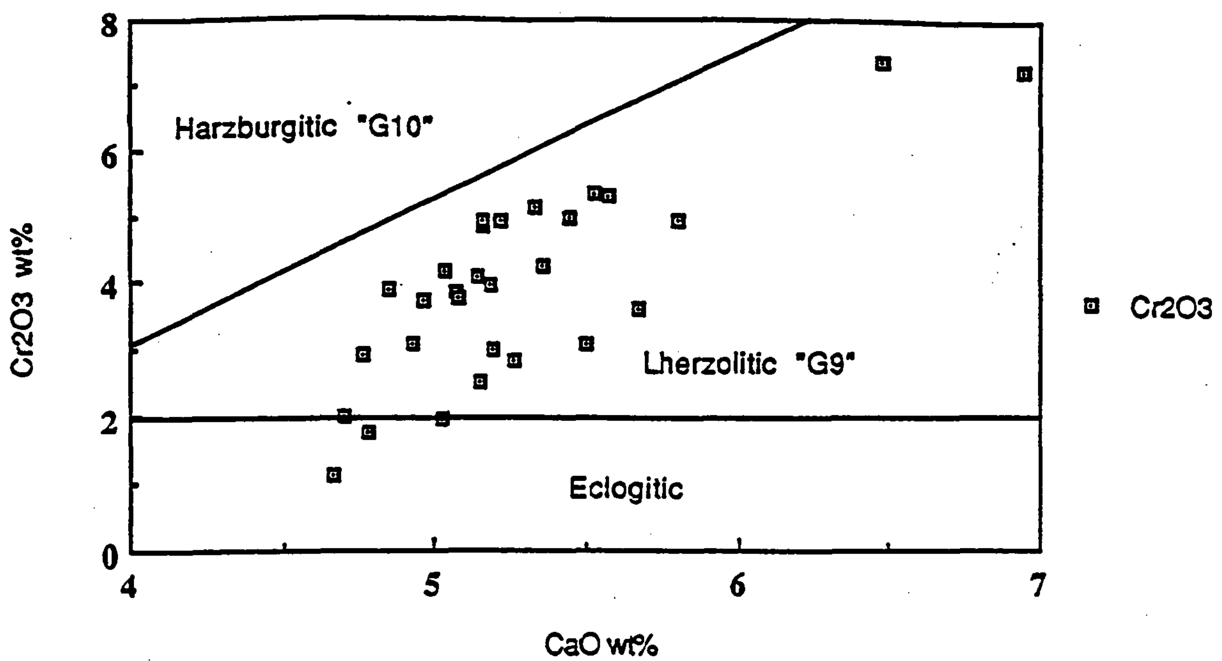
Plot of Na2O Vs TiO2 for eclogitic garnets from Rietfontein. Sixteen of these garnets (total n=23) plot within the significant field for world-wide diamond inclusion eclogitic garnets. An interpretation based on this would erroneously conclude that Rietfontein was a medium to high grade diamond source. (See Gurney and Moore, 1991).

FIGURE 23



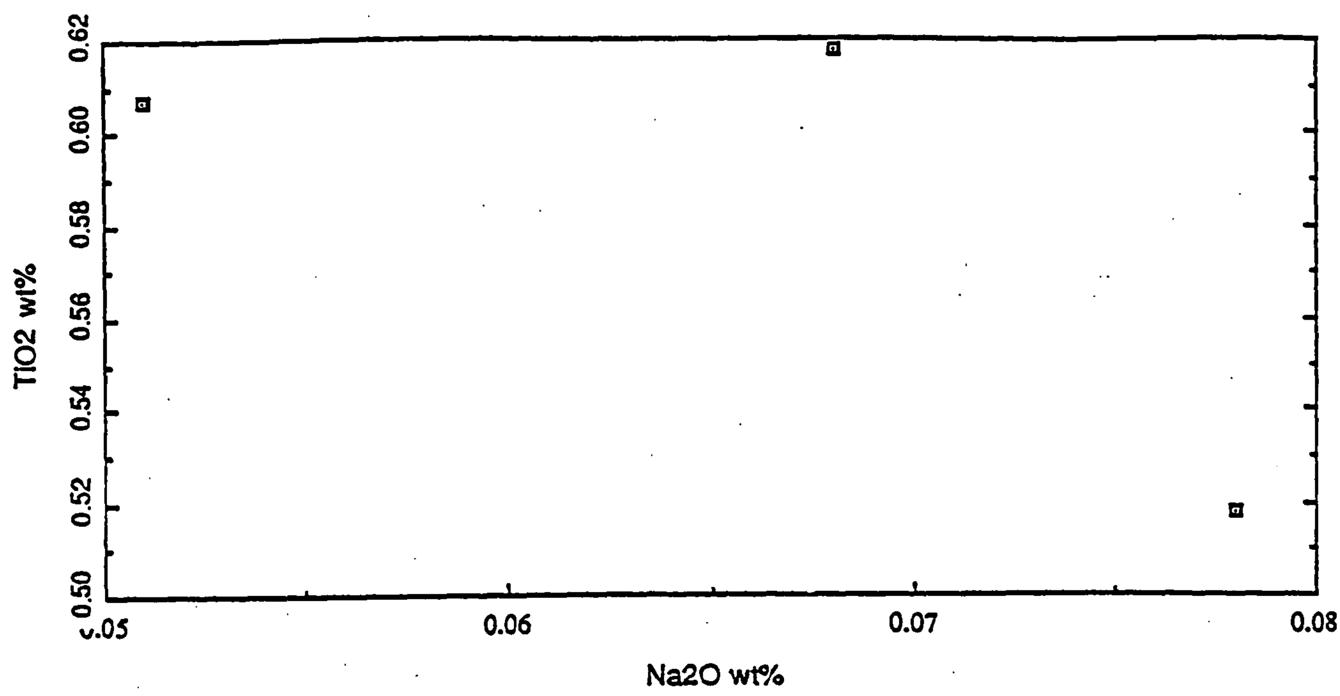
Histogram of garnet-nickel temperatures for concentrate garnets from Nouzee showing both high temperature and low temperature components. The main peak is centred at about 1175ºC. This histogram illustrates why it is necessary to take into consideration the depth of lithosphere - geotherm before attempting any interpretation for diamond potential. Nouzee is off-craton in southern Africa and is a barren kimberlite. The histogram of temperatures seems to indicate otherwise - that these garnets may have equilibrated within the diamond stability field. In this region the lithosphere is not as deep as it is beneath the central Kaapvaal craton, consequently, the temperature increases more rapidly with depth at Nouzee i.e, the geotherm is "steeper". The depth (and therefore pressure) is insufficient for diamonds to have formed. (see Griffin et al, 1989)

FIGURE 24



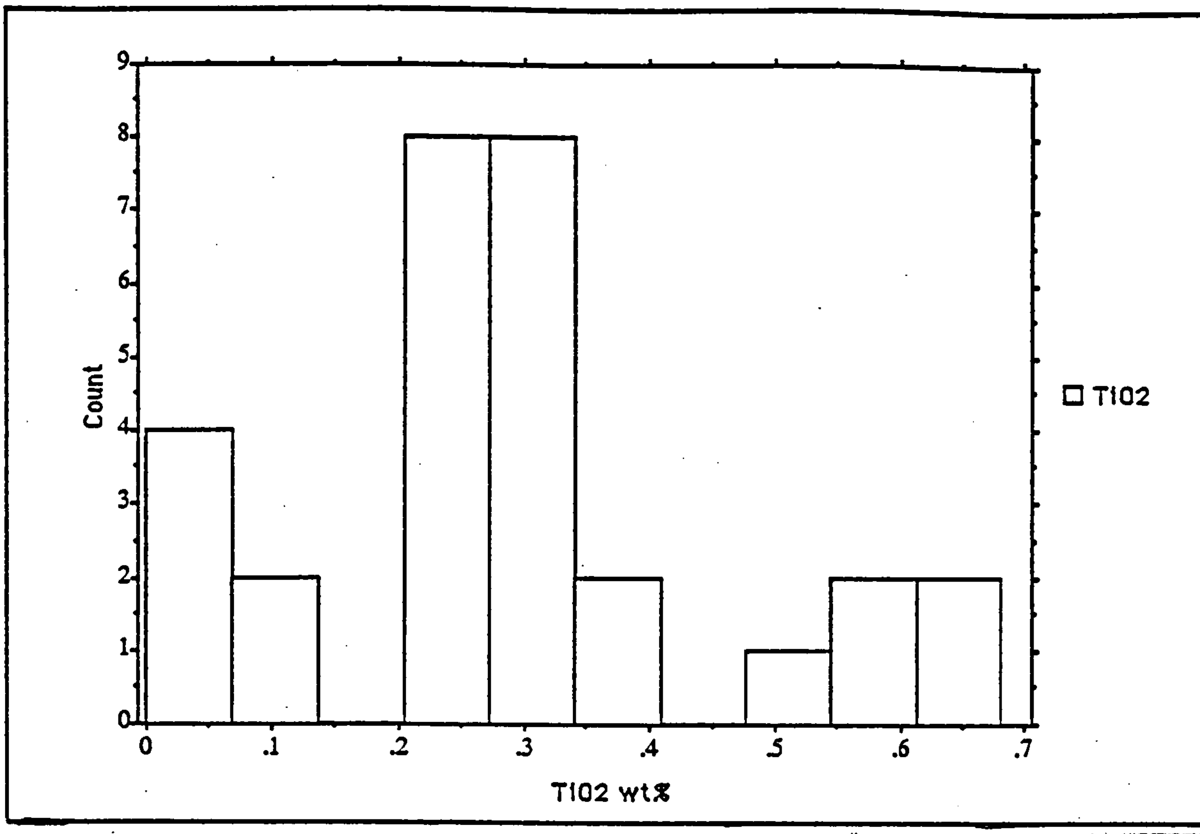
Plot of CaO Vs Cr_2O_3 for concentrate garnets (n=29) from Nouzee. Almost all (n=26) plot within the lherzolite (G9) field. This kimberlite is therefore correctly interpreted to be barren. There are no G10 garnets in this sample.(See Gurney and Moore, 1991).

FIGURE 25



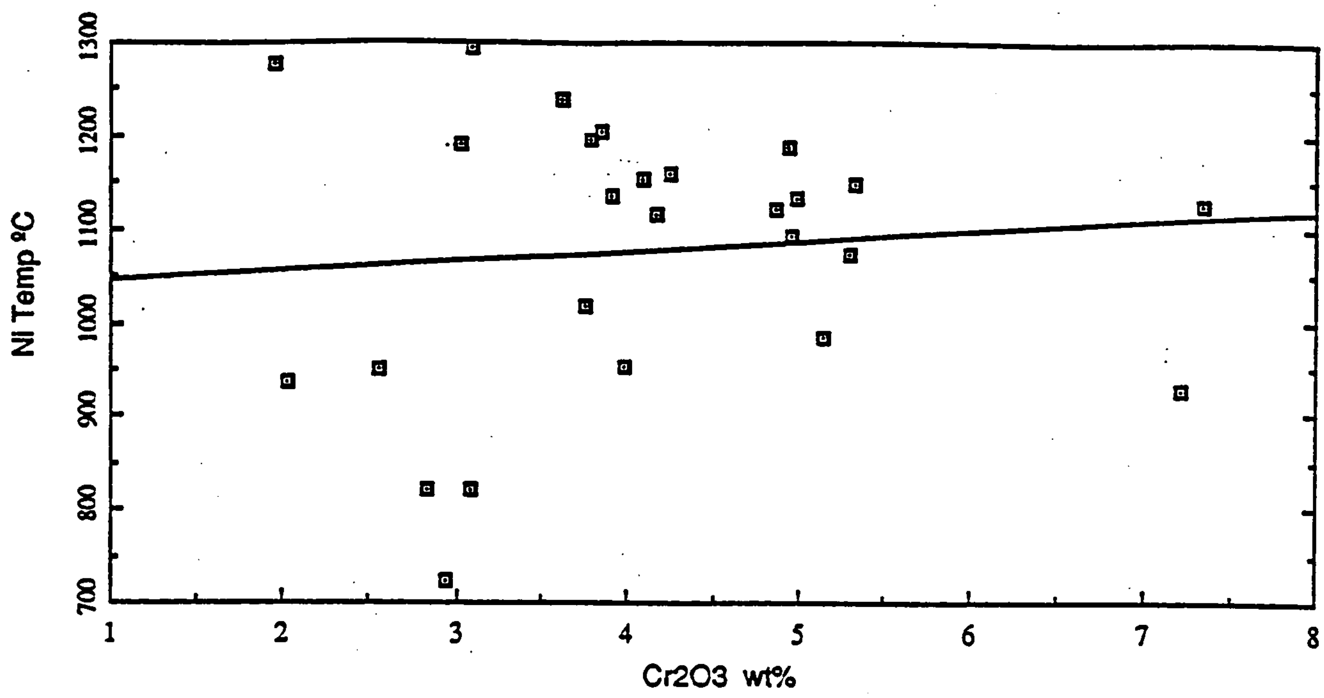
Plot of Na_2O Vs TiO_2 for eclogitic garnets from Nouzee heavy mineral concentrate. Only one plots within the significant field (see Figure 9) for diamond inclusion eclogites from world-wide localities. (See Gurney and Moore, 1991).

FIGURE 26



Histogram of TiO_2 wt% for Nouzee showing both a high temperature suite (n=20) for $TiO_2 \geq 0.2$ wt% and a low temperature suite (n=6) for $TiO_2 \leq 0.2$ wt%. (see Boyd. F.R, 1987)

FIGURE 27

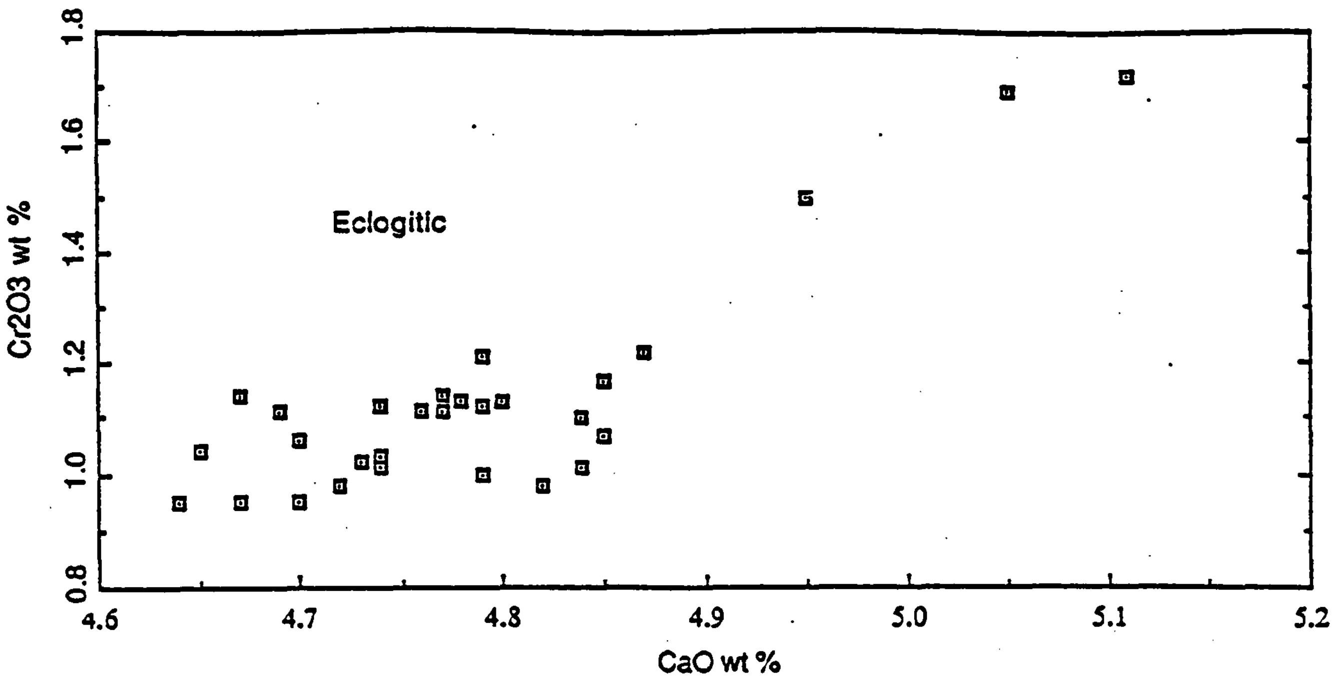


Plot of Cr2O3 Vs Garnet Equilbration Temperature (as determined by the garnet nickel geothermometer for Nouzee. The line-of-best-fit appears to be statistically valid for this sample (n=26) and shows a positive correlation for Cr2O3 against temperature. This is interpreted to indicate that there is no (substantial) megacrystal component to this concentrate sample. (See Schulze, 1987).

FIGURE 28

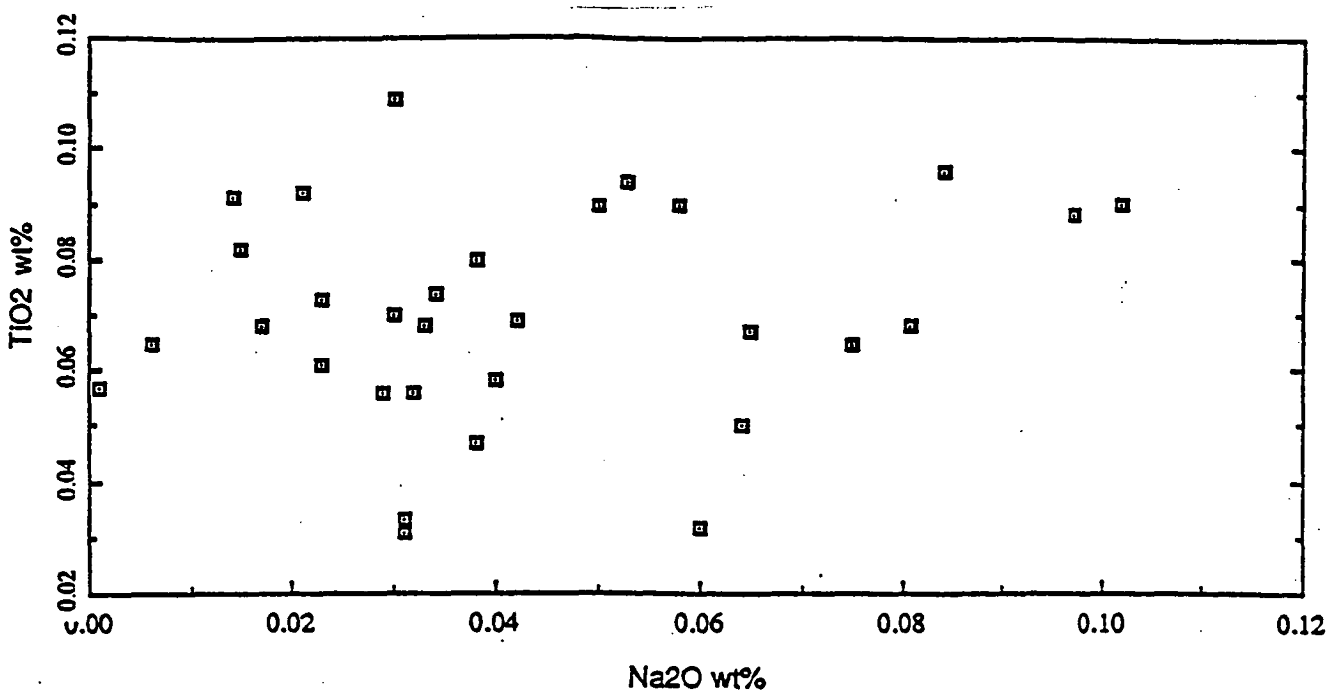
MOTHAE

Using the method of classification of Gurney & Moore, all 31 garnets plotted as eclogitic (Figure 29), however using the classification of Griffin et al, two garnet grains (#6 & #20) had > 1.5 wt% Cr_2O_3 and their nickel temperatures T_{Ni} were obtained. Their T_{Ni} were 662ºC and 688ºC respectively. Both of these are consistent with derivation from the graphite stability field. Only five out of the total of 31 garnets had $Na_2O \geq 0.07$ wt% and a plot of TiO_2 vs their Na_2O content (Figure 30) would also have placed these five within the significant field for Figure 9. Using the major element approach the kimberlite would be considered as being a low grade diamondiferous intrusive. Mothae has a grade of only 2 ct per 100 tonne with most diamonds being only 0.1 carat (0.02 grams) per stone. In this instance both methods of assessing diamond potential are in good agreement.



Plot of CaO Vs Cr_2O_3 (both wt%) for eclogitic concentrate garnets from Mothae. The two garnets with ≥ 1.5 wt% Cr_2O_3 have been assigned to the peridotitic suite and used for a (tentative) determination of garnet equilibration temperature using the method of Griffin et al, 1989. There are no G10 garnets in this sample. (See Gurney and Moore, 1991).

FIGURE 29

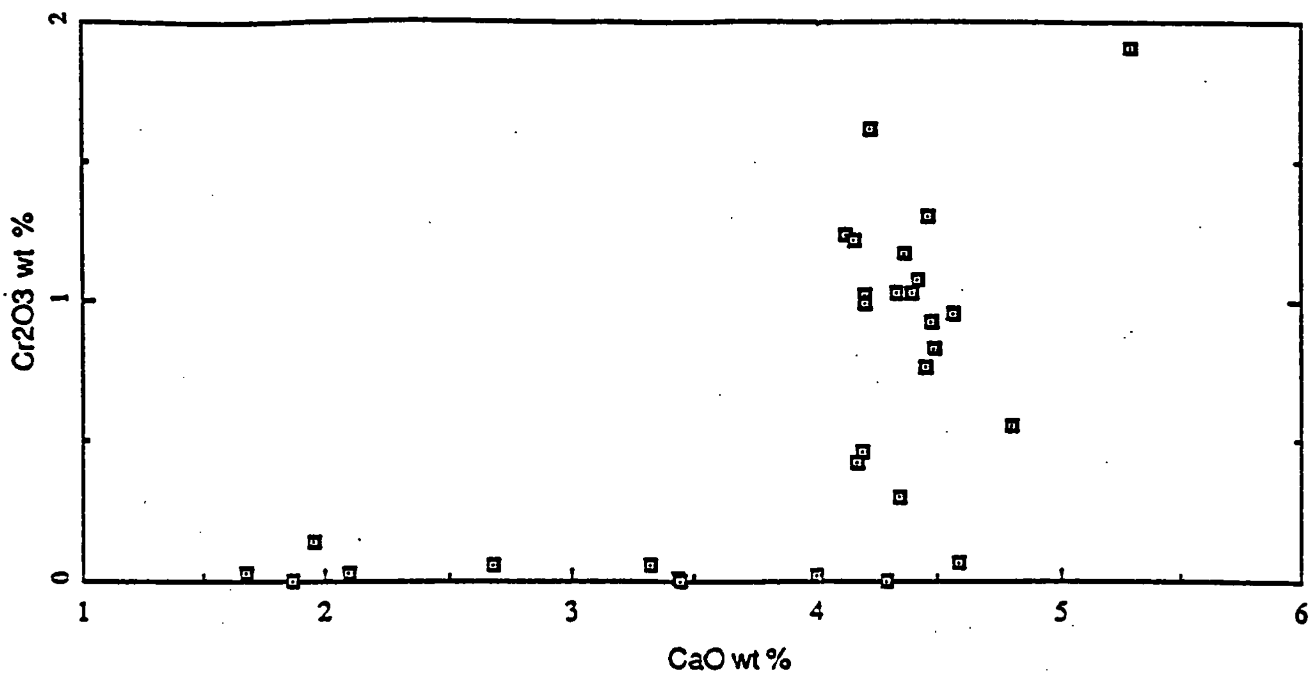


Plot of Na_2O (wt%) Vs TiO_2 (wt%) for eclogitic concentrate garnets from Mothae. The five garnets with values of $Na_2O \geq 0.07$ wt% also plot within the significant field (see Figure 9) for world-wide diamond inclusion garnets. (See Gurney and Moore, 1991).

FIGURE 30

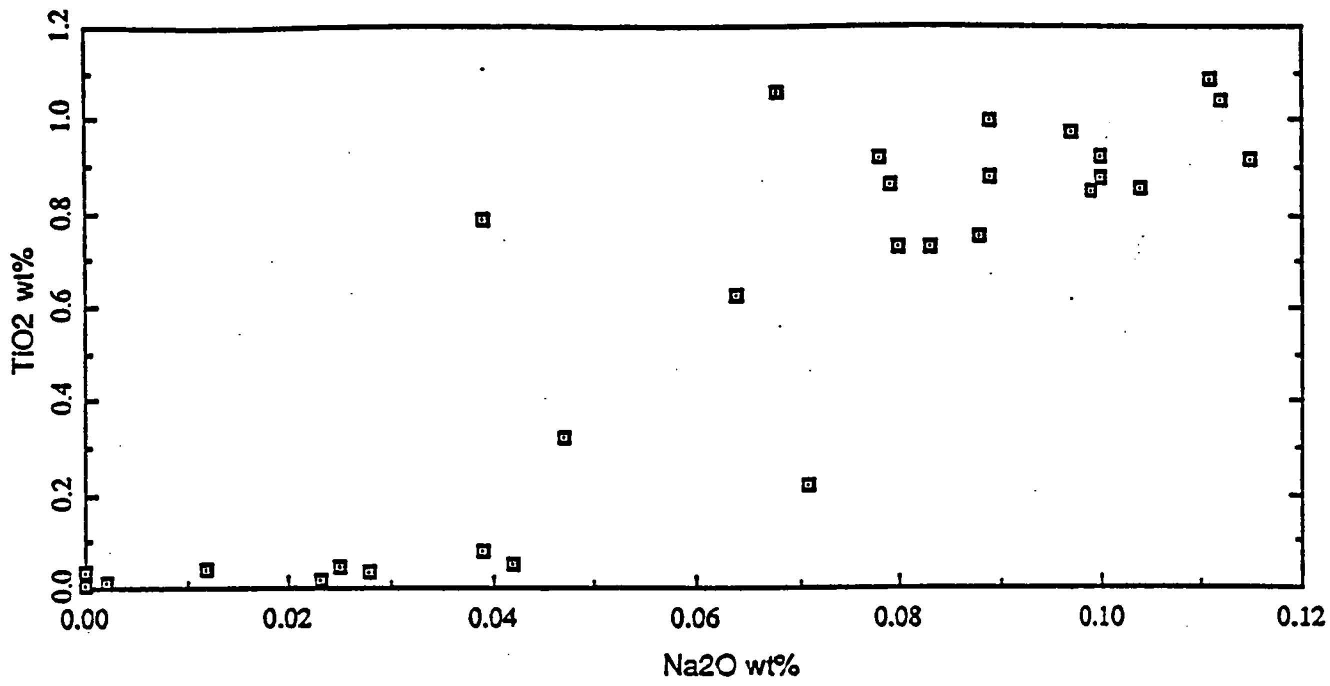
ORAPA

All garnets selected for this concentrate were eclogitic (Figure 31) and it was therefore not possible to obtain a $T_{(Ni)}$ for any of them. The major element analyses for Na_2O content resulted in sixteen out of 29 having ≥ 0.07 wt% Na_2O (Figure 32). Six of these would have plotted within the significant field for Na_2O vs TiO_2 (See Figure 9). On the basis of these analyses garnet concentrate from Orapa would be considered to have come from a potentially medium to high grade diamond source. This agrees well with published data for Orapa which gives it an average grade of 69 ct/100 tonne.



Plot of CaO Vs Cr_2O_3 for concentrate garnets from Orapa. All garnets plot within the eclogite field. There are no G10 garnets in this sample. (See Gurney and Moore, 1991).

FIGURE 31

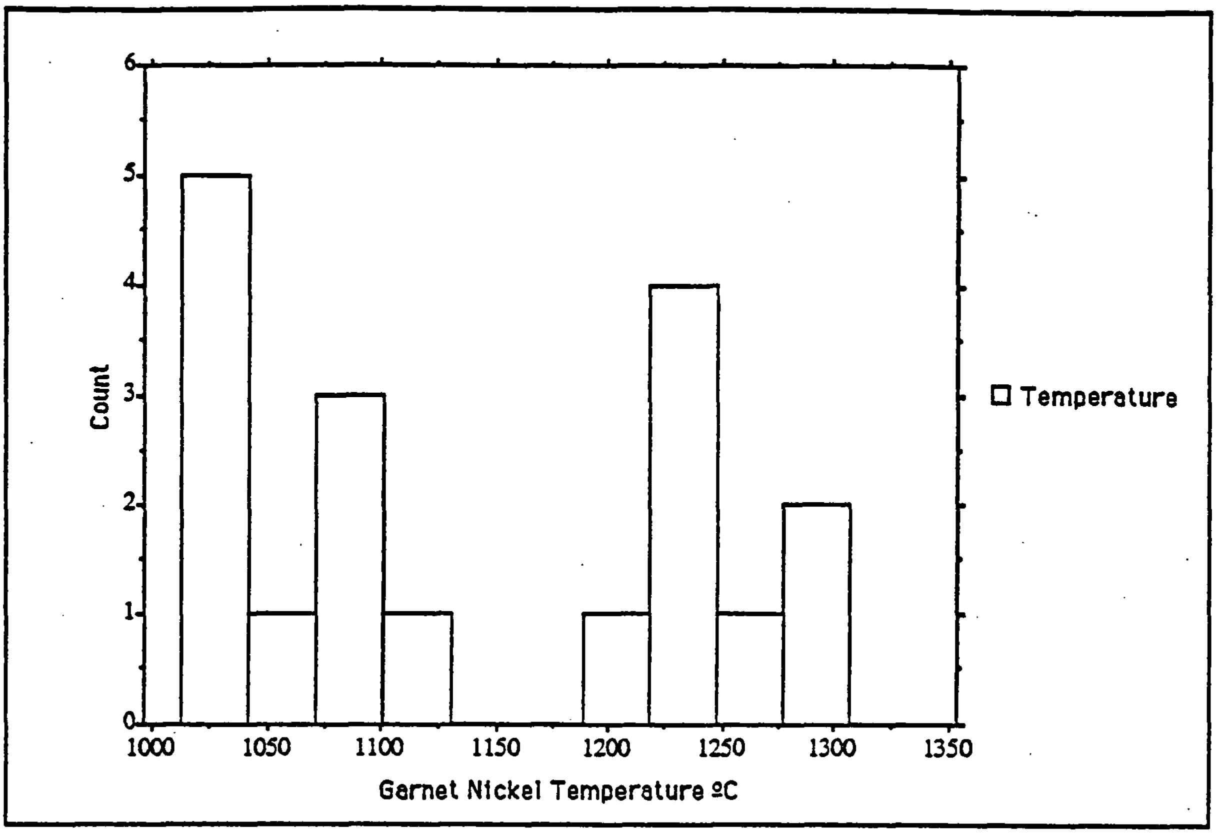


Plot of Na_2O Vs TiO_2 for eclogitic concentrate garnets from Orapa. Sixteen out of the total (n=29) have ≥ 0.07 wt% Na2O (which is considered the significant concentration in assessing diamond potential and six of these also plot within the significant field (see Figure 9) for diamond inclusion garnets. (See Gurney and Moore, 1991).

FIGURE 32

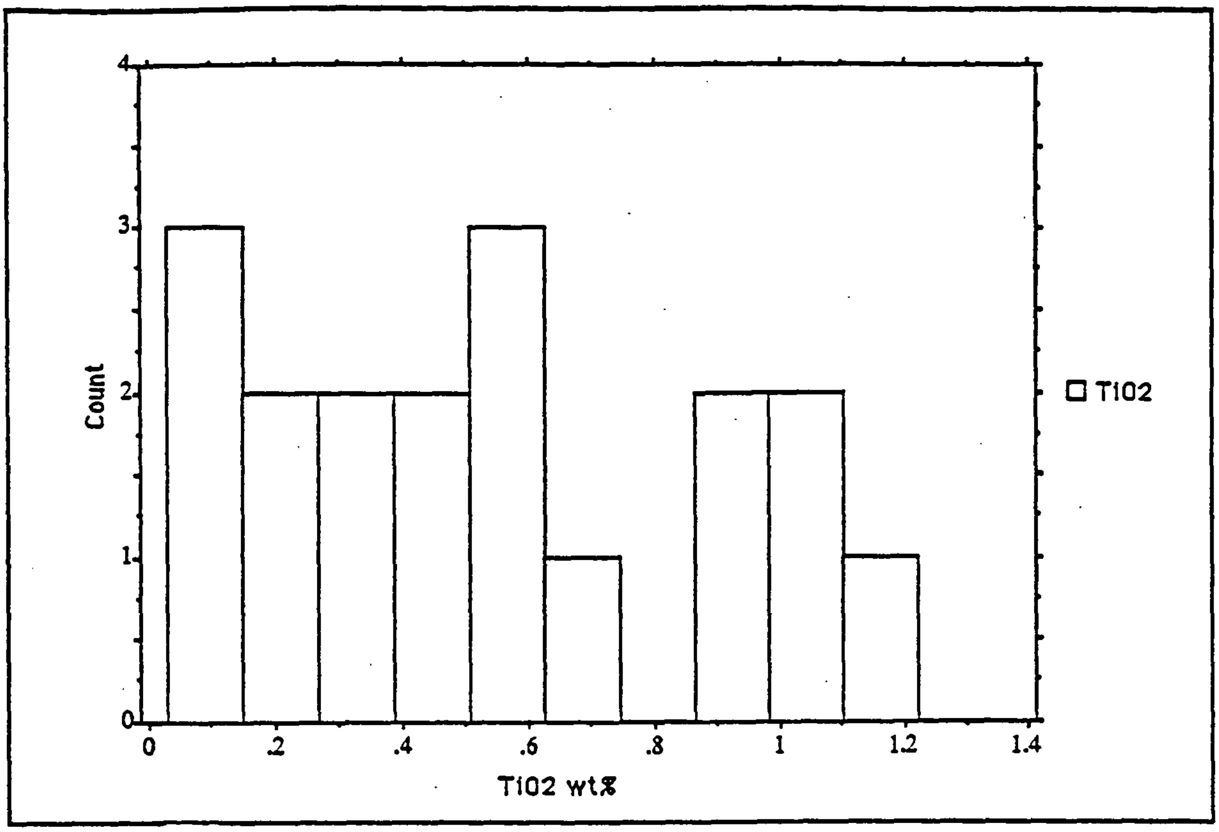
ZARNITSA

There are two temperature peaks on the $T_{(Ni)}$ histogram for Zarnitsa (Figure 33). One is centred at about 1240ºC and one at about 1060ºC. This suggests that the garnets may be derived from two sources each of which lies within the diamond stability field. Fifteen of eighteen TiO_2 analyses (Figure 34) plotted within the high temperature peridotite field for these garnets. From the major element analyses, of the twenty nine garnet grains (Figure 35), twenty one plotted as lherzolitic G9's and eight as eclogitic. Only two of the eight eclogitic garnets had ≥ 0.07 wt% Na_2O (Figure 36), and one would also have plotted within the world-wide field of eclogitic diamond inclusion garnets for Na_2O vs TiO_2 (See Figure 9). The nickel geothermometer analyses would indicate that these garnets came from a high grade diamondiferous kimberlite pipe. This contrasts with the interpretation derived from examination of the major element data which supports the (incorrect) assessment that the garnets were probably derived from a low grade diamondiferous kimberlite. The plot of Cr_2O_3 vs temperature (Figure 37) suggests that there was no significant megacryst involvement in these garnets. The high variability found in Zr/Y values for these grains (with values ranging from 1 up to 13) indicates that they may have been involved in a metasomatic event(s). This is consistent with their relatively high temperatures of equilibration and their TiO_2 histogram.



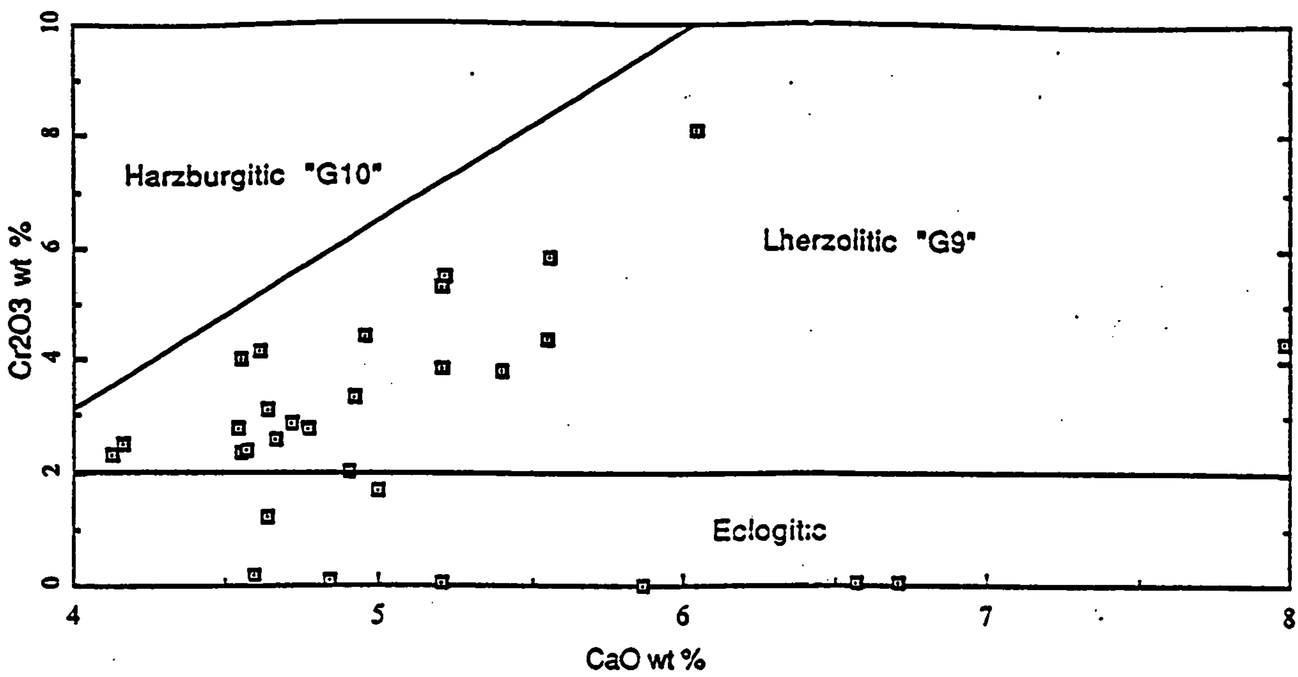
Histogram of garnet-nickel temperatures for concentrate garnets from Zarnitsa showing two temperature peaks at about 1060ºC and 1240ºC. Both these temperatures are consistent with derivation from within the diamond stability field i.e, ≥1000ºC. (see Griffin et al, 1989)

FIGURE 33



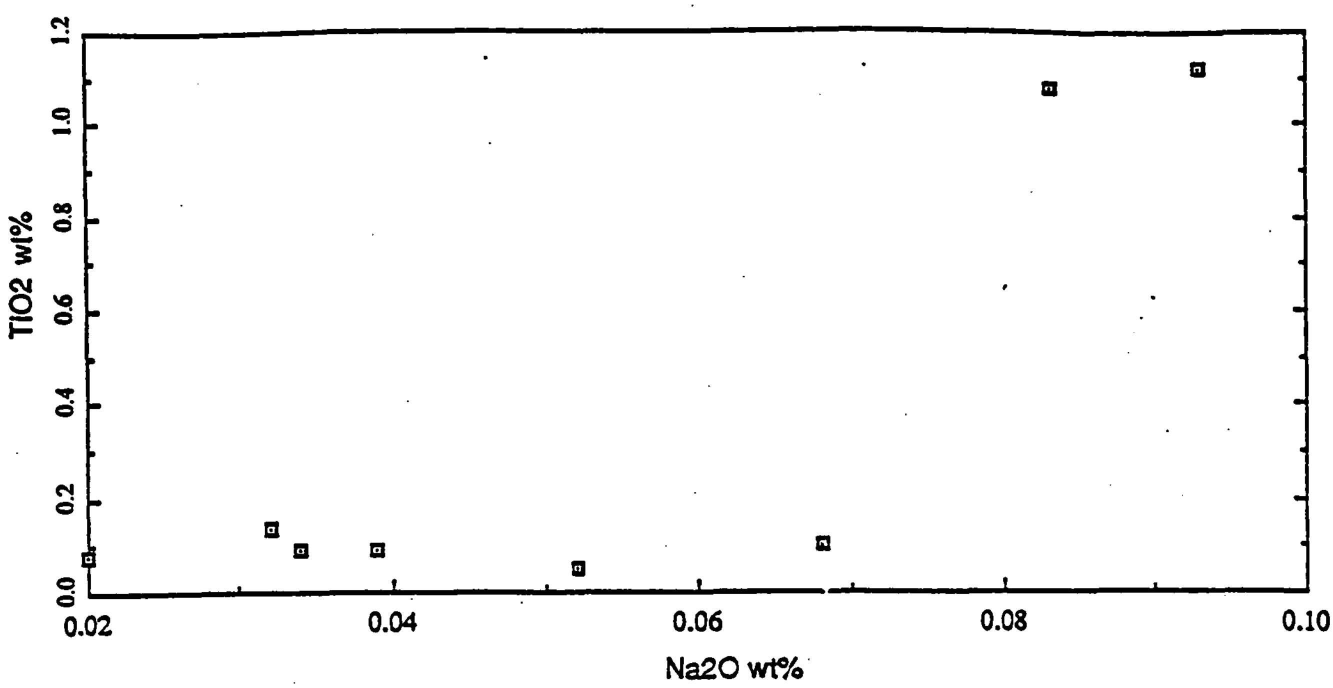
Histogram of TiO_2 wt% for Zarnitsa (n=18) showing both a high temperature suite (n=15) for $TiO_2 \geq 0.2$ wt% and a low temperature suite (n=3) for $TiO_2 \leq 0.2$ wt%. (see Boyd F.R, 1987)

FIGURE 34



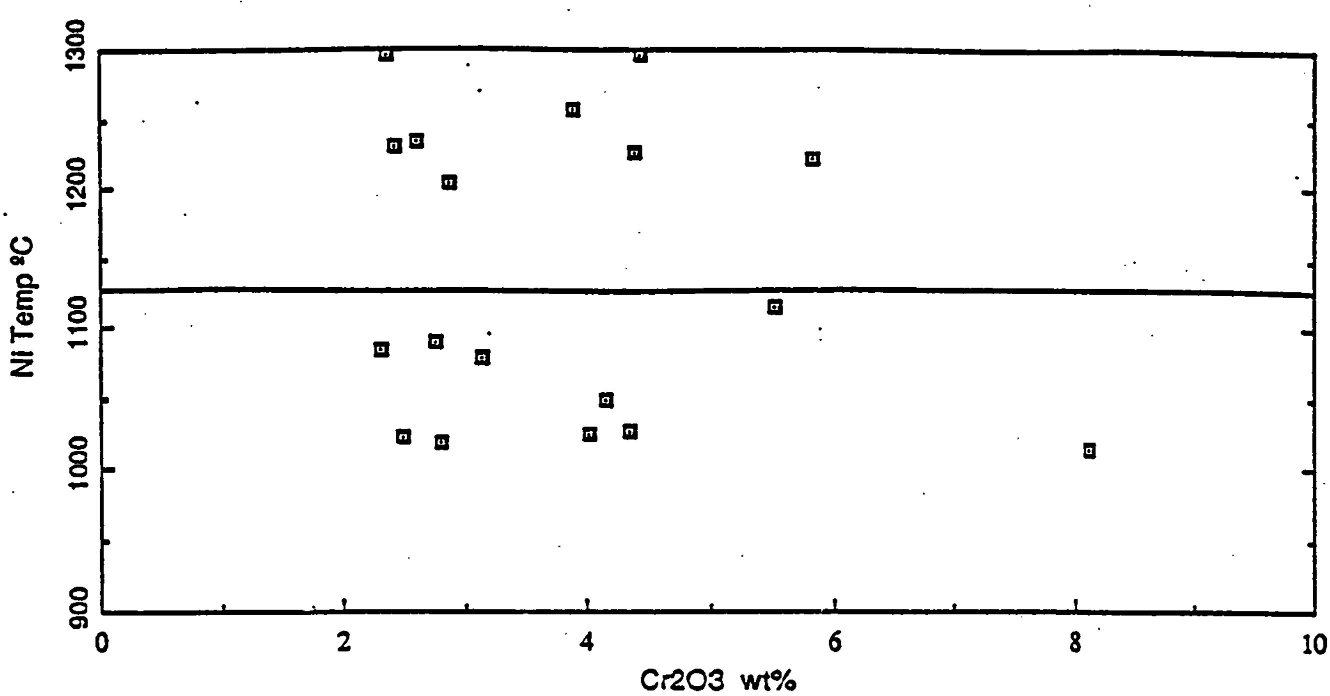
Plot of CaO Vs Cr_2O_3 for concentrate garnets from Zarnitsa. Twenty plot within the lherzolitic G9 field and eight within the field for eclogites. There are no G10 garnets in this sample. (See Gurney and Moore, 1991).

FIGURE 35



Plot of Na_2O Vs TiO_2 for concentrate eclogite garnets (n=8) from Zarnitsa. Only one plots within the significant field (see Figure 9) for diamond inclusion eclogites from world-wide localites. Only two of the garnets have ≥ 0.07 wt% Na_2O which is the concentration considered significant for assessing diamond potential. (See Gurney and Moore, 1991).

FIGURE 36

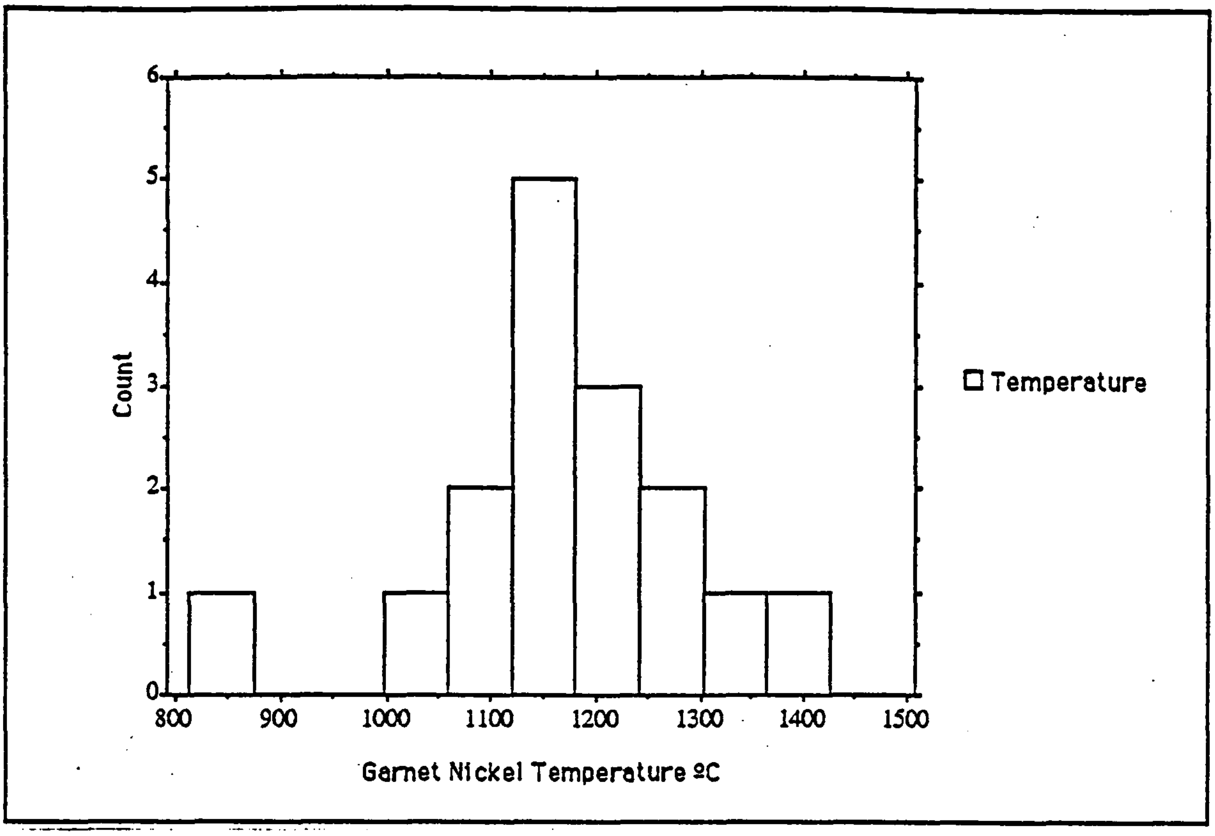


Plot of Cr_2O_3 Vs Garnet Equilbration Temperature (as determined by the garnet nickel geothermometer) for concentrate garnets from Zarnitsa. The horizontal line-of-best-fit does not show any negative correlation existing between Cr_2O_3 and temperature and this is therefore interpreted to infer that there is little or no megacrystal component in this concentrate. (See Schulze, 1987).

FIGURE 37

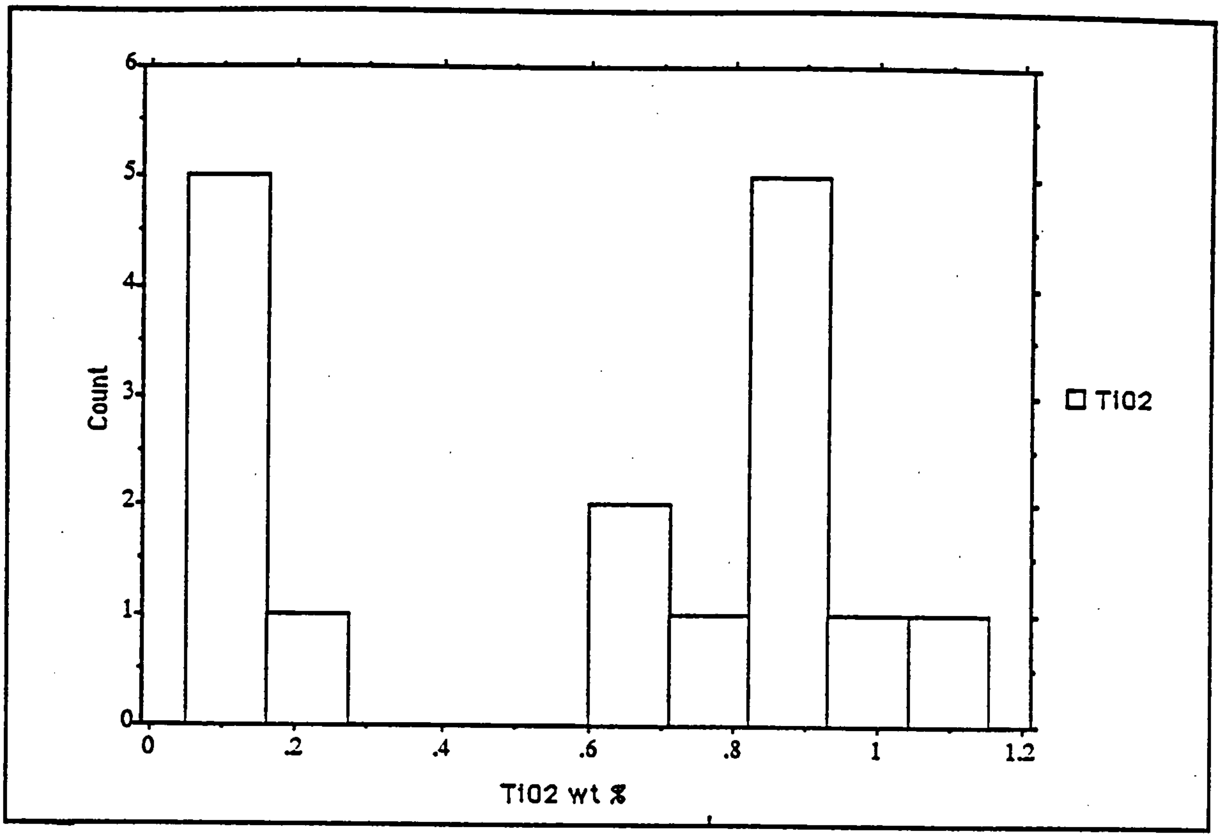
LENINGRADSKAYA

There are two temperature peaks on the $T_{(Ni)}$ histogram (Figure 38) for Leningradskaya, a strong high temperature group centred at about 1150ºC and a second, lower temperature garnet, which is centred at about 830ºC. Fifteen out of the total of sixteen garnet grains analysed for their $T_{(Ni)}$ have temperatures of ≥1000ªC. This would be considered highly significant for diamond potential using the method of Griffin et, al. Although ten of these garnets have Cr2O3 values < 1.5 wt% and hence should be classified as eclogitic I have included their garnet nickel temperatures because they appear to have both an eclogitic as well as a peridotitic component and they also give $T_{(Ni\text{'s})}$ which are consistent with those determined for the peridotitic garnets. Eleven peridotitic garnets out of sixteen plotted within the high temperature peridotite field on the basis of their TiO2 concentration (Figure 39). The two garnets which have a temperature of equilibration ≥ 1300ºC are considered to be too hot to facilitate diamond preservation. These higher temperature garnets may have undergone some metasomatism. This is supported by the large range in Zr/Y values which are mostly between 5 and 9 with ten grains having neither Zr nor Y at detectable levels for the proton probe. Eighteen garnets were identified as G9's (Figure 40). The line of best fit for the plot of Cr2O3 vs Temperature (Figure 41) suggests that there is no substantial megacryst involvement for these garnets. Using the major element approach it was found that only one garnet grain from the total eclogitic population (n=11) had ≥ 0.07 wt% Na20. (Figure 42). This eclogitic garnet did not plot within the eclogitic diamond inclusion garnet field for world-wide localities (see Figure 9). On the basis of these major element analyses it would have been erroneously determined that Leningradskaya was a barren kimberlite.



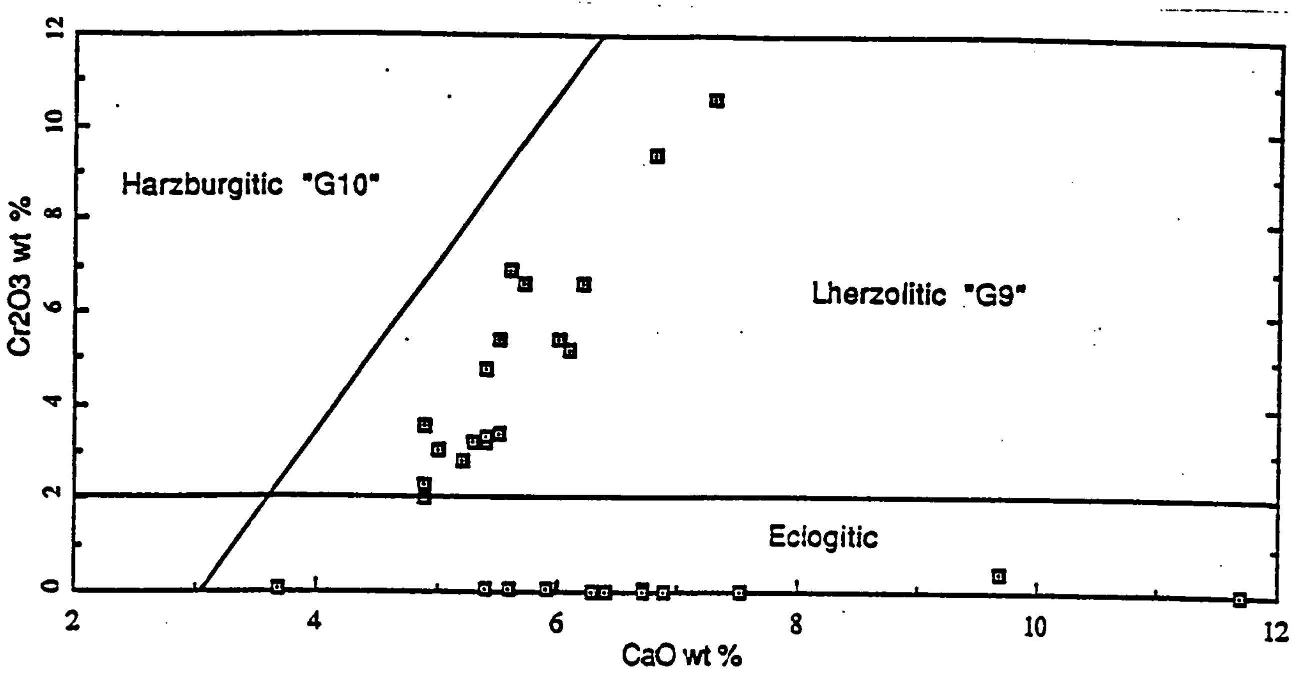
Histogram of garnet-nickel temperatures for concentrate garnets from Leningradskaya. The histogram is almost symmetrical with a single main peak centred at about 1150ºC. This histogram includes data from some garnets (n=10) which have ≤1.5 wt% Cr_2O_3. Their temperatures of garnet equilibration were consistent with those (n=6) obtained for the peridotitic garnets (having ≥ 1.5 wt% Cr_2O_3) from this concentrate. Please see the 'Conclusions and Exploration Implications' section at the end of this thesis for an explanation as to why garnet nickel temperatures for these 'eclogitic' garnets were included in this histogram.

FIGURE 38



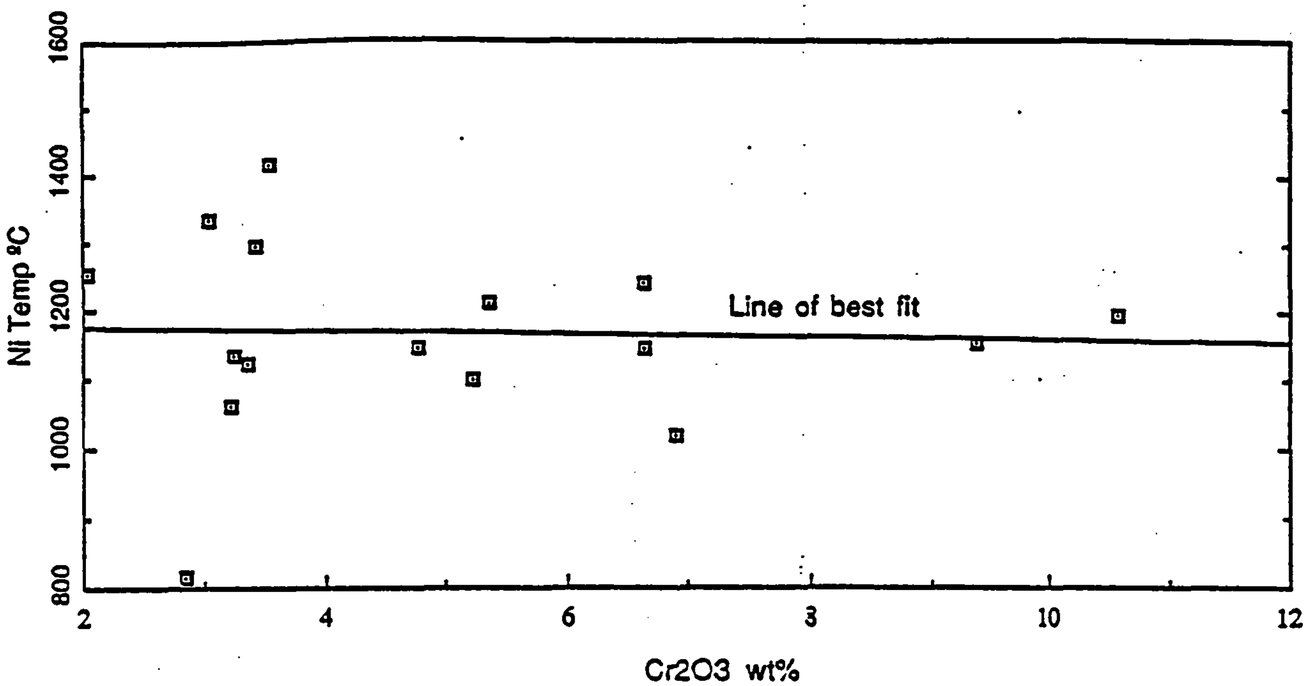
Histogram of TiO_2 wt% for Leningradskaya. The histogram is characterised by having two populations - a low temperature group (n=6) having ≤ 0.2 wt% TiO_2 and a high temperature group (n=10) which has ≥ 0.2 wt% TiO_2. (see Boyd. F.R, 1987)

FIGURE 39



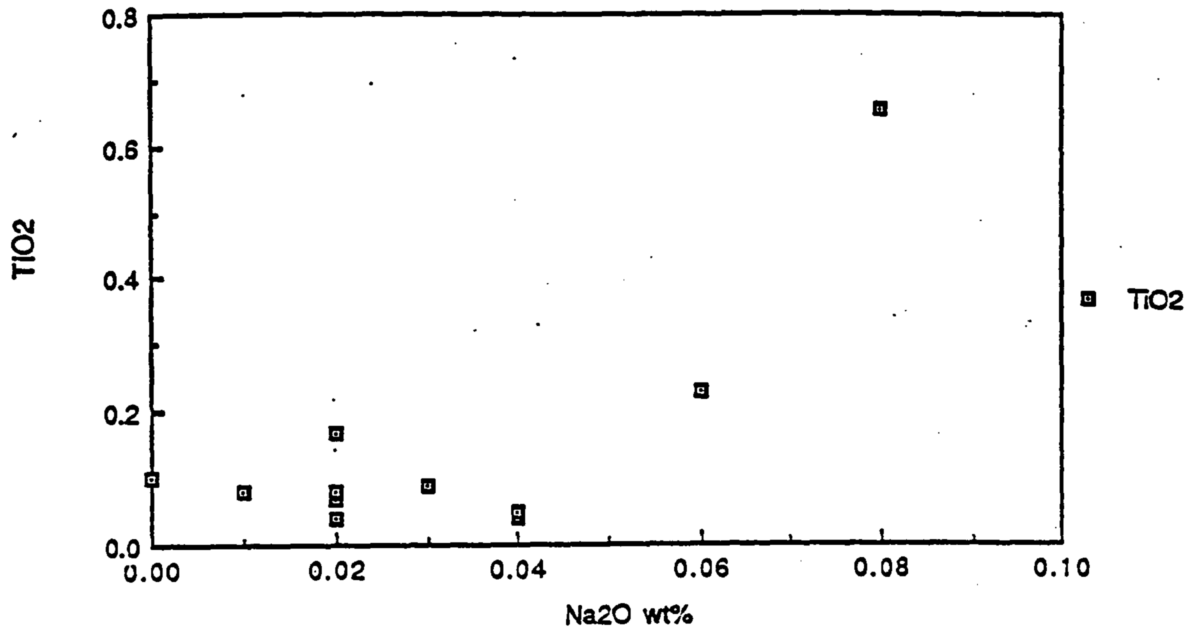
Plot of CaO Vs Cr_2O_3 for concentrate garnets from Leningradskaya. None of the peridotitic garnets (n=18) plots within the significant field (G10 - Harzburgitic) which would indicate that they were sourced from a diamondiferous kimberlite. (See Gurney and Moore, 1991).

FIGURE 40



Plot of Cr_2O_3 Vs Garnet Equilbration Temperature (as determined by the garnet nickel geothermometer) for concentrate garnets from Leningradskaya. The horizontal line-of-best-fit does not show a negative correlation for Cr_2O_3 against temperature and this is interpreted to indicate that there is little or no megacrystal component in this concentrate. (See Schulze, 1987).

FIGURE 41

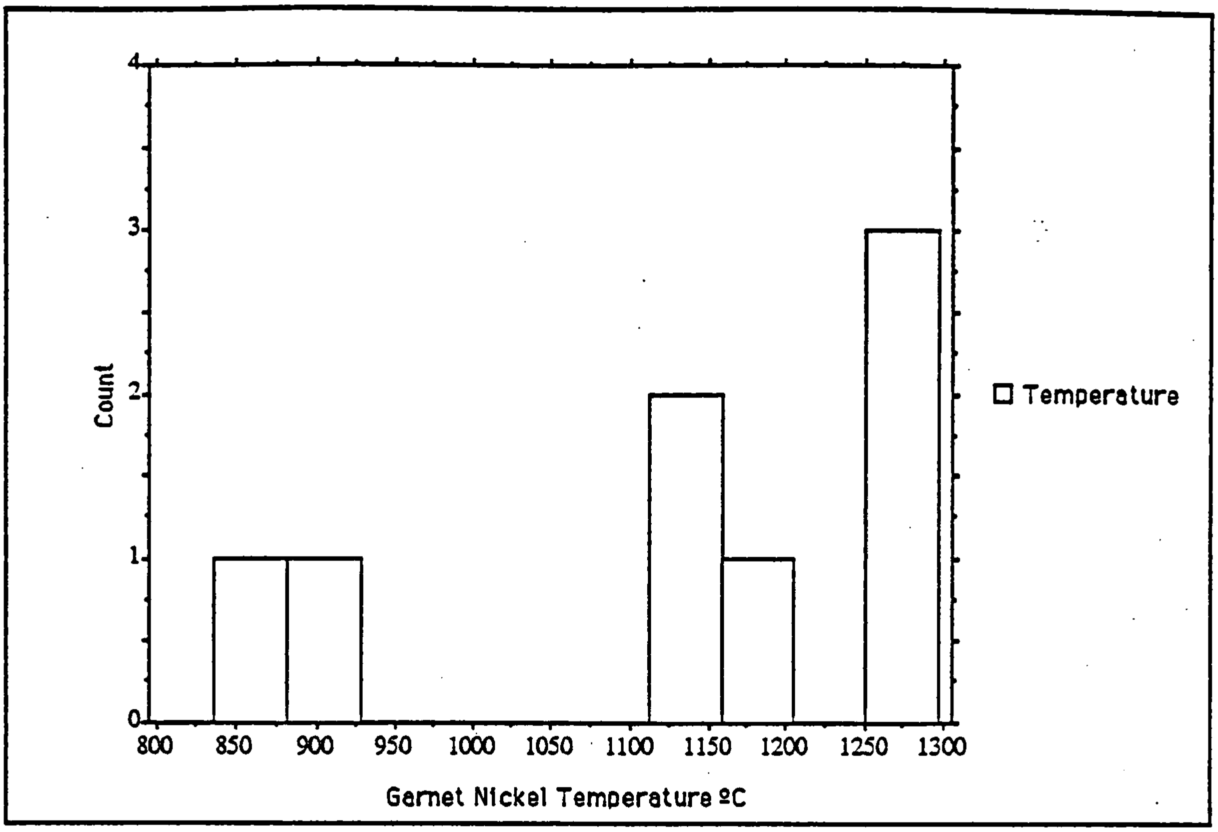


Plot of Na_2O Vs TiO_2 for concentrate eclogite garnets from Leningradskaya. None of these garnets plot within the significant field (see Figure 9) for world-wide eclogitic diamond inclusion garnets. Only one garnet grain from the total (n=11) has ≥ 0.07 wt% Na_2O which is the concentration considered significant for assessing diamond potential. (See Gurney and Moore, 1991).

FIGURE 42

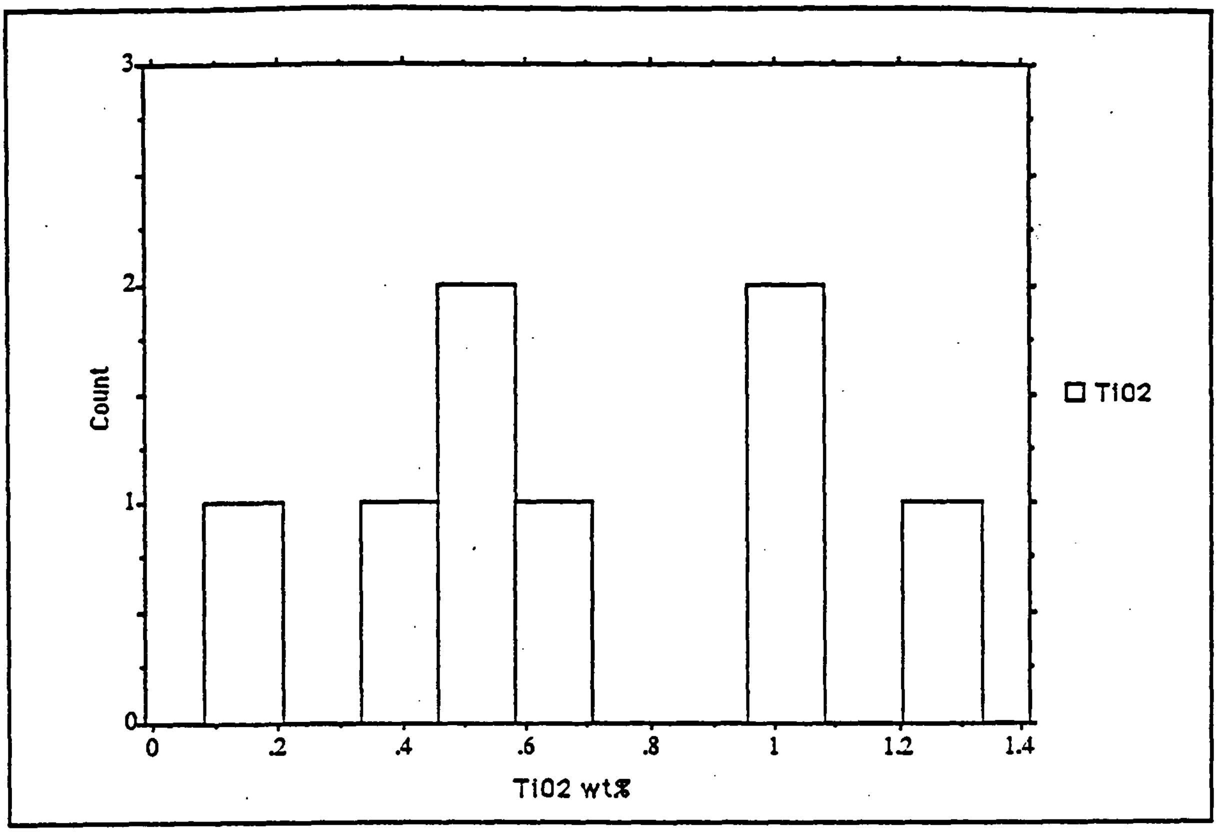
UDACHNAYA

Six out of the total population of peridotitic garnets (n=8) had $T_{(Ni)} \geq 1000^{\circ}C$ (Figure 43). The histogram for these indicates that they may have been derived from two populations of garnets, with one population centred at about 1225ºC and the other at about 900ºC. This is consistent with Udachnaya garnets having (at least) two sources, only one for certain being located within the diamond stability field. This is supported by the TiO_2 histogram (Figure 44) which places seven garnets in the high temperature peridotite field and one in the low temperature field. The higher temperature component also correlates well with that estimated for Udachnaya by Sobolev et al. (Nixon, 1987) of 1200ºC for an eclogite suite. A plot of $T_{(Ni)}$ Vs Cr_2O_3 for this data (Figure 45) gave a moderate negative correlation. Had the garnet with a Cr_2O_3 concentration of 9.92% (#12 and Figure 47) not been included in this plot the negative correlation would have been both consistent as well as significant. This sample may have an appreciable megacryst component. Values for Zr/Y were consistently erratic, ranging between 5 and 6 and most (n = 12) having below minimum detection limits for Zr and/or Y. The high variability in these Zr/Y ratios may indicate that some of the (high temperature) garnets have been metasomatised In order to further determine whether this is the case it would be necessary to obtain a profile of (proton microprobe) analyses - from garnet grain rim to core - for evidence of trace element zonation . If zonation was found it may indicate that a reaction between the garnets and an invading melt had occured. (Griffin et al, 1988). Ten out of twenty two eclogitic garnets had $Na_2O \geq 0.07$ wt% (Figure 46) while eight of them would have plotted within the eclogitic diamond inclusion field from world-wide localities (see Figure 9) These major element analyses support the evaluation that the garnets were probably derived from a high grade diamondiferous source.



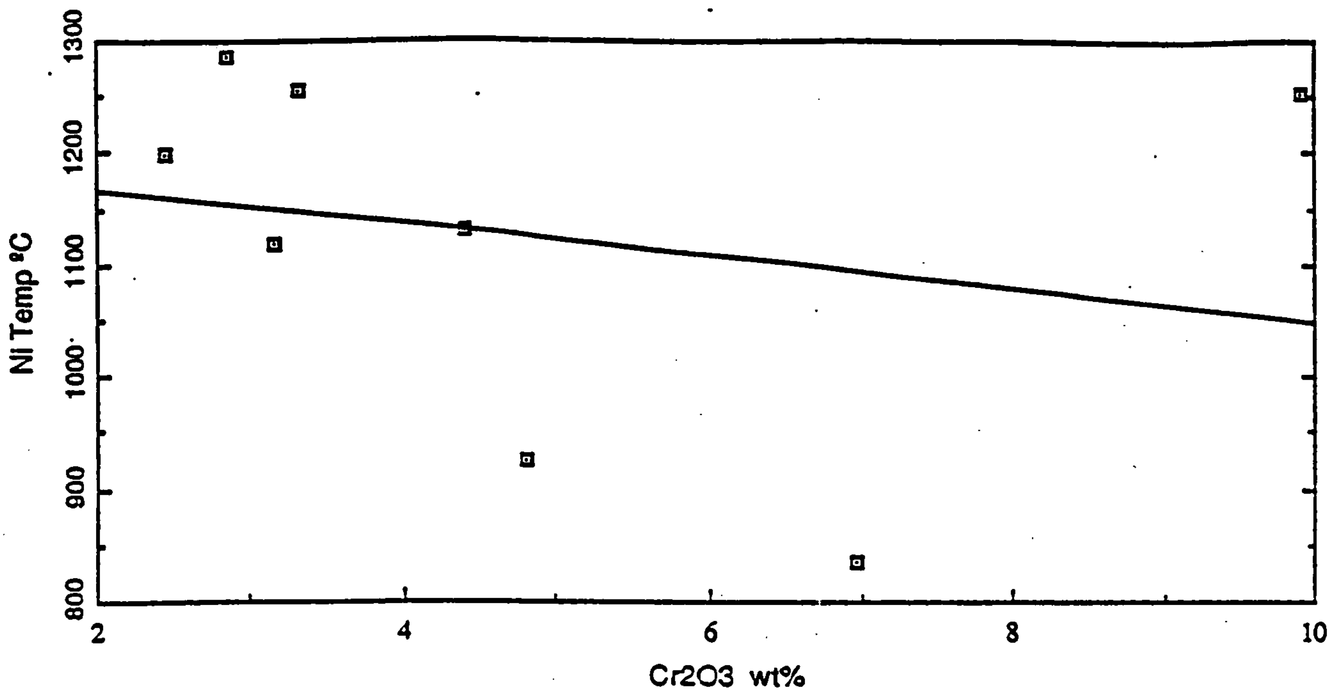
Histogram of garnet-nickel temperatures for concentrate garnets from Udachnaya. There are two temperature populations centred at about 900ºC and 1225ºC. This data is supported by that obtained using the histogram plot of TiO_2 which also has both a high and low temperature component. The higher temperature is consistent with a derivation from within the diamond stability field - ≥1000ºC. (see Griffin et al, 1989)

FIGURE 43



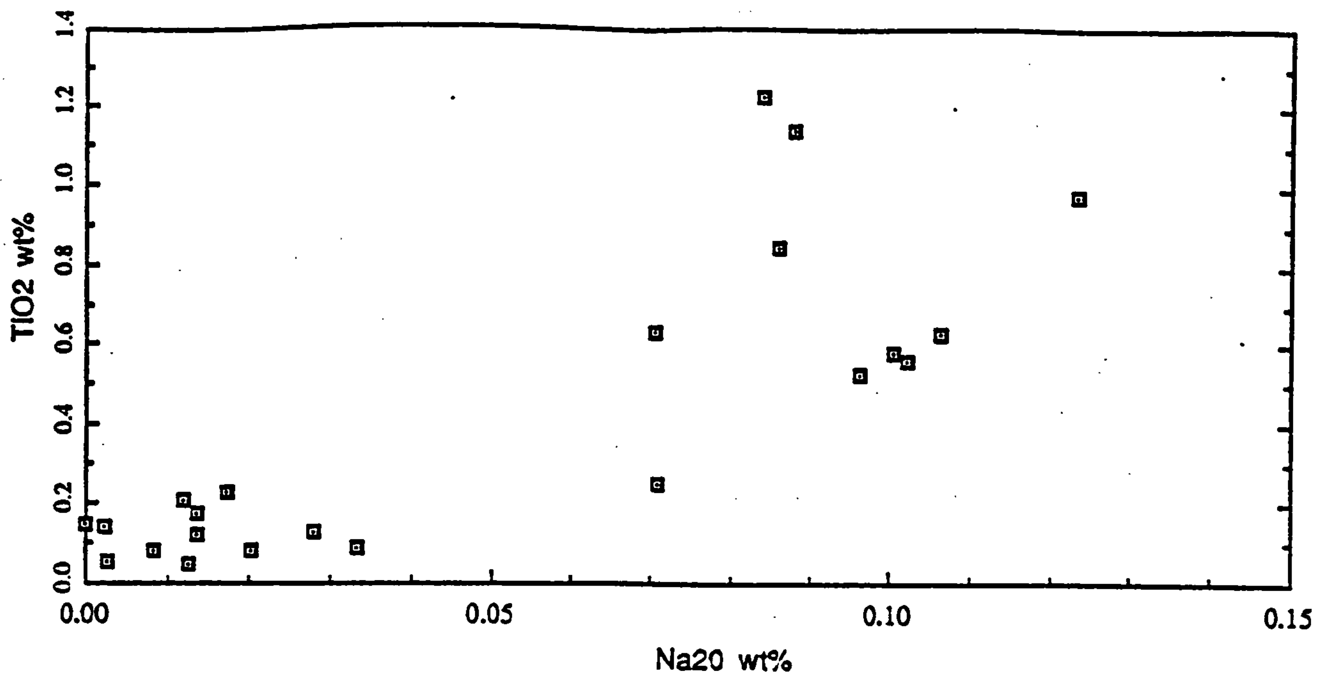
Histogram of TiO_2 wt% for Udachnaya. Seven of the eight garnets are classified as being derived from a high temperature peridotite which is in general agreement with the temperatures derived independently by the garnet nickel geothermometer. (see Boyd. F.R, 1987 and Griffin et al, 1989)

FIGURE 44



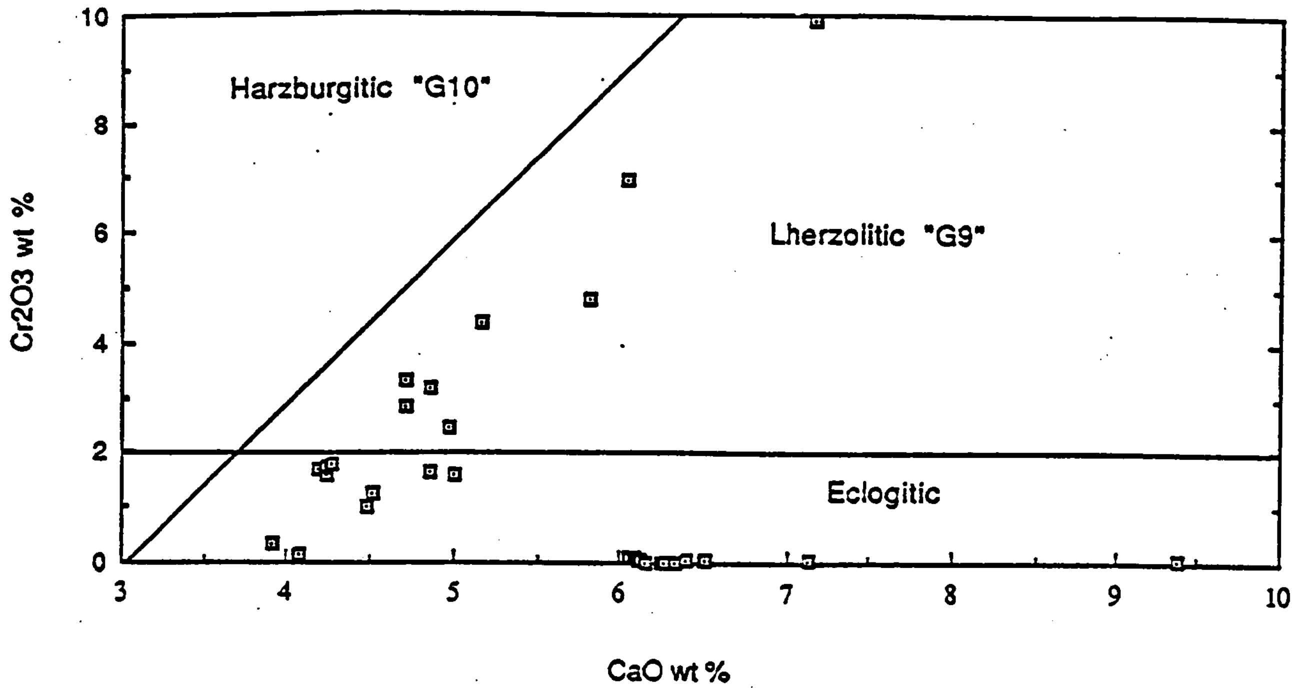
Plot of Cr_2O_3 Vs Garnet Equilbration Temperature (as determined by the garnet nickel geothermometer) for concentrate garnets from Udachnaya. If the garnet in the upper right-hand corner of the plot (1250ºC @ approx 10 wt% Cr_2O_3) were not included in this plot the line-of-best-fit would be strongly negative. The small number of data points in this sample make this a statistical uncertainty however. The data does appear to support the interpretation that Udachnaya concentrate may contain a megacryst component and hence, should be used with caution. (See Schulze, 1987).

FIGURE 45



Plot of Na_2O Vs TiO_2 for concentrate eclogite garnets from Udachnaya. Eight of these garnets plot within the significant field (see Figure 9) for diamond inclusion eclogites from world-wide localites. (See Gurney and Moore, 1991).

FIGURE 46



Plot of CaO Vs Cr_2O_3 for concentrate garnets from Udachnaya. Seventeen of the twenty two eclogitic garnets had ≥ 0.07 wt% Na_2O. This is considered significant in assessing diamond potential for the source of the garnets. (See Gurney and Moore, 1991).

FIGURE 47

There is therefore, good agreement between the two methods used to assess diamond potential.

CONCLUSIONS AND EXPLORATION IMPLICATIONS

The use of the two geochemical methods to analyse for major element concentrations with the electron probe and trace element analysis with the proton probe has provided some interesting results.

The garnet-nickel geothermometer enabled correct conclusions to be drawn as to the diamond potential of the source of the garnets in six of the eight kimberlites. Nouzee was incorrectly determined to be of medium-high economic grade. This was because the temperatures derived for the garnets were equivalent to that expected within the diamond stability field. Because Nouzee is off-craton ,with a shallower than "ideal" lithosphere, it has a steeper geotherm than that associated with a "deep keeled" craton. This highlights the need to use the garnet-nickel thermometer method only in those areas where the depth to base of lithosphere (and hence, geotherm) is confidently known.

The nickel geothermometer also incorrectly assessed Roberts Victor as being uneconomic. Roberts Victor has both high and low temperature suites of garnets. The concentrate used in this study is predominantly from the low temperature suite and interpretations of diamond potential for other kimberlites using the garnet-nickel geothermometer need to take into consideration this possibility.

The major element approach correctly assessed the diamond potential of five out of the nine concentrates examined. This may be an artifact of the restriction of limiting this study to garnets and not including analyses of chrome spinels and ilmenite as well. My application of the method may also have been hampered by my biased "selection" of eclogitic and peridotitic garnets from the Roberts Victor kimberlite.

It was not possible, in this study, to determine why the major element method (using concentrate garnets) incorrectly assessed Rietfontein, Leningradskaya, Zarnitsa and Roberts Victor. The first three of these may have a megacryst component which biased the results but this would need to be determined in a separate study. What is significant is that of the total of 127 peridotitic garnets analysed from eight kimberlite pipes (seven of which were diamondiferous with five being of economic grade) not one plotted within the harzburgitic "G10" field. This despite most of them having a colour (pale purple) associated in exploration fieldwork with G10 garnets.

Exploration managers who design programs which rely on the major element approach tend to emphasise the importance of finding a G10 (personal experience) and can sometimes be discouraged when they do not find them. These results suggest that this need not be the case. In those exploration heavy mineral sampling situations where kimberlitic garnets are the only (or the majority of) minerals sampled, the major element approach to evaluate diamond potential should still be used. It is relatively straight forward to interpret the plotted data which can be compared with that obtained using the garnet-nickel geothermometer. Its Strength lies in its ability to use eclogitic garnets for diamond evaluation - something that the garnet-nickel geothermometer lacks. Its weaknesses are that heavy mineral concentrates may have a low percentage of harzburgitic (G10) garnets in them and it cannot assess diamond potential using lherzolitic (G9) garnets. This may well affect the order of targeting priorities set by exploration companies.

In comparison, the garnet-nickel geothermometer makes good use of the lherzolitic (G9) peridotitic garnets and should be used in those exploration programs where they have been sampled. The method can quickly identify promising garnet concentrate, apparently with quite small sample numbers and may therefore be an early stage evaluator of diamond potential whenever this is the situation.

With regard to the determination of whether or not the garnets were derived from a megacryst suite; an examination of the Mg#s provided in the tables section shows significant variation for Leningradskaya, moderate variation in Udachnaya, Zarnitsa, Orapa and Rietfontein and consistency of Mg#s for Roberts Victor, Mothae, Koffiefontein and Nouzee. Except for Udachnaya, these observations do not provide good agreement for megacryst determination with those made on the basis of Cr_2O_3 (wt%) vs Temperature $T_{(Ni)}$ used earlier in this study. This may be attributable to the small data base, provided by choosing only thirty garnet grains from each kimberlite, being insufficient to provide a statistically validate interpretation. for megacryst determination. A small difference in the Cr_2O_3 content of a single garnet grain can introduce significant deviation in the line of best fit.

Although the garnet nickel geothermometer uses ($\leq$1.5 wt% Cr_2O_3) as a method for classifying eclogitic garnets from peridotitic garnets ($\geq$ 1.5 wt% Cr_2O_3), a number of analyses carried out on "eclogitic"garnets gave temperatures of equilibration consistent with those temperatures determined for the peridotitic garnets from the same concentrate. I have ignored this 1.5 wt% 'cut-off' in only one instance - that for Leningradskaya. It seems possible, in some cases, to use garnet -nickel geothermometry on garnets having a Cr2O3 content of about 1 wt% as the eclogitic/peridotitic classification is to some extent arbitrary. In addition, the garnets may have a geochemistry which is an amalgam of both - possibly due to metasomatism (Taylor. W, pers comm).

I should emphasise that in this study I used quite limited amounts of garnet grains to reach the observations and conclusions that I did. This necessarily introduces limitations on the validity of the interpretative process. Unfortunately, this is exactly the situation that is found in exploration where decisions are often made on the basis of an interpretation(s) derived from quite limited data.

Both methods of assessing diamond potential should be used in any diamond exploration program.Although proton probes are relatively new and scarce every effort should be made to include trace element analysis into the interpretative process. In exploration, any piece of data or method of interpretation that might work for a particular area or situation should be tried, provided the funding stands up. No method of analysis or piece of information should be discarded out of hand and all should be used with an open mind and with caution.

Please note:

The proton probe data for the Rietfontein and Koffiefontein samples is mis-labeled (Vice-versa) I have noted this on the relevant sheets.

REFERENCES

Atkinson, W J."Diamond exploration philosophy, practise, and promises: a review." Vol, 2. GSA Special Publication No. 14. Proceedings of the Fourth International Kimberlite Conference. Perth, 1986.

Anderson, O. L. 1979. The role of fracture dynamics in kimberlite formation. In "Kimberlites, Diatremes and Diamonds" Edited by Boyd F.R. and Meyer. H.O.A.American Geophysical Union, pp. 344-353.

Ballhaus, C. Berry, R.F. and Green.,D.H. 1991.High pressure experimental calibration of the olivine-orthopyroxene-spinel oxygen geobarometer : implications for the oxidation state of the upper mantle. Contrib Mineral Petrol 107: 27-40

Black R. & Liegois J.-P.1993 "Cratons, mobile belts, alkaline rocks and continental lithospheric mantle: the Pan-African testimony" .Journal of the Geological Society, London, Vol. 150: 89-98.

Boullier A. M. and Nicholas A. 1975. Classification of textures and fabrics of peridotite xenoliths from Soputh African kimberlites. Phys. Chem. Earth 9, 467-476.

Boyd, F. R. and John J. Gurney, 1986. "Diamonds and the African Lithosphere", Science,232: 472-476.

Boyd, F. R., Gurney, J.J., and Richarson, S.H. 1985. Evidence for a 150-200 km thick Archaean lithosphere from diamond inclusion thermobarometry. Nature, 315: 387-389.

Canil Dante and Wei.,Kejian.,1992 Constraints on the origin of mantle derived low Ca garnets. Contrib Mineral Petrol 109: 421-430.

Daniels L R. M. and Gurney, JJ. 1991 Oxygen fugacity constraints on the southern African lithosphere. Contrb Mineral Petrol 108: 154-161

Dawson, J.B. 1986. Geographic and time distribution of kimberlites and lamproites : relationships to tectonic processes. Vol, 1. GSA Special Publication No. 14. Proceedings of the Fourth International Kimberlite Conference. Perth, 1986.

Eggler, D. H. 1989. Kimberlites: How do they form ? In "Kimberlites and Related Rocks", Vol. 1. Eggler GSA Special Publication No. 14. Proceedings of the Fourth International Kimberlite Conference. Perth, 1986.

D.H., McCallum M.E. & Smith C.B. 1979. Megacryst assemblages in kimberlite from northern Colorado and southern Wyoming: petrology, geothermometry-barometry and areal distribution. In Boyd, F.R. & Myer H. O. A. eds, The Mantle Sample, pp. 213-226, A.G.U., Washington.

Fipke, C.E, Gurney, J.J, Moore, R.O, and Nassichuck, W.W. October, 1989."The Development Of Advanced Technology To Distinguish Between Diamondiferous And Barren Diatremes" Part 1. A review of Geological Material Relevant to Diamond Exploration and a Summary of Results. Summary Paper On Geological Survey Of Canada Open File Report. Calgary, Alberta.

Fraser K.J., Hawkesworth C.J., Erlank A.J., Mitchell R.H. and Scott-Smith B.H. 1985/86. Sr, Nd and Pb isotopes and minor element geochemistry of lamproites and kimberlites. Earth and Planetary Science Letters 76, 57-70

Griffin. W.L, Smith. D, Boyd. F.R, Cousens. D.R, Ryan. C.G, Sie. S.H and Suter. G.F. 1988, "Trace-element zoning in garnets from sheared mantle xenoliths" Geochemica et Cosmochimica Acta Vol. 53, 1988. .

Griffin,W.L. Cousens, D.R. Ryan, C.G.Sie S.H. and Suter.G. F. 1989 " Ni in Chrome pyrope Garnets: A New Geothermometer". CMP 103 pp. 199-202.

Griffin, W.L. Gurney J.J. and Ryan C.G. 1992.A "Variations in the trapping temperatures and trace elements in peridotite-suite inclusions from African diamonds : evidence for two inclusion suites, and the implications for lithosphere stratigraphy." Contrib. Mineral Petrol 110: 1-15

Griffin W.L. and C.G. Ryan, January 1992 B "The Nickel Thermometer: A New Tool for Diamond Exploration" in "Explore-Newsletter for the Association of Exploration Geochemists" Number 74, pp.13-15, 1992

Gurney John J.,and Rory O. Moore, 1991. Geochemical Correlations Between Diamond Indicator Minerals And Diamonds On The Kalahari Craton. Submitted to Proceedings of The International Field Seminar "Deep Seated Magmatism and Evolution of the Lithosphere of the Siberian Platform" Novosobirsk, Mirny, Udachny. N.V. Sobolev (Ed.).

Gurney, J.J. Moore, R.O. Otter, M.L. Kirkley, M.B. Hops, J.J. and McCandless,T.E. 1991. Southern African Kimberlites and their Xenoliths, in "Magmatism in Extensional Structural Settings- The Phanerozoic African Plate". Springer-Verlag, 1991.

Gurney, J.J. 1986 "Diamonds" Vol, 2. GSA Special Publication No. 14. Proceedings of the Fourth International Kimberlite Conference. Perth, 1986

Gurney J.J. 1989. Diamonds. In: Kimberlites and related rocks 2: Their crust/ mantle setting, diamonds and diamond exploration. Geological Society of Australia, Special Publication 14, 935-965.

Gurney J.J. and Hatton, C.J. 1986. Diamondiferous minerals from the Star Mine, South Africa. Vol, 2. GSA Special Publication No. 14. Proceedings of the Fourth International Kimberlite Conference. Perth, 1986.

Haggerty, S. E. 1986. Upper mantle opaque mineral stratigraphy and the genesis of metasomites and alkali-rich melts. Kimberlites And Related Rocks, Vol, 2. Their Mantle/Crust Setting Diamonds And Diamond Exploration. GSA Special Publication No. 14. Proceedings of the Fourth International Kimberlite Conference. Perth. 1986

Harte B, 1983. Mantle Peridotites And Processes - the Kimberlite Sample. In Hawkeworth C.J., & Norry M.J., eds, Continental Basalt And Mantle Xenoliths, pp. 46-91. Shiva, Nantwich.

Helmsteadt, H.H., and Gurney John J. 1991 Geotectonic Controls On The Formation Of Diamonds And Their Kimberlitic And Lamproitic Hostrocks: Applications To Diamond Exploration. Fifth International Kimberlite Conference, Araxa, Brazil, Extended Abstracts : 173-175.

Helmstaedt, H. H. 1992" 'Primary' Diamond Deposits: What Controls Their Size, Grade And Location?". Giant Ore Deposits Workshop, Department of Geological Sciences, Queens University, Kingston, Ontario, Canada, K7L 3N6. May, 1992.

Helmsteadt H. and Schulze, D.J. 1986 Southern African kimberlites and their mantle sample: implications for Archaean tectonics and lithosphere evolution. Vol, 1. GSA Special Publication No. 14. Proceedings of the Fourth International Kimberlite Conference. Perth, 1986.

Hops, J. J., Gurney, J. J., Harte B. and Winterburn. P, 1986 Megacrysts and high temperature nodules from the Jagersfontein kimberlite pipe. GSA Special Publication No. 14. Vol, 2 Proceedings of the Fourth International Kimberlite Conference. Perth, 1986.

Ionov D.A. and Wood.,B.J. 1992The oxidation state of subcontinental mantle: oxygen thermobarometry of mantle xenoliths from central Asia.

Kirkley, M.B. Gurney J.J. and Levinson, A.A. 1992, "Age, origin and emplacement of diamonds: a review of scientific advances in the last decade." Gems & Gemology, Vol. 27, No 1, pp. 2-25,.

Kennedy C.S. and Kennedy G.C, 1976, J. Geophys. Res. 81, 2467

Kirkley, Melissa B., Gurney., John J. Otter., Marshall L., Hill Stuart J. and Daniels., Leon R, 1991. Applied Geochemistry, Vol, 6, # 5, pp. 477-494,

Kramers, J. D., 1979."Lead, uranium, strontium, potassium and Rubidium in inclusion-bearing diamonds and mantle derived xenoliths from southern Africa; Earth and Planetary Science Letters, Vol. 42, pp. 58-70.

McCandless T.E. and Gurney.,J.J. 1986 Sodium in garnet and potassium in clinopyroxene: criteria for classifying mantle eclogites. GSA Special Publication No. 14. Vol, 2 Proceedings of the Fourth International Kimberlite Conference. Perth, 1986.

McGregor I.D. and Carter J.L. 1970. The chemistry of clinopyroxenes and garnets of eclogite and peridotite.

Moore, R. O. and Gurney J.J. 1985. Pyroxene solid solution in garnets included in diamond. Nature 318, pp. 553-555.

Nixon P.H, 1987 Mantle Xenoliths. John Wiley and Sons, New York. 1987

Nixon P.H. and Condliffe, E. 1986 Tanzania kimberlites: a preliminary heavy mineral study. GSA Special Publication No. 14. Vol, 1 Proceedings of the Fourth International Kimberlite Conference. Perth, 1986.

O'Reilly, Suzanne Y. Griffin, C.G. Ryan. W. L. 1991 Contrib Mineral Petrol "Residence of trace elements in metasomatized spinel lherzolite xenoliths: a proton-micrprobe study" 109:98-113

Richardson, S.H.., 1990 "Latter-day origin of diamonds of eclogitic paragenesis;" Nature, Vol. 322, pp. 623-626,

Richardson, S.H., Erlank, A.J., Harris, J.W., and Hart, S.R., 1986. "Eclogitic diamonds of Proterozoic age from Cretaceous kimberlites; Nature, Vol. 346, pp. 54-56, 1990.

Richardson S. H. 1989. Radiogenic isotope studies of diamond inclusions. 28th I.G.C., Workshop on Diamonds, Extended Abstracts, pp. 87-90.

Ringwood, A.E. Kesson, S.E. Hibberson W. and Ware,N. Origin of Kimberlites and related magmas. Earth and Planetary Science Letters, 113(1992) pp. 521-538.

Rickard, R. S. Harris, J. W. Gurney, J.J. and Cardoso, P. 1986. Mineral inclusions in diamonds from Koffiefontein Mine. 1986. GSA Special Publication No. 14. Vol, 2 Proceedings of the Fourth International Kimberlite Conference. Perth, 1986.

Schulze, D.J. Megacrysts from alkalic volcanic rocks.1987 "Mantle Xenoliths". Edited by Nixon, P.H. John Wiley and Sons Ltd. 1987.

Smith C.B. 1983. Pb, Sr, and Nd isotopic evidence for sources of southern African Cretaceaous kimberlites. Nature, 304 : 51-54

Smith C.B., Gurney J.J., Harris J.W., Otter M.L., Kirkley M.B. and Jagoutz E. 1989. Nd and Sr isotope systematics of large eclogite and lherzolite pargenesis single diamonds, Finsch and Kimberley Pool. 28th I.G.C., Workshop on Diamonds, Extended Abstracts, pp. 102-104.

Sobolev. N.V. and Nixon. P.H. 1987. Xenoliths from the USSR and Mongolia : A Selective and Brief Review. From Mantle Xenoliths Chap 13, pp 160. John Wiley and Sons, New York. 1987

Taylor W. R. and D. H. Green. The role of reduced C-O-H fluids in mantle partial melting. 1986. Vol, 1. GSA Special Publication No. 14. Proceedings of the Fourth International Kimberlite Conference. Perth, 1986.

The Northern Miner. 1992 An article by Brian Christie (Second of a three part series). Canada, November 9, 1992.

Wyllie P.J. The genesis of kimberlites and some low-SiO2, high-alkali magmas. 1986. Vol, 1. GSA Special Publication No. 14. Proceedings of the Fourth International Kimberlite Conference. Perth, 1986.

ACKNOWLEDGEMENTS

I would like to thank Dr Wayne Taylor, who was able to review a substantial component of this thesis. My diamond concentrates were given to me by Professor John Gurney of the University of Cape Town, as well as by Dr Melissa Kirkley of UCT and one of her (un-named) post-graduate students. I do thank them for their kindness and generosity.

Professor Ross Large has at all times encouraged me by his many kindnesses, as has his staff. In Sydney, (Dr.) Soey Sie at the CSIRO's HIAF proton probe helped in many ways, in his efforts toward explaining the workings of his linear accelerator and ancilliary equipment. In the process he provided some valuable insights into both physics and geology. The extra hours that he put in to help me and the many disussions that we have had have been one of the real bonuses gathered along the way.

Here at CODES I have been helped by Dr Joe Stolz, Dr Garry Davidson, Dr David Huston, Dr Peter McGoldrick and on many occassions, by Marcel Kamperman.

Finally, I would like to thank my mother who has been a great strength behind me during this course of study.

LIST OF FIGURES

Kimberlite	Country	Cratonic?	Diamonds?	Sample	Na2O	MgO	Al2O3	SiO2	CaO	TiO2	Cr2O3	MnO	FeO	ZnO	Total	Fe2O3	FeO new	Total new	Mg#
Rietfontein	RSA	No	Trace	GAR1	0.07	15.57	22.38	40.61	3.31	0.24	0.07	0.51	16.85	0.00	99.59	1.01	15.94	99.71	63.5
Rietfontein	RSA	No	Trace	GAR2	0.11	14.36	22.22	40.54	4.77	0.32	0.14	0.84	16.53	0.04	99.85	0.97	15.66	99.97	62.0
Rietfontein	RSA	No	Trace	GAR3	0.04	18.73	16.19	40.49	6.45	0.35	9.18	0.55	7.32	0.10	99.38	1.19	6.25	99.52	84.2
Rietfontein	RSA	No	Trace	GAR4	0.04	10.99	22.83	40.33	12.38	0.18	0.00	0.27	13.52	0.03	100.57	1.19	12.45	100.69	61.1
Rietfontein	RSA	No	Trace	GAR5	0.12	12.98	21.95	40.17	4.19	0.35	0.05	0.60	19.30	0.06	99.77	0.75	18.62	99.85	55.4
Rietfontein	RSA	No	Trace	GAR6	0.02	7.89	21.76	39.54	13.12	0.19	0.08	0.50	16.33	0.01	99.43	0.40	15.97	99.48	46.8
Rietfontein	RSA	No	Trace	GAR7	0.01	20.65	22.15	42.03	4.96	0.07	2.14	0.48	7.36	0.00	99.84	0.82	6.62	99.93	84.8
Rietfontein	RSA	No	Trace	GAR8	0.12	11.53	22.04	39.45	4.51	0.22	0.04	0.95	21.09	0.06	99.99	1.80	19.47	100.19	51.4
Rietfontein	RSA	No	Trace	GAR9	0.10	15.25	22.62	41.02	5.01	0.26	0.12	0.35	15.45	0.06	100.24	0.71	14.81	100.31	64.7
Rietfontein	RSA	No	Trace	GAR10	0.09	16.90	21.98	40.92	3.43	0.22	1.00	0.42	14.44	0.11	99.51	0.86	13.67	99.60	68.8
Rietfontein	RSA	No	Trace	GAR11	0.08	21.86	22.62	42.55	3.83	0.23	1.41	0.51	6.73	0.01	99.80	0.46	6.32	99.88	86.1
Rietfontein	RSA	No	Trace	GAR12	0.03	21.12	23.07	42.23	4.38	0.15	0.55	0.26	8.11	0.03	99.92	1.30	6.94	100.06	84.4
Rietfontein	RSA	No	Trace	GAR13	0.10	8.81	21.55	38.61	4.02	0.28	0.07	0.74	25.62	0.05	99.86	1.46	24.31	100.00	39.3
Rietfontein	RSA	No	Trace	GAR14	0.02	15.76	22.27	40.55	4.79	0.09	0.56	0.45	15.36	0.03	99.86	1.78	13.76	100.06	67.1
Rietfontein	RSA	No	Trace	GAR15	0.09	13.32	22.43	39.97	4.51	0.20	0.04	0.50	18.64	0.00	99.69	1.24	17.53	99.82	57.5
Rietfontein	RSA	No	Trace	GAR16	0.05	19.26	22.89	41.57	3.99	0.20	0.35	0.58	10.88	0.00	99.75	1.40	9.62	99.91	78.1
Rietfontein	RSA	No	Trace	GAR17	0.13	15.05	22.61	40.84	6.33	0.32	0.04	0.51	14.01	0.00	99.84	1.05	13.07	99.95	67.3
Rietfontein	RSA	No	Trace	GAR19	0.10	14.25	22.10	40.26	4.62	0.27	0.25	0.46	17.27	0.00	99.56	1.26	16.13	99.71	61.2
Rietfontein	RSA	No	Trace	GAR20	0.07	21.94	22.68	42.28	3.63	0.25	1.38	0.47	6.86	0.07	99.61	0.78	6.16	99.71	86.4
Rietfontein	RSA	No	Trace	GAR21	0.02	20.98	23.01	42.38	4.29	0.14	0.57	0.28	8.09	0.02	99.78	0.64	7.51	99.84	83.3
Rietfontein	RSA	No	Trace	GAR22	0.10	8.83	21.59	38.61	4.09	0.28	0.07	0.73	25.48	0.00	99.78	1.38	24.24	99.92	39.4
Rietfontein	RSA	No	Trace	GAR23	0.01	15.43	22.17	40.89	5.03	0.10	0.57	0.43	15.01	0.14	99.78	0.65	14.43	99.84	65.6
Rietfontein	RSA	No	Trace	GAR24	0.07	13.37	22.31	40.10	4.55	0.21	0.06	0.46	18.62	0.03	99.78	1.07	17.66	99.89	57.4
Rietfontein	RSA	No	Trace	GAR25	0.06	19.32	22.95	41.68	3.95	0.16	0.36	0.57	10.81	0.00	99.86	1.32	9.63	99.99	78.2
Rietfontein	RSA	No	Trace	GAR26	0.11	15.09	22.66	40.80	6.37	0.33	0.03	0.41	14.04	0.05	99.87	1.10	13.05	100.00	67.3
Rietfontein	RSA	No	Trace	GAR27	0.17	16.11	21.78	40.84	4.74	0.58	0.08	0.45	14.36	0.06	99.15	1.21	13.27	99.29	68.4
Koffiefontein	RSA	Yes	Yes	GAR1	0.07	21.90	20.85	42.21	4.60	0.78	2.63	0.40	5.57	0.00	99.00	0.07	5.51	99.02	87.6
Koffiefontein	RSA	Yes	Yes	GAR2	0.05	21.18	19.59	41.78	4.92	0.34	4.61	0.47	5.67	0.00	98.61	0.19	5.50	98.63	87.3
Koffiefontein	RSA	Yes	Yes	GAR3	0.03	20.82	18.77	41.85	5.38	0.35	5.91	0.44	5.78	0.00	99.33	0.02	5.77	99.33	86.6
Koffiefontein	RSA	Yes	Yes	GAR4	0.07	21.00	21.16	41.67	4.58	0.52	2.39	0.40	7.34	0.06	99.19	1.26	6.21	99.32	85.8
Koffiefontein	RSA	Yes	Yes	GAR5	0.05	19.93	18.98	41.59	5.85	0.23	6.48	0.53	7.09	0.00	100.70	1.05	6.15	100.83	85.3
Koffiefontein	RSA	Yes	Yes	GAR6	0.03	10.14	22.10	39.05	4.06	0.00	0.17	0.72	24.06	0.02	100.33	1.70	22.53	100.52	44.5
Koffiefontein	RSA	Yes	Yes	GAR7	0.07	21.57	21.05	42.08	4.41	0.53	2.32	0.27	6.70	0.00	98.98	0.67	6.10	99.07	86.3
Koffiefontein	RSA	Yes	Yes	GAR8	0.07	21.52	19.78	41.98	4.83	0.51	4.67	0.42	5.74	0.12	99.63	0.54	5.25	99.69	88.0
Koffiefontein	RSA	Yes	Yes	GAR9	0.08	21.22	21.48	42.07	4.41	0.88	0.90	0.22	7.30	0.00	98.56	0.31	7.03	98.59	84.3
Koffiefontein	RSA	Yes	Yes	GAR10	0.08	21.84	21.56	42.50	4.29	0.62	2.07	0.35	6.52	0.02	99.88	0.35	6.21	99.89	86.3
Koffiefontein	RSA	Yes	Yes	GAR11	0.06	21.50	19.50	41.95	4.60	0.22	5.49	0.37	5.84	0.00	99.53	0.39	5.49	99.57	87.5
Koffiefontein	RSA	Yes	Yes	GAR12	0.11	20.96	20.61	42.10	4.63	1.06	1.94	0.32	7.22	0.00	98.93	0.06	7.17	98.96	83.9
Koffiefontein	RSA	Yes	Yes	GAR13	0.07	21.70	20.73	42.01	4.48	0.93	1.45	0.33	5.85	0.00	97.55				86.9
Koffiefontein	RSA	Yes	Yes	GAR14	0.07	21.94	20.77	42.52	4.58	0.67	2.37	0.28	5.50	0.05	98.74				87.7
Koffiefontein	RSA	Yes	Yes	GAR15	0.08	21.60	20.94	41.71	4.76	0.77	2.79	0.43	6.50	0.00	99.58	1.49	5.16	99.73	88.2
Koffiefontein	RSA	Yes	Yes	GAR16	0.09	21.06	20.90	41.93	4.41	0.86	2.11	0.31	7.47	0.00	99.13	0.54	6.99	99.19	84.3
Koffiefontein	RSA	Yes	Yes	GAR17	0.10	21.69	20.90	42.55	4.45	0.97	1.36	0.31	5.88	0.04	98.24				86.8
Koffiefontein	RSA	Yes	Yes	GAR18	0.06	21.92	21.06	42.44	4.59	0.51	2.61	0.37	5.69	0.00	99.23	0.10	5.60	99.26	87.5
Koffiefontein	RSA	Yes	Yes	GAR19	0.10	20.06	20.47	42.06	4.75	1.13	1.84	0.50	7.49	0.00	98.39				82.7
Koffiefontein	RSA	Yes	Yes	GAR20	0.04	21.72	21.34	42.21	4.59	0.27	2.59	0.44	6.26	0.04	99.51	0.90	5.45	99.59	87.7
Koffiefontein	RSA	Yes	Yes	GAR21	0.05	22.17	21.23	42.48	4.54	0.27	2.52	0.37	5.36	0.05	99.03	0.34	5.05	99.07	88.7
Koffiefontein	RSA	Yes	Yes	GAR22	0.04	20.77	20.85	41.54	5.01	0.19	3.73	0.39	7.16	0.00	99.68	1.49	5.82	99.83	86.4

Kimberlite	Country	Cratonic?	Diamonds?	Sample	Na2O	MgO	Al2O3	SiO2	CaO	TiO2	Cr2O3	MnO	FeO	ZnO	Total	Fe2O3	FeO new	Total new	Mg#
Koffiefontein	RSA	Yes	Yes	GAR23	0.10	20.17	20.55	41.93	4.70	1.10	1.89	0.33	7.86	0.07	98.70				82.1
Koffiefontein	RSA	Yes	Yes	GAR24	0.03	20.39	18.20	41.56	5.72	0.29	6.96	0.39	6.18	0.02	99.74	0.50	5.73	99.79	86.4
Koffiefontein	RSA	Yes	Yes	GAR25	0.07	21.33	20.97	41.93	4.75	0.65	2.74	0.38	6.62	0.00	99.42	0.80	5.90	99.52	86.6
Koffiefontein	RSA	Yes	Yes	GAR26	0.04	21.07	23.21	42.00	4.03	0.17	0.45	0.36	8.37	0.03	99.73	1.44	7.08	99.87	84.1
Koffiefontein	RSA	Yes	Yes	GAR27	0.09	20.53	22.38	42.29	4.68	0.45	1.40	0.41	8.20	0.00	100.42	0.73	7.55	100.50	82.9
Koffiefontein	RSA	Yes	Yes	GAR28	0.02	20.98	19.44	41.65	5.02	0.07	5.73	0.47	6.69	0.03	100.10	1.39	5.44	100.24	87.3
Koffiefontein	RSA	Yes	Yes	GAR29	0.05	22.12	21.33	42.44	4.56	0.32	2.97	0.42	5.71	0.00	99.91	0.67	5.11	99.99	88.5
Koffiefontein	RSA	Yes	Yes	GAR30	0.05	21.23	19.96	42.10	5.22	0.26	4.95	0.34	6.31	0.00	100.41	0.94	5.47	100.51	87.4
Nouzees	Namibia	No	No	GARN 1	0.05	21.46	20.86	42.11	5.08	0.32	3.78	0.39	5.72	0.06	99.83	0.58	5.20	99.89	88.0
Nouzees	Namibia	No	No	GAR 2	0.03	20.87	20.54	41.85	5.07	0.26	3.84	0.37	6.26	0.01	99.09	0.23	6.05	99.12	86.0
Nouzees	Namibia	No	No	GAR3	0.03	20.83	19.51	42.05	5.53	0.25	5.33	0.41	5.71	0.06	99.70	0.03	5.68	99.71	86.7
Nouzees	Namibia	No	No	GAR4	0.01	19.92	18.16	41.38	6.48	0.06	7.34	0.47	5.84	0.00	99.66	0.71	5.20	99.73	87.2
Nouzees	Namibia	No	No	GAR5	0.00	20.08	21.68	41.80	5.26	0.03	2.84	0.53	7.66	0.04	99.92	0.84	6.90	100.00	83.8
Nouzees	Namibia	No	No	GAR6	0.04	21.34	20.11	41.89	5.22	0.32	4.93	0.42	5.93	0.00	100.20	0.99	5.04	100.30	88.3
Nouzees	Namibia	No	No	GAR7	0.03	21.64	20.34	41.86	5.03	0.29	4.18	0.34	5.60	0.00	99.33	0.88	4.81	99.40	88.9
Nouzees	Namibia	No	No	GAR8	0.04	20.60	20.24	41.87	5.36	0.33	4.25	0.34	6.33	0.00	99.35	0.10	6.24	99.37	85.5
Nouzees	Namibia	No	No	GAR9	0.03	21.08	19.49	41.79	5.57	0.30	5.30	0.31	5.46	0.06	99.39	0.49	5.02	99.44	88.2
Nouzees	Namibia	No	No	GAR10	0.04	21.55	20.69	42.18	5.14	0.26	4.09	0.24	5.73	0.00	99.93	0.54	5.24	99.97	88.0
Nouzees	Namibia	No	No	GAR11	0.07	20.04	22.05	41.40	4.66	0.62	1.11	0.39	8.71	0.01	99.05	1.19	7.64	99.18	82.4
Nouzees	Namibia	No	No	GAR12	0.06	19.87	20.80	41.35	5.15	0.67	2.55	0.39	7.88	0.00	98.72	0.58	7.36	98.78	82.8
Nouzees	Namibia	No	No	GAR13	0.05	21.09	19.69	41.77	5.33	0.26	5.14	0.33	5.92	0.09	99.66	0.90	5.11	99.76	88.0
Nouzees	Namibia	No	No	GAR14	0.03	20.88	19.68	41.76	5.45	0.30	4.98	0.38	5.85	0.01	99.31	0.43	5.47	99.36	87.2
Nouzees	Namibia	No	No	GAR15	0.02	19.73	21.24	41.87	5.50	0.06	3.09	0.46	7.53	0.00	99.49	0.21	7.34	99.52	82.7
Nouzees	Namibia	No	No	GAR16	0.03	21.06	21.19	42.19	4.76	0.27	2.94	0.45	6.50	0.00	99.40	0.05	6.46	99.39	85.3
Nouzees	Namibia	No	No	GAR17	0.03	21.57	20.76	41.59	4.96	0.38	3.75	0.41	6.03	0.01	99.48	1.47	4.70	99.64	89.1
Nouzees	Namibia	No	No	GAR18	0.05	20.70	21.34	41.81	5.02	0.61	1.95	0.39	7.27	0.03	99.16	0.79	6.56	99.25	84.9
Nouzees	Namibia	No	No	GAR19	0.03	19.43	17.98	41.50	6.95	0.10	7.23	0.39	5.77	0.05	99.43	0.20	5.60	99.45	86.1
Nouzees	Namibia	No	No	GAR20	0.01	20.43	21.60	41.65	5.19	0.00	3.02	0.52	7.23	0.01	99.66	1.20	6.15	99.78	85.5
Nouzees	Namibia	No	No	GAR23	0.04	21.79	20.75	42.36	4.85	0.26	3.91	0.31	5.75	0.00	100.01	0.47	5.33	100.07	87.9
Nouzees	Namibia	No	No	GAR24	0.03	19.79	20.77	41.77	5.67	0.12	3.61	0.44	7.04	0.03	99.26	0.16	6.90	99.29	83.6
Nouzees	Namibia	No	No	GAR25	0.06	20.07	20.59	41.85	4.93	0.60	3.09	0.32	7.51	0.00	99.02				82.7
Nouzees	Namibia	No	No	GAR26	0.04	21.78	22.07	42.21	4.70	0.34	2.02	0.34	6.19	0.00	99.69	0.88	5.40	99.78	87.8
Nouzees	Namibia	No	No	GAR27	0.08	21.05	21.69	41.97	4.78	0.52	1.76	0.34	6.77	0.00	98.96	0.53	6.29	99.01	85.6
Nouzees	Namibia	No	No	GAR28	0.06	21.18	19.90	41.93	5.16	0.33	4.95	0.34	5.93	0.02	99.80	0.56	5.43	99.86	87.4
Nouzees	Namibia	No	No	GAR29	0.05	21.28	19.69	41.71	5.16	0.31	4.86	0.34	5.56	0.00	98.96	0.59	5.03	99.02	88.3
Roberts Victor	RSA	Yes	Yes	GAR1	0.04	19.80	20.20	40.10	5.26	0.14	3.79	0.47	7.62	0.01	97.42	2.50	5.37	97.68	86.8
Roberts Victor	RSA	Yes	Yes	GAR2	0.02	19.87	19.82	39.72	5.29	0.12	4.70	0.50	7.12	0.00	97.15	2.57	4.81	97.42	88.1
Roberts Victor	RSA	Yes	Yes	GAR3	0.01	20.43	20.94	39.93	4.91	0.15	3.21	0.53	7.62	0.07	97.81	3.44	4.53	98.14	88.9
Roberts Victor	RSA	Yes	Yes	GAR4	0.04	19.92	21.52	39.52	5.13	0.12	2.15	0.62	8.23	0.03	97.28	4.21	4.44	97.70	88.9
Roberts Victor	RSA	Yes	Yes	GAR5	0.03	19.78	19.85	39.77	5.43	0.13	4.66	0.55	7.41	0.00	97.62	2.95	4.76	97.91	88.1
Roberts Victor	RSA	Yes	Yes	GAR6	0.03	19.46	18.77	39.47	5.96	0.09	6.06	0.53	7.12	0.05	97.53	3.21	4.23	97.86	89.1
Roberts Victor	RSA	Yes	Yes	GAR7	0.02	20.61	20.68	39.98	4.95	0.09	3.63	0.57	7.31	0.03	97.87	3.56	4.11	98.23	89.9
Roberts Victor	RSA	Yes	Yes	GAR8	0.03	18.29	18.55	38.98	6.39	0.13	5.87	0.63	7.95	0.00	96.82	3.10	5.16	97.13	86.3
Roberts Victor	RSA	Yes	Yes	GAR9	0.04	19.00	19.86	39.44	5.91	0.13	4.64	0.55	7.88	0.11	97.55	3.21	5.00	97.88	87.1
Roberts Victor	RSA	Yes	Yes	GAR10	0.03	20.05	21.03	39.96	5.09	0.11	3.22	0.53	8.07	0.00	98.07	3.48	4.94	98.44	87.9
Roberts Victor	RSA	Yes	Yes	GAR11	0.03	20.19	21.17	39.69	4.84	0.17	2.61	0.46	7.82	0.00	96.96	3.34	4.82	97.31	88.2

Kimberlite	Country	Cratonic?	Diamonds?	Sample	Na2O	MgO	Al2O3	SiO2	CaO	TiO2	Cr2O3	MnO	FeO	ZnO	Total	Fe2O3	FeO new	Total new	Mg#
Roberts Victor	RSA	Yes	Yes	GAR12	0.03	19.47	20.03	39.58	5.56	0.10	4.24	0.51	7.78	0.08	97.37	3.24	4.86	97.70	87.7
Roberts Victor	RSA	Yes	Yes	GAR13	0.02	19.68	21.21	39.56	5.04	0.10	2.74	0.51	8.45	0.00	97.31	3.56	5.25	97.67	87.0
Roberts Victor	RSA	Yes	Yes	GAR14	0.02	19.67	20.57	39.80	5.43	0.09	4.01	0.55	7.92	0.00	98.05	3.24	5.00	98.38	87.5
Roberts Victor	RSA	Yes	Yes	GAR15	0.05	19.40	19.04	40.32	6.00	0.16	5.85	0.51	7.15	0.00	98.49	2.01	5.34	98.68	86.6
Roberts Victor	RSA	Yes	Yes	GAR16	0.01	18.78	18.90	39.70	6.24	0.06	5.89	0.56	7.42	0.00	97.56	2.20	5.44	97.78	86.0
Roberts Victor	RSA	Yes	Yes	GAR17	0.05	19.69	19.71	39.85	5.56	0.07	5.01	0.42	7.38	0.11	97.84	2.94	4.74	98.14	88.1
Roberts Victor	RSA	Yes	Yes	GAR18	0.03	20.04	20.62	40.66	5.11	0.14	3.47	0.62	7.44	0.00	98.12	1.93	5.71	98.32	86.2
Roberts Victor	RSA	Yes	Yes	GAR19	0.05	19.87	19.62	40.32	5.42	0.16	4.88	0.59	7.18	0.05	98.12	2.29	5.12	98.37	87.4
Roberts Victor	RSA	Yes	Yes	GAR20	0.04	19.40	19.17	40.08	5.75	0.24	5.06	0.53	7.26	0.00	97.54	1.99	5.47	97.73	86.3
Roberts Victor	RSA	Yes	Yes	GAR21	0.02	19.52	19.85	39.11	5.51	0.19	4.26	0.58	7.69	0.05	96.78	3.71	4.36	97.15	88.9
Roberts Victor	RSA	Yes	Yes	GAR22	0.02	19.49	19.78	40.05	5.75	0.15	4.78	0.53	7.42	0.00	97.97	2.37	5.29	98.21	86.8
Roberts Victor	RSA	Yes	Yes	GAR23	0.03	18.94	18.98	40.74	6.06	0.17	5.78	0.71	7.38	0.00	98.79	1.00	6.48	98.89	83.9
Roberts Victor	RSA	Yes	Yes	GAR24	0.05	19.26	19.17	39.22	6.03	0.14	5.36	0.56	7.22	0.04	97.04	3.43	4.13	97.39	89.3
Roberts Victor	RSA	Yes	Yes	GAR25	0.03	19.63	19.91	40.20	5.50	0.18	4.63	0.51	7.50	0.01	98.09	2.19	5.53	98.32	86.4
Roberts Victor	RSA	Yes	Yes	GAR26	0.04	20.16	20.87	40.70	5.02	0.15	3.19	0.57	7.60	0.00	98.29	2.15	5.67	98.51	86.4
Roberts Victor	RSA	Yes	Yes	GAR27	0.04	19.57	20.18	39.70	5.42	0.10	4.04	0.54	7.62	0.00	97.20	2.91	5.00	97.50	87.5
Roberts Victor	RSA	Yes	Yes	GAR28	0.04	20.27	21.36	40.77	4.63	0.08	2.84	0.53	7.69	0.00	98.21	1.84	6.04	98.39	85.7
Roberts Victor	RSA	Yes	Yes	GAR29	0.04	19.92	20.34	38.86	5.16	0.13	3.77	0.60	7.54	0.01	96.36	4.31	3.66	96.80	90.7
Roberts Victor	RSA	Yes	Yes	GAR30	0.04	19.53	20.52	39.48	5.26	0.21	3.44	0.50	8.40	0.03	97.39	3.64	5.13	97.77	87.2
Orapa	Botswana	Yes	Yes	GAR1	0.09	21.36	21.06	41.53	4.20	0.75	1.02	0.30	6.37	0.00	96.68	0.24	6.16	96.70	86.1
Orapa	Botswana	Yes	Yes	GAR2	0.10	20.62	21.37	40.97	4.34	0.92	0.30	0.21	7.62	0.03	96.47	0.92	6.80	96.57	84.4
Orapa	Botswana	Yes	Yes	GAR3	0.05	21.79	22.96	41.68	4.16	0.33	0.42	0.48	6.43	0.04	98.33	1.36	5.21	98.48	88.2
Orapa	Botswana	Yes	Yes	GAR4	0.12	20.45	20.53	40.10	4.46	0.92	1.30	0.32	7.83	0.00	96.02	2.34	5.73	96.26	86.4
Orapa	Botswana	Yes	Yes	GAR5	0.00	5.07	20.63	36.17	1.95	0.00	0.14	0.28	33.53	0.00	97.78	2.33	31.43	98.00	22.3
Orapa	Botswana	Yes	Yes	GAR6	0.10	20.97	20.72	41.17	4.56	0.97	0.95	0.26	7.05	0.00	96.74	1.00	6.15	96.85	85.9
Orapa	Botswana	Yes	Yes	GAR7	0.08	20.23	20.81	40.22	5.30	0.73	1.91	0.40	7.13	0.04	96.86	2.27	5.09	97.08	87.6
Orapa	Botswana	Yes	Yes	GAR8	0.07	20.44	20.72	40.09	4.45	1.06	0.76	0.29	7.89	0.00	95.77	1.95	6.14	95.97	85.6
Orapa	Botswana	Yes	Yes	GAR9	0.04	19.96	22.05	39.56	4.12	0.08	1.24	0.44	9.02	0.05	96.56	3.53	5.84	96.91	85.9
Orapa	Botswana	Yes	Yes	GAR10	0.09	20.18	21.13	41.18	4.47	1.00	0.92	0.29	8.38	0.03	97.66	0.75	7.70	97.75	82.4
Orapa	Botswana	Yes	Yes	GAR11	0.02	5.70	21.07	37.06	3.43	0.02	0.01	1.88	29.31	0.11	98.60	1.81	27.68	98.79	26.8
Orapa	Botswana	Yes	Yes	GAR12	0.10	21.44	20.93	41.99	4.40	0.86	1.03	0.31	6.30	0.00	97.35				85.8
Orapa	Botswana	Yes	Yes	GAR13	0.09	21.31	21.35	41.58	4.19	0.88	0.46	0.30	6.77	0.05	96.96	0.42	6.39	97.02	85.6
Orapa	Botswana	Yes	Yes	GAR14	0.01	5.40	21.22	36.99	4.00	0.04	0.02	1.07	30.37	0.03	99.17	2.24	28.36	99.37	25.3
Orapa	Botswana	Yes	Yes	GAR15	0.08	21.05	21.27	41.51	4.42	0.86	1.08	0.32	7.16	0.00	97.73	0.70	6.53	97.82	85.2
Orapa	Botswana	Yes	Yes	GAR16	0.00	6.75	21.23	37.03	2.68	0.01	0.06	0.98	29.63	0.00	98.37	2.00	27.83	98.57	30.2
Orapa	Botswana	Yes	Yes	GAR17	0.04	20.56	21.96	40.81	4.81	0.79	0.56	0.40	7.56	0.00	97.49	1.62	6.11	97.65	85.7
Orapa	Botswana	Yes	Yes	GAR18	0.04	3.16	20.62	36.81	4.28	0.05	0.00	1.80	32.53	0.02	99.31	1.79	30.92	99.49	15.4
Orapa	Botswana	Yes	Yes	GAR19	0.00	5.85	21.04	36.49	1.68	0.00	0.03	0.41	33.08	0.05	98.61	2.76	30.59	98.91	25.4
Orapa	Botswana	Yes	Yes	GAR20	0.11	19.69	20.85	40.41	4.58	1.09	0.70	0.43	8.83	0.00	96.68	1.60	7.39	96.85	82.6
Orapa	Botswana	Yes	Yes	GAR21	0.03	2.26	20.40	35.73	2.09	0.03	0.03	1.25	36.56	0.06	98.44	2.19	34.59	98.66	10.4
Orapa	Botswana	Yes	Yes	GAR22	0.08	21.45	20.93	41.55	4.22	0.73	1.61	0.40	6.72	0.02	97.70	0.91	5.90	97.80	86.6
Orapa	Botswana	Yes	Yes	GAR23	0.10	21.31	20.77	41.08	4.36	0.85	1.17	0.33	6.41	0.00	96.37	1.00	5.51	96.48	87.3
Orapa	Botswana	Yes	Yes	GAR24	0.08	21.59	20.97	40.85	4.20	0.92	0.99	0.33	6.40	0.06	96.37	1.50	5.05	96.54	88.4
Orapa	Botswana	Yes	Yes	GAR25	0.06	21.92	21.89	41.62	4.15	0.63	1.22	0.38	6.62	0.03	98.52	1.52	5.25	98.67	88.2
Orapa	Botswana	Yes	Yes	GAR26	0.10	21.24	20.84	42.09	4.33	0.88	1.03	0.32	6.40	0.00	97.22				85.5
Orapa	Botswana	Yes	Yes	GAR27	0.02	2.93	20.65	36.10	1.86	0.04	0.00	1.78	35.27	0.00	98.66	1.74	33.70	98.82	13.4
Orapa	Botswana	Yes	Yes	GAR28	0.07	14.65	22.15	39.82	3.32	0.22	0.06	0.48	17.61	0.05	98.44	1.14	16.59	98.54	61.2
Orapa	Botswana	Yes	Yes	GAR29	0.00	5.57	21.09	36.64	3.44	0.03	0.00	0.31	31.27	0.03	98.36	2.34	29.16	98.61	25.4

Kimberlite	Country	Cratonic?	Diamonds?	Sample	Na2O	MgO	Al2O3	SiO2	CaO	TiO2	Cr2O3	MnO	FeO	ZnO	Total	Fe2O3	FeO new	Total new	Mg#
Orapa	Botswana	Yes	Yes	GAR30	0.11	19.88	20.86	40.18	4.48	1.04	0.83	0.40	8.58	0.00	96.36	1.88	6.89	96.55	83.7
Mothae	Lesotho	Yes?	Trace	GAR1	0.03	20.40	22.69	41.15	4.85	0.11	1.17	0.47	7.64	0.04	98.55	1.74	6.07	98.72	85.7
Mothae	Lesotho	Yes?	Trace	GAR2	0.05	20.79	22.82	41.82	4.74	0.09	1.12	0.35	7.34	0.06	99.18	1.14	6.32	99.29	85.4
Mothae	Lesotho	Yes?	Trace	GAR3	0.10	20.72	22.65	40.84	4.77	0.09	1.14	0.48	7.39	0.01	98.16	2.76	4.91	98.47	88.3
Mothae	Lesotho	Yes?	Trace	GAR4	0.10	20.50	22.77	40.76	4.74	0.09	1.01	0.40	7.59	0.00	97.96	2.51	5.33	98.21	87.3
Mothae	Lesotho	Yes?	Trace	GAR5	0.02	20.64	22.62	41.25	4.79	0.08	1.12	0.44	7.31	0.10	98.37	1.63	5.84	98.53	86.3
Mothae	Lesotho	Yes?	Trace	GAR6	0.04	20.46	22.13	40.92	5.11	0.07	1.72	0.49	7.48	0.02	98.43	2.45	5.27	98.69	87.4
Mothae	Lesotho	Yes?	Trace	GAR7	0.01	20.74	22.59	40.76	4.74	0.09	1.03	0.40	7.27	0.00	97.63	2.16	5.32	97.85	87.4
Mothae	Lesotho	Yes?	Trace	GAR8	0.06	20.64	22.69	41.03	4.80	0.09	1.13	0.41	7.48	0.00	98.32	2.19	5.51	98.55	87.0
Mothae	Lesotho	Yes?	Trace	GAR9	0.08	20.85	23.06	41.66	4.64	0.07	0.95	0.43	7.32	0.00	99.05	1.51	5.96	99.21	86.2
Mothae	Lesotho	Yes?	Trace	GAR10	0.08	20.58	22.63	40.98	4.87	0.10	1.22	0.46	7.29	0.12	98.32	2.30	5.22	98.56	87.5
Mothae	Lesotho	Yes?	Trace	GAR11	0.04	20.65	22.60	41.13	4.78	0.06	1.13	0.49	7.51	0.00	98.38	2.10	5.62	98.60	86.8
Mothae	Lesotho	Yes?	Trace	GAR12	0.02	20.53	22.73	41.25	4.73	0.07	1.02	0.47	7.58	0.00	98.39	1.58	6.16	98.56	85.6
Mothae	Lesotho	Yes?	Trace	GAR13	0.03	20.96	23.06	41.88	4.82	0.07	0.98	0.39	7.32	0.01	99.51	1.40	6.06	99.66	86.0
Mothae	Lesotho	Yes?	Trace	GAR14	0.02	20.74	22.92	41.54	4.67	0.07	0.95	0.46	7.52	0.02	98.92	1.46	6.20	99.06	85.6
Mothae	Lesotho	Yes?	Trace	GAR15	0.03	20.78	22.67	41.21	4.79	0.07	1.00	0.42	7.24	0.00	98.22	1.83	5.60	98.39	86.9
Mothae	Lesotho	Yes?	Trace	GAR16	0.06	20.72	22.69	41.62	4.69	0.05	1.11	0.40	7.30	0.00	98.65	1.24	6.18	98.76	85.7
Mothae	Lesotho	Yes?	Trace	GAR17	0.07	20.68	22.76	41.39	4.70	0.07	1.06	0.40	7.42	0.00	98.53	1.65	5.94	98.71	86.1
Mothae	Lesotho	Yes?	Trace	GAR18	0.03	20.70	22.86	41.51	4.79	0.05	1.21	0.42	7.41	0.00	98.97	1.48	6.08	99.13	85.9
Mothae	Lesotho	Yes?	Trace	GAR19	0.06	20.76	22.68	41.12	4.67	0.03	1.14	0.55	7.43	0.07	98.52	2.36	5.31	98.75	87.5
Mothae	Lesotho	Yes?	Trace	GAR20	0.08	20.46	22.80	41.18	4.72	0.07	1.06	0.42	7.56	0.00	98.34	1.75	5.99	98.52	85.9
Mothae	Lesotho	Yes?	Trace	GAR20	0.02	20.56	22.40	41.24	4.95	0.06	1.50	0.40	7.35	0.00	98.49	1.64	5.88	98.64	86.2
Mothae	Lesotho	Yes?	Trace	GAR21	0.03	20.54	22.79	41.75	4.84	0.06	1.10	0.39	7.32	0.00	98.83	0.77	6.63	98.90	84.7
Mothae	Lesotho	Yes?	Trace	GAR22	0.03	20.92	23.06	41.76	4.70	0.03	0.95	0.43	7.37	0.00	99.24	1.44	6.07	99.39	86.0
Mothae	Lesotho	Yes?	Trace	GAR23	0.03	20.70	22.75	41.25	4.77	0.06	1.11	0.36	7.56	0.00	98.59	1.89	5.86	98.78	86.3
Mothae	Lesotho	Yes?	Trace	GAR24	0.05	20.96	22.89	41.76	4.72	0.09	0.98	0.41	7.20	0.03	99.10	1.41	5.93	99.23	86.3
Mothae	Lesotho	Yes?	Trace	GAR25	0.04	20.87	22.70	41.48	4.84	0.08	1.01	0.34	7.04	0.00	98.39	1.45	5.74	98.54	86.6
Mothae	Lesotho	Yes?	Trace	GAR26	0.01	20.34	22.22	41.36	5.05	0.06	1.69	0.46	7.39	0.04	98.60	1.28	6.23	98.75	85.3
Mothae	Lesotho	Yes?	Trace	GAR27	0.01	20.80	22.91	41.54	4.76	0.06	1.11	0.43	7.56	0.00	99.17	1.66	6.07	99.35	85.9
Mothae	Lesotho	Yes?	Trace	GAR28	0.02	20.92	22.90	41.36	4.84	0.09	1.01	0.42	7.42	0.01	99.00	2.12	5.52	99.20	87.1
Mothae	Lesotho	Yes?	Trace	GAR29	0.03	20.74	22.87	41.60	4.85	0.07	1.07	0.47	7.26	0.09	99.04	1.48	5.93	99.20	86.2
Mothae	Lesotho	Yes?	Trace	GAR30	0.03	20.75	22.92	41.48	4.65	0.03	1.04	0.43	7.46	0.06	98.85	1.56	6.05	99.01	85.9
Leningradkaya	Russia	Yes	Yes?	GAR1	0.05	20.09	16.96	41.13	6.16	0.85	6.64	0.45	5.43	0.04	97.79				86.8
Leningradkaya	Russia	Yes	Yes?	GAR2	0.00	6.73	20.68	38.06	6.32	0.10	0.02	1.16	25.43	0.07	98.55	1.29	24.27	98.70	33.1
Leningradkaya	Russia	Yes	Yes?	GAR3	0.02	10.14	21.91	39.56	5.64	0.07	0.03	0.51	21.41	0.00	99.27				45.8
Leningradkaya	Russia	Yes	Yes?	GAR4	0.07	19.34	15.00	40.76	6.79	0.93	9.39	0.43	5.01	0.00	97.72				87.3
Leningradkaya	Russia	Yes	Yes?	GAR5	0.02	6.24	20.61	37.94	6.92	0.08	0.00	1.03	25.08	0.03	97.94	0.88	24.29	98.04	31.4
Leningradkaya	Russia	Yes	Yes?	GAR6	0.07	19.79	18.66	41.34	5.37	1.05	3.36	0.32	6.59	0.06	96.61				84.3
Leningradkaya	Russia	Yes	Yes?	GAR7	0.06	20.09	18.77	41.32	6.05	0.67	5.21	0.47	6.14	0.00	98.77	0.50	5.69	98.83	86.3
Leningradkaya	Russia	Yes	Yes?	GAR8	0.01	5.79	20.89	38.10	6.72	0.08	0.06	1.54	25.91	0.00	99.09	0.91	25.09	99.19	29.1
Leningradkaya	Russia	Yes	Yes?	GAR9	0.07	21.64	19.25	41.89	4.93	0.90	3.55	0.26	5.13	0.00	97.62				88.3
Leningradkaya	Russia	Yes	Yes?	GAR10	0.06	20.21	17.39	40.98	5.74	0.72	6.65	0.42	5.68	0.00	97.84	0.13	5.57	97.86	86.6
Leningradkaya	Russia	Yes	Yes?	GAR11	0.04	9.73	21.57	38.95	6.73	0.05	0.01	0.60	20.77	0.00	98.44	1.01	19.86	98.55	46.6
Leningradkaya	Russia	Yes	Yes?	GAR12	0.06	6.26	20.75	38.61	11.71	0.23	0.02	0.62	20.03	0.00	98.29	0.80	19.31	98.37	36.6
Leningradkaya	Russia	Yes	Yes?	GAR13	0.06	19.20	19.45	41.29	5.19	0.84	2.84	0.51	7.82	0.03	97.25				81.4
Leningradkaya	Russia	Yes	Yes?	GAR14	0.07	21.40	20.26	42.16	4.90	0.88	2.04	0.35	5.23	0.00	97.28				87.9
Leningradkaya	Russia	Yes	Yes?	GAR15	0.08	15.25	20.87	40.43	9.70	0.65	0.40	0.75	9.05	0.00	97.18	0.96	8.19	97.28	76.9
Leningradkaya	Russia	Yes	Yes?	GAR16	0.04	21.20	19.57	41.85	4.99	0.91	3.04	0.28	5.89	0.00	97.77				86.5

Kimberlite	Country	Cratonic?	Diamonds?	Sample	Na2O	MgO	Al2O3	SiO2	CaO	TiO2	Cr2O3	MnO	FeO	ZnO	Total	Fe2O3	FeO new	Total new	Mg#
Leningradkaya	Russia	Yes	Yes?	GAR17	0.02	5.68	20.48	38.11	7.46	0.17	0.02	0.52	25.63	0.00	98.10	0.23	25.42	98.11	28.5
Leningradkaya	Russia	Yes	Yes?	GAR18	0.04	10.13	21.77	39.28	5.44	0.04	0.04	0.57	21.58	0.03	98.91	0.44	21.19	98.96	46.0
Leningradkaya	Russia	Yes	Yes?	GAR19	0.08	19.76	18.80	41.09	5.45	1.07	3.42	0.43	7.03	0.00	97.13				83.4
Leningradkaya	Russia	Yes	Yes?	GAR20	0.02	6.39	20.92	38.09	6.42	0.04	0.00	1.00	25.62	0.14	98.65	0.98	24.74	98.74	31.5
Leningradkaya	Russia	Yes	Yes?	GAR20	0.04	20.54	17.75	41.44	5.60	0.33	6.90	0.45	5.53	0.00	98.58	0.13	5.42	98.59	87.1
Leningradkaya	Russia	Yes	Yes?	GAR21	0.06	19.77	18.85	41.51	5.37	1.12	3.22	0.44	6.99	0.02	97.35				83.4
Leningradkaya	Russia	Yes	Yes?	GAR22	0.09	20.02	18.91	41.48	5.27	1.07	3.24	0.42	6.89	0.00	97.39				83.8
Leningradkaya	Russia	Yes	Yes?	GAR23	0.06	20.07	18.66	41.60	5.42	0.87	4.77	0.41	6.55	0.00	98.41				84.5
Leningradkaya	Russia	Yes	Yes?	GAR24	0.03	12.41	22.16	39.37	3.69	0.09	0.03	0.16	20.86	0.00	98.79	0.95	20.01	98.90	52.5
Leningradkaya	Russia	Yes	Yes?	GAR25	0.08	18.44	13.71	40.10	7.31	1.16	10.57	0.50	5.42	0.05	97.34				85.8
Leningradkaya	Russia	Yes	Yes?	GAR26	0.01	19.15	19.49	41.26	5.96	0.04	5.37	0.64	7.33	0.00	99.24	0.47	6.91	99.30	83.2
Leningradkaya	Russia	Yes	Yes?	GAR27	0.08	20.95	18.39	41.48	5.47	0.86	5.35	0.35	5.46	0.00	98.39	0.19	5.29	98.41	87.6
Leningradkaya	Russia	Yes	Yes?	GAR28	0.02	8.71	21.46	39.07	5.94	0.04	0.03	0.56	23.39	0.00	99.22	0.48	22.96	99.27	40.3
Leningradkaya	Russia	Yes	Yes?	GAR29	0.08	20.84	19.76	41.71	4.89	0.95	2.33	0.41	6.25	0.00	97.21				85.6
Leningradkaya	Russia	Yes	Yes?	GAR30	0.07	20.70	19.59	41.87	4.93	1.02	2.23	0.34	6.10	0.04	96.88				85.8
Udachnaya	Russia	Yes	Yes?	GAR1	0.05	21.78	20.62	41.55	4.70	0.46	2.86	0.45	5.82	0.03	98.32	1.43	4.54	98.46	89.5
Udachnaya	Russia	Yes	Yes?	GAR2	0.12	19.65	20.79	40.57	4.49	0.97	1.01	0.46	8.91	0.04	97.00	1.52	7.55	97.16	82.3
Udachnaya	Russia	Yes	Yes?	GAR3	0.10	20.54	21.39	40.35	4.19	0.58	1.66	0.44	8.44	0.00	97.69	2.85	5.88	97.98	86.2
Udachnaya	Russia	Yes	Yes?	GAR4	0.08	20.09	19.64	40.45	4.86	1.23	1.62	0.45	7.78	0.03	96.23	1.33	6.58	96.36	84.5
Udachnaya	Russia	Yes	Yes?	GAR5	0.10	21.26	22.58	41.21	3.92	0.52	0.34	0.47	7.83	0.00	98.22	2.16	5.88	98.45	86.6
Udachnaya	Russia	Yes	Yes?	GAR6	0.08	20.49	19.30	40.52	4.97	0.98	2.44	0.34	6.91	0.03	96.06	1.35	5.70	96.19	86.5
Udachnaya	Russia	Yes	Yes?	GAR7	0.02	7.75	21.13	37.66	6.12	0.08	0.06	0.87	24.80	0.00	98.49	2.59	22.47	98.75	38.1
Udachnaya	Russia	Yes	Yes?	GAR8	0.07	21.37	20.18	40.58	4.71	0.35	3.31	0.35	6.23	0.00	97.15	2.44	4.03	97.39	90.4
Udachnaya	Russia	Yes	Yes?	GAR9	0.07	20.08	22.14	40.49	4.51	0.25	1.24	0.53	8.55	0.00	97.86	2.61	6.21	98.12	85.2
Udachnaya	Russia	Yes	Yes?	GAR10	0.00	7.92	21.01	37.42	6.41	0.15	0.03	1.20	23.97	0.09	98.20	3.02	21.25	98.50	39.9
Udachnaya	Russia	Yes	Yes?	GAR11	0.00	4.81	21.01	36.93	9.38	0.14	0.07	0.81	25.08	0.00	98.23	2.45	22.87	98.48	27.3
Udachnaya	Russia	Yes	Yes?	GAR12	0.03	18.87	15.37	39.65	7.17	0.14	9.92	0.46	6.15	0.00	97.75	2.27	4.11	97.99	89.1
Udachnaya	Russia	Yes	Yes?	GAR13	0.03	20.90	19.86	41.28	5.16	0.15	4.39	0.49	6.54	0.00	98.78	1.72	4.99	98.97	88.2
Udachnaya	Russia	Yes	Yes?	GAR14	0.01	7.10	20.62	36.70	6.35	0.12	0.01	0.80	25.26	0.08	97.06	3.32	22.27	97.38	36.2
Udachnaya	Russia	Yes	Yes?	GAR15	0.01	20.08	19.95	40.13	5.81	0.03	4.81	0.43	6.91	0.03	98.18	2.94	4.27	98.48	89.4
Udachnaya	Russia	Yes	Yes?	GAR16	0.03	5.88	20.47	36.55	6.25	0.13	0.01	1.03	26.68	0.01	97.03	2.82	24.14	97.32	30.3
Udachnaya	Russia	Yes	Yes?	GAR17	0.02	19.19	18.25	39.07	6.04	0.02	6.97	0.56	7.61	0.00	97.72	3.87	4.13	98.12	89.2
Udachnaya	Russia	Yes	Yes?	GAR18	0.03	7.36	20.89	36.73	6.11	0.09	0.06	0.92	25.41	0.04	97.64	3.85	21.95	98.03	37.4
Udachnaya	Russia	Yes	Yes?	GAR19	0.09	19.45	21.19	40.14	4.08	0.84	0.16	0.50	9.58	0.01	96.04	1.84	7.92	96.22	81.4
Udachnaya	Russia	Yes	Yes?	GAR20	0.11	21.41	21.35	40.63	4.24	0.62	1.75	0.49	6.99	0.08	97.66	2.81	4.47	97.95	89.5
Udachnaya	Russia	Yes	Yes?	GAR21	0.07	21.59	20.82	41.22	4.28	0.63	1.77	0.45	6.20	0.03	97.05	1.25	5.08	97.18	88.3
Udachnaya	Russia	Yes	Yes?	GAR22	0.00	7.22	20.76	37.29	6.52	0.06	0.03	0.95	24.26	0.10	97.19	2.10	22.37	97.40	36.5
Udachnaya	Russia	Yes	Yes?	GAR23	0.01	10.01	21.58	37.99	6.10	0.05	0.09	0.61	21.67	0.07	98.15	2.87	19.09	98.47	48.3
Udachnaya	Russia	Yes	Yes?	GAR24	0.10	19.75	19.51	40.25	4.85	0.78	3.16	0.37	8.23	0.00	96.99	1.84	6.57	97.18	84.3
Udachnaya	Russia	Yes	Yes?	GAR25	0.10	20.51	21.54	40.82	4.23	0.56	1.59	0.40	8.20	0.00	97.95	1.93	6.46	98.14	85.0
Udachnaya	Russia	Yes	Yes?	GAR26	0.01	8.65	21.15	36.93	6.06	0.21	0.08	0.51	23.63	0.06	97.29	3.43	20.55	97.63	42.9
Udachnaya	Russia	Yes	Yes?	GAR27	0.02	7.27	20.82	36.97	6.16	0.23	0.01	0.79	25.23	0.04	97.52	2.89	22.63	97.83	36.4
Udachnaya	Russia	Yes	Yes?	GAR28	0.09	19.85	19.82	40.54	5.01	1.14	1.58	0.45	8.14	0.01	96.63	1.47	6.82	96.78	83.9
Udachnaya	Russia	Yes	Yes?	GAR29	0.01	6.81	20.92	37.06	6.27	0.08	0.01	0.90	25.80	0.00	97.86	2.83	23.26	98.14	34.3
Udachnaya	Russia	Yes	Yes?	GAR30	0.01	4.54	20.11	36.28	7.13	0.17	0.04	0.93	27.76	0.04	97.00	2.75	25.28	97.29	24.2
Zarnitsa	Russia	Yes	Yes?	GAR2	0.06	20.17	18.69	40.21	5.21	0.40	5.53	0.42	6.87	0.08	97.63	2.04	5.04	97.84	87.7
Zarnitsa	Russia	Yes	Yes?	GAR3	0.09	20.52	18.51	40.06	4.96	0.88	4.43	0.39	6.07	0.00	95.91	1.25	4.95	96.04	88.1
Zarnitsa	Russia	Yes	Yes?	GAR4	0.10	19.28	19.63	39.71	5.00	1.12	1.71	0.32	8.54	0.00	95.41	1.79	6.93	95.59	83.2

Kimberlite	Country	Cratonic?	Diamonds?	Sample	Na2O	MgO	Al2O3	SiO2	CaO	TiO2	Cr2O3	MnO	FeO	ZnO	Total	Fe2O3	FeO new	Total new	Mg#
Zarnitsa	Russia	Yes	Yes?	GAR5	0.09	20.66	20.02	40.50	4.77	0.72	2.76	0.40	6.73	0.03	96.69	1.60	5.29	96.84	87.4
Zarnitsa	Russia	Yes	Yes?	GAR6	0.05	20.92	20.23	40.26	4.66	0.51	2.59	0.34	6.57	0.00	96.13	2.01	4.76	96.33	88.7
Zarnitsa	Russia	Yes	Yes?	GAR7	0.01	22.43	21.55	41.31	4.16	0.03	2.49	0.29	5.47	0.00	97.73	1.89	3.77	97.93	91.4
Zarnitsa	Russia	Yes	Yes?	GAR8	0.07	21.19	19.69	40.42	4.61	0.39	4.15	0.50	6.08	0.00	97.10	2.12	4.17	97.31	90.1
Zarnitsa	Russia	Yes	Yes?	GAR9	0.10	19.98	18.62	40.69	5.20	0.28	5.32	0.41	6.80	0.00	97.38	1.17	5.75	97.52	86.1
Zarnitsa	Russia	Yes	Yes?	GAR10	0.04	12.09	21.61	38.62	4.84	0.09	0.10	0.44	19.75	0.09	97.67	2.17	17.80	97.89	54.8
Zarnitsa	Russia	Yes	Yes?	GAR11	0.05	20.81	20.28	41.14	4.72	0.19	2.86	0.26	6.43	0.00	96.74	0.78	5.73	96.82	86.6
Zarnitsa	Russia	Yes	Yes?	GAR12	0.05	21.09	20.37	40.90	4.55	0.58	2.35	0.37	6.28	0.00	96.55	0.98	5.40	96.64	87.4
Zarnitsa	Russia	Yes	Yes?	GAR13	0.03	8.31	21.15	37.59	5.87	0.14	0.00	0.78	23.97	0.05	97.89	2.45	21.77	98.14	40.5
Zarnitsa	Russia	Yes	Yes?	GAR14	0.06	20.97	20.36	40.65	4.64	0.32	3.12	0.35	6.48	0.04	96.98	1.76	4.90	97.17	88.4
Zarnitsa	Russia	Yes	Yes?	GAR15	0.04	19.34	19.77	40.49	7.98	0.23	4.34	0.38	5.09	0.10	97.75	2.03	3.27	97.96	91.4
Zarnitsa	Russia	Yes	Yes?	GAR16	0.08	20.75	19.61	41.09	4.90	0.98	2.04	0.40	6.08	0.04	95.98	0.16	5.94	95.99	86.2
Zarnitsa	Russia	Yes	Yes?	GAR17	0.09	20.21	17.39	40.06	5.56	1.00	5.83	0.37	5.86	0.00	96.37	1.11	4.86	96.48	88.1
Zarnitsa	Russia	Yes	Yes?	GAR18	0.04	20.91	19.39	41.06	5.20	0.51	3.87	0.43	5.89	0.03	97.32	1.02	4.97	97.43	88.2
Zarnitsa	Russia	Yes	Yes?	GAR19	0.03	8.89	20.84	36.87	6.71	0.09	0.03	0.58	21.82	0.04	95.89	3.18	18.96	96.22	45.5
Zarnitsa	Russia	Yes	Yes?	GAR20	0.14	20.75	20.84	41.01	4.12	0.52	2.30	0.40	7.53	0.00	97.60	1.50	6.18	97.76	85.7
Zarnitsa	Russia	Yes	Yes?	GAR21	0.17	19.97	16.48	40.32	6.04	0.41	8.13	0.32	5.39	0.00	97.23	1.40	4.13	97.37	89.6
Zarnitsa	Russia	Yes	Yes?	GAR22	0.11	21.28	20.48	41.19	4.57	0.65	2.41	0.33	6.31	0.00	97.32	1.23	5.20	97.45	87.9
Zarnitsa	Russia	Yes	Yes?	GAR23	0.09	20.01	20.11	40.86	4.54	0.61	2.80	0.42	8.09	0.00	97.52	1.13	7.08	97.64	83.4
Zarnitsa	Russia	Yes	Yes?	GAR24	0.02	9.10	21.77	38.60	6.57	0.08	0.03	0.55	22.13	0.08	98.93	1.40	20.87	99.07	43.7
Zarnitsa	Russia	Yes	Yes?	GAR25	0.08	20.29	18.64	40.93	5.40	1.03	3.84	0.30	6.08	0.00	96.59				85.6
Zarnitsa	Russia	Yes	Yes?	GAR26	0.05	10.28	21.39	38.70	4.59	0.05	0.21	0.67	22.53	0.00	98.46	1.47	21.20	98.62	46.4
Zarnitsa	Russia	Yes	Yes?	GAR27	0.08	20.58	20.04	40.90	4.64	1.08	1.25	0.38	6.91	0.03	95.88	0.50	6.46	95.94	85.0
Zarnitsa	Russia	Yes	Yes?	GAR28	0.07	7.91	21.15	37.74	5.20	0.10	0.01	0.80	24.84	0.00	97.82	1.69	23.32	97.99	37.7
Zarnitsa	Russia	Yes	Yes?	GAR29	0.05	21.15	20.01	41.14	4.55	0.17	4.01	0.52	6.05	0.07	97.71	1.17	4.99	97.84	88.3
Zarnitsa	Russia	Yes	Yes?	GAR30	0.07	20.77	18.44	40.68	5.55	1.21	4.38	0.40	5.70	0.00	97.19	0.93	4.87	97.29	88.4

Current CLASS = GARNET, scheme = 2

1/ Low-Ca harzburgite

2/ Ca harzburgite

3/ Lherzolite

4/ Low-Cr garnets

5/ Wehrlite

Conc	Data	Norm	Scale	T(Ni)	Class
* 1	1/ [SOEY.PROJECT_GARNET.PIXE]LEAR1_PX1_01_54517	0.766	1.141E+03	+ 41.5	-
2	2/ [SOEY.PROJECT_GARNET.PIXE]LEAR1_PX1_02_54518	0.911		+	-
3	3/ [SOEY.PROJECT_GARNET.PIXE]LEAR1_PX1_03_54519	0.904		+	-
4	4/ [SOEY.PROJECT_GARNET.PIXE]LEAR1_PX1_04_54520	0.786	1.061E+03	+ 38.4	-
5	5/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_05_54521	1.22	8.956E+03	+ 1.911E+03	-
6	6/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_06_54522	0.533	1.036E+03	+ 41.3	-
7	7/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_07_54523	0.835	1.017E+03	+ 37.4	-
8	8/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_08_54524	0.768		+	-
9	9/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_09_54525	0.645	1.152E+03	+ 41.2	-
10	10/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_10_54526	0.751	761.	+ 47.2	-
11	11/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_11_54527	0.883		+	-
12	12/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_12_54528	0.894		+	-
13	13/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_13_54529	0.851	1.057E+03	+ 38.9	-
14	14/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_14_54530	0.673	1.291E+03	+ 48.5	-
15	15/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_15_54531	1.20	946.	+ 59.8	-
16	16/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_16_54532	0.663	1.220E+03	+ 44.9	-
17	17/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_17_54533	0.833		+	-
18	18/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_18_54534	0.853		+	-
19	19/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_19_54535	0.693	1.188E+03	+ 43.8	-
20	20/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_20_54536	0.796		+	-
21	21/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_21_54537	0.723	946.	+ 34.9	-
22	22/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_22_54538	0.615	980.	+ 35.0	-
23	23/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_23_54539	0.722	1.047E+03	+ 39.2	-
24	24/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_24_54540	0.727	1.058E+03	+ 38.4	-
25	25/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_25_54541	0.730	1.053E+03	+ 37.9	-
26	26/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_26_54542	0.882		+	-
27	27/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_27_54543	0.788	1.099E+03	+ 40.1	-
28	28/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_28_54544	0.889	379.	+ 141.	-
29	29/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_29_54545	0.739	1.115E+03	+ 41.6	-
30	30/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_30_54546	0.824		+	-
31	31/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_31_54547	0.846	1.102E+03	+ 42.5	-
32	32/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_32_54548	0.862	1.108E+03	+ 40.7	-
33	33/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_33_54549	0.875	1.059E+03	+ 40.0	-
34	34/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_34_54550	0.906	1.037E+03	+ 38.7	-

Leningradskaya (rows 1–30)

Nouzee (rows 31–34)

35	35/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_35_54551		0.908	766.	+	37.7	-
36	36/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_36_54552		0.901	1.093E+03	+	40.7	-
37	37/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_37_54553		0.829	1.030E+03	+	39.8	-
38	38/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_38_54554		0.869	1.067E+03	+	39.6	-
39	39/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_39_54555		0.866	993.	+	37.4	-
40	40/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_40_54556		0.865	1.064E+03	+	39.0	-
41	41/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_41_54557		0.835	875.	+	43.4	-
42	42/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_42_54558		0.825	883.	+	37.2	-
43	43/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_43_54559		0.617	914.	+	32.7	-
44	44/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_44_54560		0.841	1.046E+03	+	38.5	-
45	45/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_45_54561		1.08	1.186E+03	+	47.9	-
46	46/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_46_54562		0.748	678.	+	40.8	-
47	47/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_47_54563		0.753	945.	+	34.9	-
48	48/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_48_54564	Nouzee	1.02	1.172E+03	+	47.9	-
49	49/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_49_54565		0.632	862.	+	32.4	-
50	50/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_50_54566		1.09	1.096E+03	+	42.7	-
51	51/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_51_54567		0.552	630.	+	39.9	-
52	52/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_52_54568		0.520	886.	+	30.0	-
53	53/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_53_54569		0.855	1.048E+03	+	38.8	-
54	54/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_54_54570		1.03	1.139E+03	+	45.0	-
55	55/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_55_54571		0.905	768.	+	39.6	-
56	56/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_56_54572		0.669	868.	+	35.5	-
57	57/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_57_54573		0.907	1.135E+03	+	45.4	-
58	58/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_58_54574		0.699	1.011E+03	+	36.1	-
59	59/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_59_54575		0.810	1.035E+03	+	37.9	-
60	60/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_60_54576		1.00	1.493E+03	+	62.5	-
61	61/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_61_54577		1.00	1.124E+03	+	43.6	-
62	62/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_62_54578		1.00	1.531E+03	+	67.4	-
63	63/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_63_54579		1.00	1.129E+03	+	43.8	-
64	64/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_64_54580		1.00	1.308E+03	+	51.6	-
65	65/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_65_54581		1.00	914.	+	42.3	-
66	66/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_66_54582		1.00	1.091E+03	+	42.3	-
67	67/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_67_54583	Zarnitsa	1.00	1.233E+03	+	47.6	-
68	68/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_68_54584		1.00	1.005E+03	+	48.5	-
69	69/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_69_54585		1.00	1.070E+03	+	42.5	-
70	70/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_70_54586		1.00		+		-
71	71/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_71_54587		1.00	1.224E+03	+	49.3	-
72	72/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_72_54588		1.00	1.320E+03	+	52.0	-
73	73/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_73_54589		1.00		+		-
74	74/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_74_54590		1.00	1.069E+03	+	46.8	-
75	75/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_75_54591		1.00	999.	+	38.8	-
76	76/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_76_54592		1.00	1.363E+03	+	54.9	-
77	77/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_77_54593		1.00	1.231E+03	+	48.0	-

78	78/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_78_54594		1.00	1.318E+03	+	52.4	-
79	79/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_79_54595		1.00		+		-
80	80/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_80_54596		1.00	1.065E+03	+	42.5	-
81	81/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_81_54597		1.00	1.000E+03	+	40.0	-
82	82/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_82_54598	Zarnitsa	1.00	1.277E+03	+	51.1	-
83	83/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_83_54599		1.00	1.013E+03	+	41.3	-
84	84/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_84_54600		1.00		+		-
85	85/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_85_54601		1.00	1.324E+03	+	59.0	-
86	86/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_86_54602		1.00		+		-
87	87/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_87_54603		1.00	1.328E+03	+	53.0	-
88	88/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_88_54604		1.00		+		-
89	89/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_89_54605		1.00	1.036E+03	+	41.4	-
90	90/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_90_54606		1.00	1.253E+03	+	50.0	-
91	91/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_91_54607		1.00	485.	+	103.	-
92	92/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_92_54608		1.00		+		-
93	93/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_93_54609		1.00	669.	+	64.0	-
94	94/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_94_54610		1.00		+		-
95	95/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_95_54611		1.00	543.	+	96.7	-
96	96/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_96_54612		1.00	643.	+	82.6	-
97	97/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_97_54613		1.00	534.	+	93.8	-
98	98/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_98_54614		1.00	585.	+	69.0	-
99	99/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_99_54615		1.00	599.	+	63.2	-
100	100/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_100_54616	Mothae	1.00	648.	+	57.9	-
101	101/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_101_54617		1.00	621.	+	57.3	-
102	102/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_102_54618		1.00	558.	+	80.9	-
103	103/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_103_54619		1.00	638.	+	90.2	-
104	104/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_104_54620		1.00	535.	+	78.2	-
105	105/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_105_54621		1.00		+		-
106	106/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_106_54622		1.00	488.	+	114.	-
107	107/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_107_54623		1.00		+		-
108	108/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_108_54624		1.00	553.	+	73.5	-
109	109/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_109_54625		1.00		+		-
110	110/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_110_54626		1.00	669.	+	57.9	-
111	111/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_111_54627		1.00	550.	+	69.2	-
112	112/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_112_54628		1.00	610.	+	57.3	-
113	113/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_113_54629		1.00	667.	+	48.9	-
114	114/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_114_54630		1.00	607.	+	58.6	-
115	115/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_115_54631		1.00	466.	+	133.	-
116	116/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_116_54632	Udachnaya	1.00	1.323E+03	+	55.4	-
117	117/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_117_54633		1.00	923.	+	41.2	-
118	118/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_118_54634		1.00	891.	+	39.7	-
119	119/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_119_54635		1.00	1.124E+03	+	44.8	-
120	120/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_120_54636		1.00	1.051E+03	+	41.0	-

HIAF Proton Microprobe
CSIRO, Heavy Ion Analytical Facility.

GEO_TRACE 6.1
CSIRO, Australia.

Trace Element Summary: concentration (ppm or wt%), uncertainty (1 sigma) and MDL (99% confidence) 16-APR-93 11:40:58

	Ti	Cr	Mn	Fe	Ni	Cu	Zn	Rb	Sr	Y	Zr
1 Lear1_PX1.01	-	3.21 %	0.301 %	4.23 %	57.4	2.31	12.3	5.31	-	6.71	57.7
lenin gn1	<	0.808 %	630.	0.665 %	6.47	<	1.94	2.84	<	1.51	2.77
	5.79 %	312.	74.0	26.9	8.71	5.21	3.86	2.67	2.83	2.70	2.96
2 Lear1_PX1.02	-	102.	0.712 %	19.8 %	-	49.0	108.	103.	-	91.6	30.0
lenin gn2	<	<	0.143 %	3.11 %	<	9.04	10.5	37.5	<	15.4	8.87
	11.6 %	613.	137.	46.1	13.7	9.94	8.21	8.03	6.71	6.34	7.02
3 Lear1_PX1.03	-	341.	0.391 %	16.6 %	-	41.5	166.	83.5	-	39.2	0.451
lenin gn3	<	<	787.	2.62 %	<	6.35	13.1	29.3	<	13.2	<
	10.4 %	545.	122.	41.6	12.4	9.08	7.48	7.42	6.32	5.93	6.24
4 Lear1_PX1.04	-	4.56 %	0.359 %	3.89 %	46.0	1.71	9.83	3.55	-	24.7	125.
lenin gn4	<	1.15 %	755.	0.613 %	5.39	<	1.28	2.68	<	1.75	3.22
	6.07 %	329.	77.2	27.8	8.94	5.45	3.97	2.71	2.98	3.00	3.09
5 XLear1_PX1.05	-	484.	0.526 %	19.5 %	0.137 %	35.7	151.	117.	-	219.	34.6
lenin gn5	<	<	0.105 %	3.07 %	141.	5.07	11.5	25.0	<	17.2	6.79
	13.7 %	732.	172.	64.8	22.3	14.4	11.2	10.2	9.26	8.54	8.55
6 XLear1_PX1.06	-	1.11 %	0.193 %	5.12 %	42.5	5.71	15.5	10.8	-	8.93	49.9
lenin gn6	<	0.281 %	388.	0.805 %	5.60	1.24	1.44	4.61	<	1.39	2.81
	4.85 %	268.	60.7	21.2	6.94	4.43	3.33	2.23	2.22	2.16	2.14
7 XLear1_PX1.07	-	2.73 %	0.325 %	4.77 %	40.1	-	12.0	3.93	-	13.2	87.0
lenin gn7	<	0.688 %	667.	0.751 %	4.92	<	1.54	1.95	<	1.26	4.34
	6.15 %	358.	84.0	30.1	9.70	5.64	4.15	2.56	2.63	2.72	2.89
8 XLear1_PX1.08	-	0.166 %	0.325 %	7.03 %	-	4.33	23.6	24.3	-	38.7	314.
lenin gn8	<	483.	648.	1.11 %	<	<	2.13	6.66	<	2.53	11.0
	6.74 %	381.	85.6	29.5	9.36	6.15	4.63	3.85	3.42	3.30	3.73
9 XLear1_PX1.09	-	0.843 %	0.210 %	4.07 %	59.1	1.86	11.6	9.40	1.01	7.96	51.2
lenin gn9	<	0.213 %	425.	0.639 %	6.51	<	1.25	2.78	<	2.03	2.92
	5.04 %	276.	63.6	22.9	7.42	4.52	3.36	2.15	2.16	2.23	2.48
10 XLear1_PX1.10	-	1.49 %	0.301 %	6.08 %	14.5	-	17.0	8.86	-	16.4	78.6

Substitutes into Zircon

	lenin gn10	<	0.374 %	621.	0.956 %	3.64	<	1.75	7.25	<	1.34	6.07
		6.45 %	350.	80.7	28.9	9.76	6.05	4.56	3.35	2.93	2.96	3.04
11	XLear1_PX1.11	-	783.	0.362 %	15.6 %	-	39.4	140.	77.0	-	2.10	-
	lenin gn11	<	415.	726.	2.45 %	<	5.55	11.5	27.1	<	<	<
		9.98 %	532.	118.	41.3	12.7	9.09	7.51	7.36	6.33	5.87	6.32
12	XLear1_PX1.12	-	560.	0.387 %	16.1 %	-	26.6	145.	81.1	-	34.8	71.8
	lenin gn12	<	331.	776.	2.54 %	<	5.53	12.5	24.8	<	9.46	10.5
		10.0 %	552.	123.	41.3	12.2	8.82	7.19	6.62	5.57	5.43	5.76
13	XLear1_PX1.13	-	3.52 %	0.342 %	4.42 %	45.4	7.89	23.2	7.43	-	9.24	94.0
	lenin gn13	<	0.888 %	727.	0.694 %	5.43	1.66	2.38	3.07	<	1.41	4.10
		6.25 %	331.	78.8	28.7	9.55	6.05	4.48	2.88	3.01	3.01	3.15
14	XLear1_PX1.14	-	1.60 %	0.206 %	3.99 %	82.3	-	11.6	4.11	-	7.79	49.4
	lenin gn14	<	0.402 %	417.	0.627 %	8.82	<	1.23	1.20	<	0.909	2.25
		5.03 %	283.	65.9	23.6	7.47	4.50	3.26	2.17	2.42	2.33	2.37
15	XLear1_PX1.15	-	321.	0.939 %	20.1 %	31.6	41.8	121.	138.	213.	160.	3.51
	lenin gn15	<	<	0.187 %	3.17 %	7.10	7.44	11.5	32.8	9.63	21.0	<
		13.7 %	689.	160.	58.8	19.9	13.7	10.9	10.4	8.90	8.25	8.70
16	XLear1_PX1.16	-	1.44 %	0.200 %	4.58 %	70.0	-	15.9	3.29	-	11.7	50.7
	lenin gn16	<	0.362 %	404.	0.720 %	7.64	<	1.58	3.97	<	1.20	3.93
		5.49 %	293.	67.8	24.3	8.07	5.01	3.74	2.97	2.75	2.67	2.75
17	XLear1_PX1.17	-	794.	0.358 %	19.9 %	-	74.6	201.	138.	-	0.297	19.5
	lenin gn17	<	493.	736.	3.13 %	<	14.7	18.0	48.7	<	<	12.7
		11.1 %	590.	132.	45.1	13.6	10.2	8.69	8.97	7.57	7.26	8.11
18	XLear1_PX1.18	-	295.	0.360 %	16.8 %	-	49.5	199.	97.1	-	0.151	-
	lenin gn18	<	<	721.	2.64 %	<	8.46	16.7	37.1	<	<	<
		10.5 %	558.	124.	41.8	12.6	9.36	7.78	7.59	6.40	6.17	6.94
19	XLear1_PX1.19	-	1.51 %	0.246 %	5.46 %	64.9	2.65	15.7	16.2	1.71	11.3	75.5
	lenin gn19	<	0.383 %	519.	0.859 %	7.22	<	1.61	4.10	<	1.40	4.28
		5.66 %	325.	76.3	27.5	9.19	5.67	4.23	2.98	2.54	2.58	2.98
20	XLear1_PX1.20	-	492.	0.651 %	19.9 %	-	89.5	297.	172.	-	117.	-
	lenin gn20	<	<	0.131 %	3.13 %	<	15.2	25.8	53.0	<	23.4	<
		11.2 %	589.	132.	44.8	13.5	10.2	8.75	9.52	8.08	7.77	8.51

				Fe	Ni						
21 XLear1_PX1.21	-	3.64 %	0.335 %	4.30 %	31.6	0.272	10.9	5.70	-	1.13	67.9
lenin gn21	<	0.917 %	712.	0.676 %	4.06	<	1.41	2.83	<	<	3.56
	5.77 %	318.	75.3	27.2	8.97	5.55	4.08	2.64	2.73	2.80	2.90
22 XLear1_PX1.22	-	1.40 %	0.269 %	5.43 %	35.6	1.57	16.0	12.2	-	13.3	80.1
lenin gn22	<	0.352 %	541.	0.855 %	4.33	<	1.55	3.76	<	1.43	3.17
	5.28 %	313.	72.6	25.8	8.45	5.16	3.84	2.61	2.70	2.51	2.40
23 XLear1_PX1.23	-	1.47 %	0.255 %	5.36 %	44.0	-	16.1	10.0	-	13.9	70.5
lenin gn23	<	0.369 %	535.	0.842 %	5.40	<	1.68	2.96	<	1.22	2.83
	5.97 %	327.	75.5	27.0	8.81	5.32	3.94	2.57	2.69	2.65	2.78
24 XLear1_PX1.24	-	2.32 %	0.281 %	5.09 %	45.5	1.66	16.0	10.4	-	7.22	68.6
lenin gn24	<	0.585 %	596.	0.801 %	5.38	<	1.63	4.01	<	1.15	4.74
	5.52 %	331.	78.3	28.3	9.25	5.65	4.23	3.18	2.84	2.88	3.05
25 XLear1_PX1.25	-	2.25 %	0.281 %	5.09 %	44.9	-	12.9	2.11	-	12.1	69.0
lenin gn25	<	0.566 %	568.	0.801 %	5.26	<	1.41	<	<	1.05	4.57
	6.02 %	326.	76.1	27.2	8.67	5.28	3.91	2.88	2.67	2.70	2.86
26 XLear1_PX1.26	-	615.	0.212 %	16.2 %	-	35.5	136.	84.3	-	24.5	28.0
lenin gn26	<	421.	436.	2.55 %	<	7.58	10.8	31.9	<	9.06	9.78
	10.5 %	536.	117.	40.6	12.4	8.96	7.35	6.97	5.82	5.69	6.29
27 XLear1_PX1.27	-	5.37 %	0.386 %	4.21 %	51.3	0.502	11.2	0.964	-	12.7	112.
lenin gn27	<	1.35 %	832.	0.663 %	5.94	<	1.42	<	<	1.11	3.63
	6.20 %	342.	80.5	29.0	9.44	5.71	4.18	2.86	3.06	3.10	3.14
28 XLear1_PX1.28	-	3.17 %	0.483 %	5.70 %	0.724	5.80	13.5	9.20	-	-	0.149
lenin gn28	<	0.797 %	997.	0.896 %	<	<	1.62	4.13	<	<	<
	6.77 %	387.	90.1	31.9	10.5	6.67	4.89	3.23	3.31	3.27	3.37
29 XLear1_PX1.29	-	2.56 %	0.292 %	4.24 %	53.6	-	11.9	1.93	-	14.2	63.0
lenin gn29	<	0.642 %	600.	0.667 %	6.29	<	1.34	<	<	1.23	2.13
	5.73 %	321.	74.7	26.7	8.43	5.05	3.75	2.47	2.64	2.54	2.37
30 XLear1_PX1.30	-	733.	0.428 %	18.2 %	-	63.0	172.	122.	-	26.4	-
lenin gn30	<	452.	855.	2.86 %	<	11.1	14.6	34.6	<	14.1	<
	10.6 %	560.	125.	42.7	12.9	9.64	8.04	7.92	6.72	6.45	7.11
31 XLear1_PX1.31	-	2.03 %	0.268 %	4.45 %	51.6	0.930	10.9	6.73	-	10.6	24.0
nouzees gn1	<	0.510 %	542.	0.699 %	6.32	<	1.37	2.77	<	2.20	3.19
	6.37 %	370.	85.1	30.2	9.51	5.72	4.18	3.14	2.96	3.01	3.22

32 XLear1_PX1.32	-	2.26 %	0.295 %	4.87 %	52.5	0.165	15.5	7.33	-	9.40	22.6
nouzees gn2	<	0.568 %	597.	0.765 %	6.09	<	1.62	2.67	<	1.38	1.49
	6.33 %	373.	87.5	30.5	9.35	5.53	4.12	3.23	3.08	2.90	3.07
33 XLear1_PX1.33	-	3.07 %	0.298 %	4.44 %	45.6	-	14.4	3.50	-	11.2	35.2
nouzees gn3	<	0.775 %	640.	0.698 %	5.61	<	1.58	2.61	<	1.25	2.50
	6.35 %	350.	82.6	30.0	9.86	5.76	4.30	2.91	3.13	2.99	2.88
34 XLear1_PX1.34	-	4.39 %	0.391 %	4.54 %	42.7	0.727	14.0	5.30	0.942	2.008E-02	25.1
nouzees gn4	<	1.10 %	831.	0.714 %	5.25	<	1.91	2.82	<	<	2.44
	6.73 %	366.	87.1	31.7	10.2	6.17	4.58	2.83	2.97	2.69	2.76
35 XLear1_PX1.35	-	1.65 %	0.355 %	5.95 %	14.9	-	13.1	9.88	1.08	6.33	7.02
nouzees gn5	<	0.417 %	712.	0.936 %	2.91	<	1.54	2.46	<	1.37	1.64
	6.93 %	372.	86.8	31.0	10.0	6.01	4.46	2.95	3.10	2.77	3.09
36 XLear1_PX1.36	-	2.73 %	0.300 %	4.61 %	50.4	0.858	11.3	5.57	-	6.73	24.1
nouzees gn6	<	0.686 %	609.	0.725 %	5.97	<	1.56	1.95	<	1.19	2.06
	6.66 %	365.	86.3	31.2	10.3	6.17	4.54	3.11	3.38	3.32	3.46
37 XLear1_PX1.37	-	2.32 %	0.285 %	4.35 %	41.8	-	13.3	5.99	-	7.24	33.0
nouzees gn7	<	0.583 %	590.	0.685 %	5.34	<	1.71	1.79	<	1.75	1.95
	6.18 %	338.	78.8	28.2	9.31	5.73	4.20	2.79	2.95	2.93	2.87
38 XLear1_PX1.38	-	2.35 %	0.343 %	4.92 %	46.8	-	16.2	8.25	-	9.78	30.6
nouzees gn8	<	0.592 %	696.	0.774 %	5.61	<	2.34	3.89	<	1.31	3.22
	6.48 %	369.	86.9	31.0	10.0	6.07	4.55	3.61	3.54	3.38	3.42
39 XLear1_PX1.39	-	3.05 %	0.312 %	4.24 %	37.1	0.569	10.9	5.86	-	6.68	44.8
nouzees gn9	<	0.766 %	645.	0.667 %	4.73	<	1.58	2.84	<	1.23	3.27
	6.47 %	361.	84.9	30.7	10.2	6.00	4.40	2.79	2.89	2.94	3.26
40 XLear1_PX1.40	-	2.25 %	0.287 %	4.45 %	46.4	0.542	10.3	4.91	0.238	12.0	26.1
nouzees gn10	<	0.566 %	578.	0.700 %	5.51	<	1.75	2.42	<	1.15	1.99
	6.51 %	367.	84.5	30.0	9.67	5.69	4.11	2.35	2.50	2.72	2.88
41 XLear1_PX1.41	-	0.622 %	0.274 %	6.77 %	24.2	-	22.0	21.9	-	9.88	49.6
nouzees gn11	<	0.158 %	557.	1.06 %	4.41	<	2.10	5.69	<	1.96	4.78
	6.61 %	388.	87.7	31.0	10.4	6.51	4.93	3.77	3.34	3.29	3.65
42 XLear1_PX1.42	-	1.34 %	0.278 %	6.13 %	24.9	1.80	18.1	17.1	-	11.2	46.6
nouzees gn12	<	0.340 %	572.	0.963 %	3.82	<	1.98	4.83	<	1.53	3.51

	6.27 %	369.	85.1	30.3	9.90	6.15	4.63	3.44	3.08	3.00	3.08
43 XLear1_PX1.43	-	0.514 %	0.177 %	4.60 %	28.1	2.55	15.5	14.3	0.140	9.21	37.9
nouzees gn13	<	0.130 %	356.	0.724 %	3.57	<	1.49	4.25	<	1.38	3.18
	4.98 %	276.	63.8	22.5	7.44	4.73	3.56	2.64	2.33	2.32	2.50
44 XLear1_PX1.44	-	2.82 %	0.288 %	4.55 %	43.9	0.978	12.2	4.30	0.657	7.66	27.0
nouzees gn14	<	0.709 %	622.	0.715 %	5.29	<	1.74	1.74	<	1.32	1.57
	6.41 %	362.	84.1	30.0	9.77	5.78	4.22	2.74	2.95	2.94	3.01
45 XLear1_PX1.45	-	3.56 %	0.347 %	5.85 %	64.5	-	16.4	4.87	-	13.6	36.7
nouzees gn15	<	0.898 %	791.	0.920 %	7.88	<	1.86	3.04	<	1.80	2.66
	8.18 %	460.	106.	37.7	11.8	7.18	5.26	3.35	3.63	3.78	3.81
46 XLear1_PX1.46	-	1.44 %	0.311 %	5.05 %	9.29	-	14.2	9.88	3.39	-	26.7
nouzees gn16	<	0.362 %	626.	0.794 %	2.39	<	1.66	3.58	1.05	<	3.22
	5.69 %	333.	77.3	27.6	9.01	5.57	4.11	3.40	3.12	2.97	3.04
47 XLear1_PX1.47	-	1.41 %	0.252 %	4.69 %	31.4	2.01	14.4	8.90	1.21	11.0	9.27
nouzees gn17	<	0.356 %	512.	0.737 %	4.05	<	1.52	3.86	<	1.83	1.34
	6.02 %	335.	76.8	27.1	8.72	5.36	4.01	2.82	2.52	2.31	2.71
48 XLear1_PX1.48	-	2.49 %	0.331 %	5.65 %	62.2	-	15.9	9.75	-	14.7	38.6
nouzees gn18	<	0.626 %	669.	0.889 %	7.76	<	1.84	2.82	<	1.80	3.64
	8.01 %	435.	101.	36.0	11.7	7.02	5.26	3.57	3.79	3.80	3.78
49 XLear1_PX1.49	-	0.846 %	0.201 %	4.49 %	22.9	8.486E-02	14.4	12.4	-	6.92	38.6
nouzees gn19	<	0.214 %	413.	0.705 %	3.16	<	1.89	3.59	<	1.35	2.55
	5.14 %	279.	64.5	23.3	7.83	4.86	3.68	2.91	2.64	2.54	2.58
50 XLear1_PX1.50	-	5.16 %	0.439 %	5.62 %	50.9	3.08	16.6	6.51	-	-	2.61
nouzees gn20	<	1.30 %	903.	0.884 %	6.31	<	2.09	4.04	<	<	<
	8.13 %	442.	105.	38.1	12.5	7.57	5.64	3.75	3.95	3.93	4.14
51 XLear1_PX1.51	-	1.08 %	0.239 %	3.47 %	6.90	0.752	6.88	8.00	-	0.280	42.2
nouzees gn21	<	0.273 %	479.	0.546 %	1.95	<	0.902	2.70	<	<	2.56
	4.27 %	234.	54.1	19.3	6.32	3.80	2.83	2.18	1.99	2.03	2.14
52 XLear1_PX1.52	-	1.66 %	0.198 %	2.93 %	25.2	0.941	7.43	0.593	-	1.82	4.38
nouzees gn22	<	0.419 %	405.	0.461 %	3.08	<	0.904	<	<	<	0.877
	3.95 %	217.	50.7	18.2	5.80	3.62	2.70	1.88	1.97	1.91	1.92
53 XLear1_PX1.53	-	2.20 %	0.288 %	4.47 %	44.2	0.712	12.5	7.07	-	5.53	29.5

nouzees gn23	<	0.555 %	589.	0.703 %	5.35	<	1.69	2.27	<	1.47	2.97
	6.43 %	358.	83.2	30.0	9.81	5.80	4.31	3.27	3.04	2.98	3.22
54 XLear1_PX1.54	-	2.64 %	0.335 %	5.47 %	57.2	3.82	16.4	6.44	-	11.6	30.2
nouzees gn24	<	0.665 %	676.	0.861 %	7.03	<	1.89	2.67	<	2.26	2.99
	7.88 %	421.	99.8	36.3	11.6	6.81	5.11	3.93	3.63	3.48	3.67
55 XLear1_PX1.55	-	2.12 %	0.381 %	5.84 %	15.0	2.09	14.5	10.4	-	4.20	36.8
nouzees gn25	<	0.534 %	762.	0.918 %	3.08	<	1.70	5.17	<	2.07	2.97
	6.63 %	388.	90.4	32.3	10.6	6.70	4.99	3.77	3.37	3.31	3.50
56 XLear1_PX1.56	-	1.39 %	0.227 %	4.81 %	23.5	1.02	17.0	14.4	-	5.15	31.9
nouzees gn26	<	0.351 %	456.	0.757 %	3.53	<	1.66	3.84	<	1.18	2.75
	5.43 %	301.	69.5	24.8	8.20	5.05	3.80	2.97	2.64	2.38	2.46
57 XLear1_PX1.57	-	1.21 %	0.252 %	5.26 %	56.5	2.13	16.1	10.1	-	14.3	40.1
nouzees gn27	<	0.305 %	509.	0.828 %	7.05	<	1.73	3.13	<	1.46	3.33
	6.98 %	381.	88.0	31.3	10.2	6.25	4.64	3.63	3.36	3.12	2.96
58 XLear1_PX1.58	-	0.922 %	0.201 %	4.61 %	39.3	-	15.7	12.2	8.49	9.73	41.7
nouzees gn28	<	0.234 %	421.	0.725 %	4.69	<	1.54	3.62	1.01	1.29	3.28
	4.96 %	266.	63.8	23.8	8.33	5.14	3.80	2.50	2.55	2.53	2.40
59 XLear1_PX1.59	-	2.59 %	0.267 %	4.32 %	42.4	0.518	12.6	6.98	-	11.4	36.9
nouzees gn29	<	0.651 %	550.	0.680 %	5.12	<	1.94	2.36	<	1.26	2.56
	6.30 %	345.	80.5	28.9	9.34	5.62	4.17	3.15	2.95	2.80	2.99
60 XLear1_PX1.60	-	2.08 %	0.266 %	6.57 %	121.	1.33	22.6	14.7	-	15.7	75.4
zarnit gz1	<	0.525 %	540.	1.03 %	13.1	<	2.42	5.03	<	2.16	4.29
	7.71 %	408.	97.6	36.1	12.3	7.52	5.58	4.36	4.08	3.83	4.02
61 XLear1_PX1.61	-	4.02 %	0.464 %	6.60 %	54.9	-	18.1	8.89	-	6.31	45.4
zarnit gz2	<	1.01 %	940.	1.04 %	6.67	<	2.02	4.95	<	2.45	4.70
	8.28 %	460.	108.	38.6	12.7	7.79	5.76	4.55	4.18	3.75	3.90
62 XLear1_PX1.62	-	2.04 %	0.270 %	6.60 %	129.	-	23.6	19.1	4.27	13.6	77.3
zarnit gz3	<	0.513 %	552.	1.04 %	14.4	<	2.28	3.72	1.38	2.12	4.96
	7.76 %	438.	103.	37.3	12.3	7.14	5.37	3.78	3.30	3.41	3.62
63 XLear1_PX1.63	-	4.16 %	0.454 %	6.76 %	55.6	-	17.0	8.29	2.863E-02	4.90	41.3
zarnit gz4	<	1.05 %	927.	1.06 %	6.75	<	1.97	4.24	<	1.43	2.15
	7.63 %	477.	111.	39.7	13.0	7.94	5.87	3.98	4.17	4.01	4.05

64 XLear1_PX1.64	-	2.92 %	0.336 %	6.22 %	85.3	5.01	19.7	13.7	2.23	15.1	80.8
zarnit gz5	<	0.734 %	695.	0.978 %	9.51	<	2.85	5.05	<	1.62	5.63
	8.02 %	431.	102.	36.6	12.1	7.37	5.51	3.55	3.58	3.67	4.11
65 XLear1_PX1.65	-	1.14 %	0.339 %	8.81 %	28.1	-	30.0	32.4	-	7.02	81.8
zarnit gz6	<	0.288 %	685.	1.39 %	4.66	<	2.86	8.40	<	2.63	6.95
	8.80 %	484.	110.	39.0	13.2	8.44	6.38	4.84	4.23	4.23	4.74
66 XLear1_PX1.66	-	1.81 %	0.360 %	6.71 %	50.0	-	21.0	18.4	-	20.3	104.
zarnit 0gz7	<	0.458 %	738.	1.06 %	6.20	<	2.17	6.09	<	3.28	6.69
	8.19 %	447.	104.	37.3	12.5	7.68	5.71	4.42	3.97	3.69	3.94
67 XLear1_PX1.67	-	1.72 %	0.329 %	6.58 %	72.2	0.141	16.8	8.64	0.436	15.5	42.5
zarnit gz8	<	0.436 %	667.	1.04 %	8.21	<	1.86	3.19	<	1.62	3.88
	7.33 %	447.	103.	36.5	11.4	6.91	5.13	3.85	3.61	3.35	3.16
68 XLear1_PX1.68	-	1.57 %	0.252 %	5.19 %	38.6	-	11.4	7.26	2.22	7.74	1.83
zarnit gz9	<	0.396 %	534.	0.816 %	6.31	<	1.55	2.65	<	1.89	<
	6.98 %	393.	92.4	33.5	11.4	6.88	4.97	3.47	3.14	2.96	3.15
69 XLear1_PX1.69	-	3.56 %	0.407 %	6.52 %	47.2	1.95	22.6	9.38	-	1.72	27.3
zarnit gz10	<	0.895 %	826.	1.02 %	6.06	<	3.23	4.53	<	<	2.71
	7.86 %	438.	104.	37.7	12.4	7.10	5.31	4.19	3.80	3.64	3.92
70 XLear1_PX1.70	-	771.	0.457 %	20.1 %	-	43.0	146.	107.	-	-	-
zarnit gz12	<	456.	926.	3.16 %	<	9.45	13.7	46.2	<	<	<
	12.2 %	666.	149.	50.3	14.9	11.0	9.10	8.90	7.43	7.05	7.73
71 XLear1_PX1.71	-	1.94 %	0.336 %	6.76 %	70.8	-	23.5	8.45	-	6.02	8.62
zarnit gz13	<	0.488 %	675.	1.06 %	8.43	<	2.56	3.26	<	2.25	2.24
	7.79 %	449.	103.	36.7	11.9	7.16	5.32	3.67	3.84	3.56	3.61
72 XLear1_PX1.72	-	1.58 %	0.313 %	6.61 %	87.4	0.237	21.5	13.0	-	10.8	57.9
zarnit gz14	<	0.399 %	642.	1.04 %	9.69	<	2.13	3.61	<	2.20	3.57
	7.90 %	432.	100.	36.0	11.7	6.95	5.19	3.42	3.53	3.44	3.60
73 XLear1_PX1.73	-	952.	0.554 %	19.9 %	-	60.7	185.	117.	-	21.5	15.1
zarnit gz15	<	386.	0.110 %	3.13 %	<	12.3	18.0	48.5	<	16.1	11.5
	12.5 %	640.	142.	48.0	13.8	10.3	8.78	9.59	8.14	7.73	8.43
74 XLear1_PX1.74	-	2.34 %	0.350 %	6.28 %	47.0	2.90	20.4	11.2	-	13.1	26.0
zarnit gz16	<	0.588 %	710.	0.987 %	6.69	<	2.88	6.44	<	3.18	2.40
	7.90 %	423.	101.	37.3	12.6	7.48	5.67	4.50	4.02	3.58	3.22

75 XLear1_PX1.75	-	2.90 %	0.350 %	4.67 %	37.9	-	9.72	8.99	2.40	9.27	13.7
zarnit gz17	<	0.730 %	731.	0.734 %	4.96	<	1.94	3.07	<	2.38	1.73
	6.32 %	395.	94.1	33.9	11.2	7.00	5.10	3.59	3.31	2.76	2.95
76 XLear1_PX1.76	-	1.45 %	0.286 %	7.25 %	95.5	0.982	25.7	18.4	-	18.4	96.6
zarnit gz18	<	0.365 %	584.	1.14 %	10.6	<	2.47	6.68	<	1.89	4.95
	8.16 %	452.	106.	38.3	12.9	7.88	5.86	4.54	4.15	4.09	4.37
77 XLear1_PX1.77	-	3.85 %	0.416 %	6.02 %	71.9	3.44	15.8	9.41	-	5.08	67.6
zarnit gz19	<	0.967 %	855.	0.947 %	8.27	<	1.91	4.89	<	2.65	4.14
	7.92 %	435.	103.	37.6	12.5	7.68	5.73	4.31	3.87	3.99	4.33
78 XLear1_PX1.78	-	2.69 %	0.373 %	6.73 %	87.2	2.58	24.5	17.8	-	-	32.3
zarnit gz20	<	0.677 %	758.	1.06 %	9.75	<	2.66	4.99	<	<	3.67
	7.85 %	418.	101.	37.1	12.4	7.68	5.80	4.42	3.97	4.01	4.30
79 XLear1_PX1.79	-	760.	0.438 %	18.3 %	-	84.3	200.	134.	-	-	-
zarnit gz21	<	438.	881.	2.88 %	<	13.8	18.5	55.3	<	<	<
	12.4 %	633.	140.	48.1	14.6	11.0	9.42	10.5	8.89	8.41	9.08
80 XLear1_PX1.80	-	1.68 %	0.314 %	7.11 %	46.5	1.50	20.9	16.4	-	3.31	50.2
zarnit gz22	<	0.424 %	638.	1.12 %	6.02	<	2.17	7.75	<	<	4.48
	7.78 %	413.	97.2	35.3	12.1	7.60	5.71	4.29	3.76	3.44	3.82
81 XLear1_PX1.81	-	5.50 %	0.408 %	5.16 %	38.0	20.4	11.1	8.96	-	12.8	83.8
zarnit gz23	<	1.38 %	873.	0.812 %	5.13	3.30	1.64	2.71	<	1.52	4.16
	7.54 %	438.	103.	37.2	12.1	7.54	5.54	3.53	3.64	3.70	3.79
82 XLear1_PX1.82	-	1.64 %	0.307 %	7.02 %	79.9	1.49	25.5	20.2	-	12.1	44.9
zarnit gz24	<	0.414 %	618.	1.10 %	9.19	<	2.68	5.82	<	4.20	4.11
	7.82 %	446.	104.	37.5	12.6	7.88	5.93	4.70	4.26	3.95	4.16
83 XLear1_PX1.83	-	1.94 %	0.420 %	7.97 %	39.6	-	32.6	24.9	-	5.84	72.6
zarnit gz25	<	0.490 %	843.	1.25 %	5.41	<	3.35	9.10	<	3.11	7.08
	8.59 %	470.	109.	39.1	13.3	8.41	6.37	5.03	4.50	4.44	4.87
84 XLear1_PX1.84	-	886.	0.382 %	19.0 %	-	57.9	242.	115.	-	-	7.62
zarnit gz26	<	511.	772.	2.98 %	<	10.3	20.1	39.9	<	<	<
	12.2 %	632.	139.	48.4	14.6	10.9	9.11	9.48	8.18	7.83	8.61
85 XLear1_PX1.85	-	2.70 %	0.367 %	7.14 %	88.2	1.58	23.9	18.6	-	19.5	94.0
zarnit gz27	<	0.679 %	740.	1.12 %	11.1	<	2.38	6.60	<	2.39	6.31

	8.35 %	460.	107.	38.3	12.4	7.94	5.96	4.60	4.19	4.19	4.62
86 XLear1_PX1.86	-	0.163 %	0.467 %	19.9 %	-	49.6	128.	94.4	-	-	-
zarnit gz28	<	653.	938.	3.12 %	<	8.97	10.5	36.8	<	<	<
	12.2 %	645.	144.	49.4	14.5	10.6	8.67	8.49	7.36	7.03	7.85
87 XLear1_PX1.87	-	0.865 %	0.292 %	8.28 %	89.0	7.48	28.7	26.2	-	15.6	92.3
zarnit gz29	<	0.219 %	586.	1.30 %	9.94	<	2.65	7.52	<	2.74	5.10
	8.48 %	460.	107.	38.5	12.9	8.13	6.06	4.08	4.21	4.15	4.34
88 XLear1_PX1.88	-	666.	0.719 %	22.7 %	-	164.	310.	206.	-	-	32.8
zarnit gz30	<	<	0.145 %	3.57 %	<	26.0	31.0	79.4	<	<	22.7
	13.5 %	720.	161.	54.3	16.8	12.9	11.0	13.2	11.4	11.1	12.5
89 XLear1_PX1.89	-	2.83 %	0.412 %	6.25 %	42.6	59.0	14.0	8.72	-	-	4.72
zarnit gz31	<	0.713 %	831.	0.982 %	5.62	5.59	1.89	4.92	<	<	2.86
	8.03 %	452.	106.	38.6	13.1	8.32	6.14	4.50	4.03	3.89	4.05
90 XLear1_PX1.90	-	2.86 %	0.359 %	6.07 %	75.6	14.8	15.9	18.8	-	3.67	72.2
zarnit gz32	<	0.721 %	753.	0.955 %	8.80	2.43	2.39	6.32	<	<	5.64
	7.87 %	449.	105.	37.8	12.8	8.05	6.02	4.52	4.12	4.04	4.31
91 XLear1_PX1.91	-	0.786 %	0.332 %	6.57 %	2.24	3.53	17.6	7.06	-	29.8	33.0
motha gm1	<	0.200 %	665.	1.03 %	<	<	2.59	8.79	<	3.57	4.53
	7.65 %	435.	98.9	34.5	11.1	7.19	5.41	4.12	3.63	3.56	3.62
92 XLear1_PX1.92	-	0.757 %	0.303 %	6.60 %	-	2.49	17.1	18.0	-	13.5	38.5
motha gm2	<	0.193 %	610.	1.04 %	<	<	2.25	5.09	<	2.38	4.00
	7.98 %	411.	95.1	34.0	11.4	7.29	5.42	4.26	3.88	3.72	3.87
93 XLear1_PX1.93	-	0.766 %	0.303 %	6.63 %	8.82	-	18.2	18.0	-	17.5	29.0
motha gm3	<	0.194 %	611.	1.04 %	<	<	2.17	7.91	<	2.31	3.66
	7.65 %	427.	98.2	34.6	11.2	7.43	5.71	4.65	4.13	3.96	4.02
94 XLear1_PX1.94	-	0.674 %	0.304 %	6.71 %	-	1.22	20.0	19.4	-	22.4	27.6
motha gm4	<	0.172 %	608.	1.06 %	<	<	2.17	8.38	<	3.95	3.26
	8.01 %	424.	98.4	35.2	11.8	7.55	5.68	4.31	3.72	3.62	3.78
95 XLear1_PX1.95	-	0.698 %	0.316 %	6.61 %	3.70	-	17.5	19.0	-	22.6	24.6
motha gm5	<	0.178 %	633.	1.04 %	<	<	1.94	7.61	<	3.87	3.83
	7.91 %	405.	94.8	34.5	11.8	7.12	5.35	3.96	3.41	3.36	3.54
96 XLear1_PX1.96	-	0.704 %	0.336 %	6.71 %	7.53	-	18.1	16.6	-	16.2	23.3

	motha gm6	<	0.180 %	671.	1.05 %	<	<	1.98	6.15	<	3.53	3.12
		7.69 %	420.	93.7	33.7	11.7	7.20	5.39	4.16	3.69	3.65	3.98
97	XLear1_PX1.97	-	1.24 %	0.358 %	6.72 %	3.44	4.39	17.9	9.16	-	25.1	31.2
	motha gm7	<	0.314 %	719.	1.06 %	<	<	2.04	7.95	<	1.99	5.02
		7.84 %	436.	99.7	34.9	11.5	7.43	5.59	4.10	3.49	3.53	4.08
98	XLear1_PX1.98	-	0.735 %	0.327 %	6.62 %	5.09	-	17.3	14.9	-	16.9	26.9
	motha gm8	<	0.187 %	655.	1.04 %	<	<	2.65	7.18	<	2.44	2.58
		7.72 %	388.	91.9	33.7	11.4	7.36	5.45	4.26	3.83	3.86	4.03
99	XLear1_PX1.99	-	0.792 %	0.351 %	6.74 %	5.61	1.72	17.9	18.3	-	18.3	22.2
	motha gm9	<	0.201 %	706.	1.06 %	<	<	1.96	5.58	<	3.02	3.42
		7.90 %	426.	97.5	34.5	11.5	7.24	5.36	3.50	3.43	3.47	3.88
100	XLear1_PX1.100	-	0.672 %	0.309 %	6.56 %	7.75	2.15	19.6	18.6	-	13.7	27.2
	motha gm10	<	0.171 %	624.	1.03 %	<	<	2.56	6.47	<	2.82	3.57
		7.54 %	391.	91.4	32.9	11.1	7.26	5.49	4.42	3.94	3.91	4.13
101	XLear1_PX1.101	-	0.766 %	0.338 %	6.64 %	6.51	1.38	17.3	7.96	-	23.5	34.1
	motha gm11	<	0.194 %	679.	1.04 %	<	<	1.94	6.57	<	2.62	3.42
		7.99 %	424.	96.4	34.3	11.6	7.36	5.46	3.69	3.74	3.81	4.06
102	XLear1_PX1.102	-	0.748 %	0.318 %	6.71 %	4.17	2.68	16.4	11.0	-	17.4	25.5
	motha gm12	<	0.193 %	636.	1.06 %	<	<	2.11	4.91	<	2.64	2.94
		7.58 %	409.	95.4	34.3	11.4	7.41	5.52	4.28	3.84	3.78	4.02
103	XLear1_PX1.103	-	0.702 %	0.328 %	6.65 %	7.26	2.25	14.7	12.0	-	23.9	33.1
	motha gm13	<	0.178 %	657.	1.05 %	<	<	2.55	8.37	<	2.23	4.89
		7.73 %	427.	98.0	34.8	11.5	7.25	5.38	4.03	3.54	3.46	3.49
104	XLear1_PX1.104	-	0.657 %	0.329 %	6.65 %	3.46	2.04	15.7	18.8	0.272	21.8	27.5
	motha gm14	<	0.169 %	657.	1.05 %	<	<	1.84	4.55	<	3.06	3.23
		7.70 %	426.	97.5	34.5	11.5	7.24	5.37	3.97	3.54	3.53	3.83
105	XLear1_PX1.105	-	0.688 %	0.328 %	6.71 %	-	-	15.5	16.2	-	17.2	20.4
	motha gm15	<	0.177 %	658.	1.06 %	<	<	1.86	3.78	<	2.31	3.18
		7.36 %	420.	97.2	34.6	11.6	7.53	5.61	4.45	4.12	3.89	3.88
106	XLear1_PX1.106	-	0.725 %	0.321 %	6.59 %	2.31	2.86	23.9	16.7	-	17.9	28.7
	motha gm16	<	0.185 %	642.	1.04 %	<	<	2.51	5.30	<	2.26	3.18
		7.86 %	419.	96.1	34.0	11.4	7.27	5.41	4.32	3.73	3.38	3.87

107	XLear1_PX1.107	-	0.728 %	0.334 %	6.58 %	-	2.39	19.2	15.3	-	14.7	26.9
	motha gm17	<	0.187 %	668.	1.03 %	<	<	2.23	6.77	<	2.61	3.81
		7.64 %	414.	95.9	34.4	11.7	7.45	5.53	4.49	4.08	4.04	4.14
108	XLear1_PX1.108	-	0.740 %	0.340 %	6.69 %	3.99	2.56	16.6	16.9	-	15.1	28.4
	motha gm18	<	0.188 %	684.	1.05 %	<	<	1.92	6.30	<	2.37	4.66
		8.12 %	449.	101.	35.2	11.5	7.46	5.56	4.44	3.94	3.84	4.16
109	XLear1_PX1.109	-	0.760 %	0.327 %	6.65 %	-	2.82	18.7	19.2	-	16.3	24.6
	motha gm19	<	0.193 %	664.	1.05 %	<	<	2.19	6.20	<	3.14	3.67
		8.12 %	432.	99.2	35.0	11.6	7.55	5.70	4.38	3.86	3.71	3.87
110	XLear1_PX1.110	-	0.935 %	0.336 %	6.60 %	8.78	4.71	18.4	18.0	-	15.9	32.1
	motha gm20	<	0.237 %	672.	1.04 %	<	<	2.15	5.91	<	2.41	3.34
		7.98 %	413.	95.4	33.7	11.0	7.17	5.49	4.41	3.90	3.75	4.22
111	XLear1_PX1.111	-	0.685 %	0.335 %	6.68 %	3.91	-	14.5	9.20	-	25.4	26.3
	motha gm22	<	0.175 %	670.	1.05 %	<	<	1.92	3.69	<	3.11	2.09
		7.54 %	409.	94.1	33.3	10.8	6.76	4.96	3.81	3.53	3.41	3.15
112	XLear1_PX1.112	-	0.746 %	0.329 %	6.67 %	6.05	-	14.3	12.4	-	18.7	32.4
	motha gm23	<	0.189 %	668.	1.05 %	<	<	1.70	3.58	<	2.03	1.94
		7.83 %	426.	97.4	34.0	11.1	6.66	4.96	3.63	3.22	3.09	3.39
113	XLear1_PX1.113	-	0.567 %	0.333 %	6.62 %	8.71	2.94	14.3	10.4	-	21.9	33.8
	motha gm24	<	0.145 %	668.	1.04 %	<	<	1.73	3.42	<	2.57	2.64
		7.82 %	419.	95.6	33.6	11.0	6.88	5.13	4.00	3.67	3.41	3.26
114	XLear1_PX1.114	-	0.708 %	0.342 %	6.64 %	5.93	-	12.7	12.9	-	23.9	32.8
	motha gm25	<	0.183 %	685.	1.04 %	<	<	1.66	2.90	<	2.58	3.62
		7.80 %	421.	92.7	33.2	11.2	7.05	5.25	3.93	3.59	3.59	3.40
115	XLear1_PX1.115	-	0.646 %	0.354 %	6.70 %	1.88	-	15.6	14.9	-	18.1	29.5
	motha gm33	<	0.165 %	707.	1.05 %	<	<	1.83	5.55	<	2.82	3.00
		7.88 %	430.	98.1	34.9	11.5	7.15	5.37	4.25	3.91	3.80	4.02
116	XLear1_PX1.116	-	1.92 %	0.334 %	6.30 %	88.0	-	19.3	11.8	-	8.69	30.8
	udach gud1	<	0.484 %	690.	0.991 %	10.4	<	2.02	4.22	<	2.14	1.91
		7.58 %	424.	99.0	35.9	12.0	7.13	5.28	3.58	3.85	3.86	3.98
117	XLear1_PX1.117	-	0.735 %	0.361 %	9.65 %	29.1	-	34.5	28.1	-	10.7	58.7
	udach gud2	<	0.187 %	730.	1.52 %	4.61	<	3.07	10.6	<	2.86	3.36
		8.66 %	472.	111.	39.8	13.7	8.60	6.53	5.14	4.52	4.44	4.80

118 XLear1_PX1.118	-	1.16 %	0.358 %	8.06 %	25.7	1.93	28.1	19.7	-	17.8	40.7
udach gud3	<	0.293 %	720.	1.27 %	4.16	<	2.61	6.72	<	2.25	4.20
	8.52 %	470.	108.	38.1	12.5	7.87	5.89	4.09	3.54	3.50	3.89
119 XLear1_PX1.119	-	1.10 %	0.340 %	8.94 %	54.9	2.84	33.9	34.3	-	18.7	116.
udach gud4	<	0.277 %	689.	1.41 %	6.87	<	3.21	9.94	<	2.74	7.51
	9.17 %	488.	112.	40.0	13.6	8.70	6.59	4.97	4.26	4.29	4.92
120 XLear1_PX1.120	-	0.248 %	0.332 %	7.85 %	44.6	3.50	25.9	19.5	-	9.27	45.2
udach gud5	<	666.	667.	1.23 %	5.69	<	2.46	5.59	<	1.93	4.27
	8.15 %	464.	103.	36.4	12.0	7.61	5.73	4.49	4.08	3.99	3.79
Weighted average	-	0.165 %	0.301 %	5.53 %	21.9	2.51	15.5	8.51	1.83	10.1	28.1
Weighted error	<	93.6	57.7	844.	0.435	0.192	0.178	0.342	0.249	0.165	0.257
Weighted MDL	0.647 %	35.7	8.28	2.96	0.966	0.602	0.451	0.326	0.313	0.305	0.318
Arith. mean Conc	-	1.61 %	0.342 %	7.72 %	44.7	10.4	40.2	27.0	2.03	16.6	42.5
Stand. deviation	-	1.27 %	0.104 %	4.70 %	125.	23.9	60.8	39.2	19.5	27.1	37.3
Std. dev./ error	-	12.4	1.65	5.08	26.3	11.3	31.3	10.4	7.13	15.0	13.2
	Ti	Cr	Mn	Fe	Ni	Cu	Zn	Rb	Sr	Y	Zr

n/a not available (i.e. not fitted, or not in yield list)

Continued on next page ...

HIAF Proton Microprobe
CSIRO, Heavy Ion Analytical Facility.

GEO_TRACE 6.1
CSIRO, Australia.

Trace Element Summary: concentration (ppm or wt%), uncertainty (1 sigma) and MDL (99% confidence)

16-APR-93 11:40:58

	Nb	Ag	Ba\K\	Ce\K\	Hf\L\	La\K\	Pb\L\	Sm\K\	Ta\L\
1	-	4.80	65.9	-	-	-	17.6	-	-
	<	<	19.6	-	-	-	2.96	-	-
	3.21	6.91	50.5	-	-	-	6.20	-	-
2	-	-	63.3	-	-	-	329.	-	-
	<	<	24.4	-	-	-	39.9	-	-
	7.84	12.0	61.8	-	-	-	17.3	-	-
3	-	5.54	55.5	-	-	-	269.	-	-
	<	<	<	-	-	-	33.5	-	-
	6.85	10.2	68.3	-	-	-	15.7	-	-
4	-	5.23	31.2	-	-	-	15.8	-	-
	<	<	<	-	-	-	2.67	-	-
	3.24	7.16	50.7	-	-	-	6.27	-	-
5	0.190	-	161.	-	-	-	287.	-	-
	<	<	36.7	-	-	-	30.7	-	-
	8.69	15.9	88.2	-	-	-	20.3	-	-
6	2.83	1.44	39.2	-	-	-	41.7	-	-
	0.967	<	13.5	-	-	-	4.52	-	-
	2.34	4.93	35.9	-	-	-	5.63	-	-
7	7.480E-02	-	-	-	-	-	-	-	-
	<	<	<	-	-	-	<	-	-
	2.99	7.16	51.0	-	-	-	6.49	-	-
8	-	11.3	-	-	-	-	66.9	-	-
	<	3.03	<	-	-	-	7.10	-	-
	4.18	7.88	51.2	-	-	-	8.09	-	-
9	8.358E-02	0.541	25.6	-	-	-	29.2	-	-
	<	<	<	-	-	-	2.74	-	-
	2.75	5.88	45.6	-	-	-	5.51	-	-
10	0.167	4.26	44.1	-	-	-	-	-	-

	<	<	<	-	-	-	<	-	-
	3.34	7.02	52.6	-	-	-	7.75	-	-
11	-	2.78	50.1	-	-	-	254.	-	-
	<	<	<	-	-	-	30.0	-	-
	6.95	8.60	66.6	-	-	-	15.7	-	-
12	3.32	4.18	20.7	-	-	-	243.	-	-
	<	<	<	-	-	-	28.0	-	-
	6.36	10.4	66.9	-	-	-	14.7	-	-
13	1.98	5.94	47.0	-	-	-	27.5	-	-
	<	<	<	-	-	-	3.88	-	-
	3.48	7.07	56.6	-	-	-	7.05	-	-
14	1.45	4.69	30.5	-	-	-	17.1	-	-
	<	<	<	-	-	-	2.09	-	-
	2.45	5.55	43.9	-	-	-	4.98	-	-
15	1.92	6.19	216.	-	-	-	399.	-	-
	<	<	51.3	-	-	-	44.5	-	-
	9.93	15.6	81.8	-	-	-	21.5	-	-
16	0.509	3.46	29.0	-	-	-	-	-	-
	<	<	<	-	-	-	<	-	-
	2.85	5.82	47.2	-	-	-	6.27	-	-
17	3.51	10.7	-	-	-	-	440.	-	-
	<	<	<	-	-	-	54.2	-	-
	9.16	12.1	65.9	-	-	-	19.4	-	-
18	2.54	-	35.5	-	-	-	314.	-	-
	<	<	<	-	-	-	36.7	-	-
	7.81	10.0	63.6	-	-	-	16.6	-	-
19	1.57	6.10	48.5	-	-	-	50.3	-	-
	<	<	<	-	-	-	5.55	-	-
	3.31	6.22	48.7	-	-	-	7.01	-	-
20	-	-	50.1	-	-	-	523.	-	-
	<	<	<	-	-	-	65.2	-	-
	9.55	13.2	60.0	-	-	-	19.9	-	-

21	2.60	4.57	-	-	-	-	27.4	-	-	
	<	<	<	-	-	-	2.88	-	-	
	3.12	6.45	54.5	-	-	-	6.58	-	-	
22	3.19	6.39	62.9	-	-	-	40.4	-	-	
	0.887	2.01	17.1	-	-	-	6.03	-	-	
	2.61	5.65	43.1	-	-	-	6.21	-	-	
23	0.509	3.48	49.3	-	-	-	35.6	-	-	
	<	<	<	-	-	-	3.61	-	-	
	2.95	6.46	50.2	-	-	-	6.24	-	-	
24	2.22	1.36	-	-	-	-	38.8	-	-	
	<	<	<	-	-	-	5.97	-	-	
	3.19	6.94	50.1	-	-	-	7.06	-	-	
25	0.479	2.14	18.2	-	-	-	-	-	-	
	<	<	<	-	-	-	<	-	-	
	3.08	6.74	54.0	-	-	-	6.25	-	-	
26	1.17	3.83	39.1	-	-	-	239.	-	-	
	<	<	<	-	-	-	28.6	-	-	
	7.04	9.63	63.5	-	-	-	15.2	-	-	
27	0.466	4.46	36.6	-	-	-	-	-	-	
	<	<	<	-	-	-	<	-	-	
	3.38	6.80	56.4	-	-	-	6.59	-	-	
28	1.41	-	43.6	-	-	-	29.8	-	-	
	<	<	<	-	-	-	5.34	-	-	
	3.68	8.00	59.1	-	-	-	8.00	-	-	
29	1.46	-	29.9	-	-	-	-	-	-	
	<	<	<	-	-	-	<	-	-	
	2.27	6.42	44.5	-	-	-	6.00	-	-	
30	-	2.01	132.	-	-	-	364.	-	-	
	<	<	26.5	-	-	-	43.4	-	-	
	8.06	11.9	56.3	-	-	-	17.2	-	-	
31	-	7.04	40.4	-	-	-	24.6	-	-	
	<	2.22	<	-	-	-	3.76	-	-	
	3.57	6.60	60.3	-	-	-	6.51	-	-	

32	0.715	11.0	27.8	-	-	-	22.4	-	-
	<	2.58	<	-	-	-	2.85	-	-
	3.39	7.30	54.0	-	-	-	6.81	-	-
33	0.168	-	22.2	-	-	-	22.1	-	-
	<	<	<	-	-	-	2.92	-	-
	3.12	5.80	62.9	-	-	-	6.91	-	-
34	2.06	5.05	36.5	-	-	-	19.7	-	-
	<	<	<	-	-	-	4.44	-	-
	3.30	7.16	67.3	-	-	-	7.33	-	-
35	0.708	6.05	79.5	-	-	-	26.9	-	-
	<	<	25.6	-	-	-	3.93	-	-
	3.13	7.27	64.1	-	-	-	7.12	-	-
36	9.724E-02	5.81	36.0	-	-	-	25.6	-	-
	<	<	<	-	-	-	3.46	-	-
	3.75	7.29	54.0	-	-	-	7.14	-	-
37	2.84	5.70	42.4	-	-	-	21.3	-	-
	<	<	<	-	-	-	3.40	-	-
	3.11	7.22	62.0	-	-	-	6.51	-	-
38	2.33	2.53	39.6	-	-	-	27.3	-	-
	<	<	<	-	-	-	3.49	-	-
	3.54	6.96	61.1	-	-	-	7.41	-	-
39	0.786	-	-	-	-	-	23.3	-	-
	<	<	<	-	-	-	3.60	-	-
	3.66	7.39	59.0	-	-	-	7.00	-	-
40	-	3.08	82.8	-	-	-	11.4	-	-
	<	<	22.7	-	-	-	2.22	-	-
	3.22	6.51	54.4	-	-	-	6.12	-	-
41	-	7.31	34.9	-	-	-	57.4	-	-
	<	3.09	<	-	-	-	7.58	-	-
	4.09	6.91	59.5	-	-	-	8.33	-	-
42	0.189	6.67	18.2	-	-	-	50.3	-	-
	<	<	<	-	-	-	6.29	-	-

	3.52	7.29	57.2	-	-	-	7.85	-	-
43	0.397	-	37.1	-	-	-	43.8	-	-
	<	<	<	-	-	-	4.54	-	-
	2.78	5.46	45.8	-	-	-	6.02	-	-
44	1.72	7.53	29.7	-	-	-	25.0	-	-
	<	2.46	<	-	-	-	2.87	-	-
	3.24	6.52	55.5	-	-	-	6.47	-	-
45	1.89	6.14	87.9	-	-	-	-	-	-
	<	<	34.3	-	-	-	<	-	-
	4.08	8.61	73.8	-	-	-	8.18	-	-
46	-	5.16	41.1	-	-	-	34.0	-	-
	<	<	<	-	-	-	3.56	-	-
	3.25	6.82	53.1	-	-	-	7.00	-	-
47	-	-	21.0	-	-	-	31.4	-	-
	<	<	<	-	-	-	3.04	-	-
	3.06	6.76	54.1	-	-	-	6.58	-	-
48	0.221	2.84	81.4	-	-	-	30.4	-	-
	<	<	25.7	-	-	-	4.28	-	-
	3.96	8.60	68.1	-	-	-	8.67	-	-
49	2.12	2.64	30.5	-	-	-	42.1	-	-
	<	<	<	-	-	-	4.32	-	-
	2.66	5.70	42.0	-	-	-	6.34	-	-
50	3.71	7.33	-	-	-	-	35.1	-	-
	<	<	<	-	-	-	6.18	-	-
	4.41	7.96	71.8	-	-	-	9.23	-	-
51	0.616	2.52	31.1	-	-	-	18.9	-	-
	<	<	<	-	-	-	2.44	-	-
	2.41	4.54	37.4	-	-	-	4.64	-	-
52	1.25	1.89	32.1	-	-	-	-	-	-
	<	<	<	-	-	-	<	-	-
	2.06	4.05	36.4	-	-	-	4.47	-	-
53	0.674	-	30.5	-	-	-	23.0	-	-

	<	<	<	-	-	-	2.93	-	-
	3.55	7.63	61.0	-	-	-	7.09	-	-
54	1.92	-	31.8	-	-	-	30.3	-	-
	<	<	<	-	-	-	3.60	-	-
	4.02	8.26	80.0	-	-	-	8.41	-	-
55	-	6.28	54.0	-	-	-	44.6	-	-
	<	<	<	-	-	-	5.65	-	-
	3.77	7.47	70.6	-	-	-	8.30	-	-
56	1.75	5.98	43.8	-	-	-	34.4	-	-
	<	2.68	<	-	-	-	3.83	-	-
	2.90	5.86	51.8	-	-	-	6.45	-	-
57	4.30	4.03	87.2	-	-	-	33.1	-	-
	1.13	<	34.8	-	-	-	4.34	-	-
	3.25	8.29	66.9	-	-	-	7.42	-	-
58	2.97	2.58	89.7	-	-	-	31.0	-	-
	1.11	<	24.9	-	-	-	3.79	-	-
	2.54	6.56	44.7	-	-	-	6.21	-	-
59	1.32	-	-	-	-	-	23.6	-	-
	<	<	<	-	-	-	4.25	-	-
	3.38	7.21	53.2	-	-	-	6.77	-	-
60	2.76	3.60	44.7	-	-	-	46.5	-	-
	<	<	<	-	-	-	5.84	-	-
	4.38	9.00	67.8	-	-	-	9.10	-	-
61	2.10	-	70.7	-	-	-	41.8	-	-
	<	<	24.8	-	-	-	5.59	-	-
	4.41	8.96	66.8	-	-	-	9.46	-	-
62	0.581	5.91	103.	-	-	-	50.8	-	-
	<	<	35.4	-	-	-	4.23	-	-
	4.00	8.36	67.9	-	-	-	8.83	-	-
63	2.31	3.23	26.2	-	-	-	36.9	-	-
	<	<	<	-	-	-	4.29	-	-
	4.36	8.65	73.5	-	-	-	9.43	-	-

64	1.56	7.74	81.9	-	-	-	46.3	-	-
	<	<	26.5	-	-	-	5.84	-	-
	4.47	8.66	67.8	-	-	-	9.10	-	-
65	-	7.02	81.2	-	-	-	94.3	-	-
	<	<	29.4	-	-	-	10.8	-	-
	5.32	9.01	69.5	-	-	-	11.0	-	-
66	0.508	4.29	68.2	-	-	-	57.8	-	-
	<	<	<	-	-	-	6.42	-	-
	4.52	9.14	68.6	-	-	-	9.42	-	-
67	2.66	6.70	84.0	-	-	-	37.0	-	-
	<	<	25.4	-	-	-	4.47	-	-
	3.51	8.01	67.5	-	-	-	8.26	-	-
68	2.53	-	99.1	-	-	-	22.7	-	-
	<	<	29.1	-	-	-	3.10	-	-
	3.50	8.51	63.4	-	-	-	7.25	-	-
69	2.95	3.89	13.9	-	-	-	40.5	-	-
	<	<	<	-	-	-	4.52	-	-
	4.30	8.84	61.3	-	-	-	8.87	-	-
70	-	1.69	59.3	-	-	-	336.	-	-
	<	<	<	-	-	-	40.4	-	-
	8.59	12.2	81.1	-	-	-	19.3	-	-
71	3.87	5.22	70.2	-	-	-	38.1	-	-
	1.29	<	29.0	-	-	-	6.01	-	-
	3.80	6.29	66.7	-	-	-	8.47	-	-
72	3.47	4.33	60.6	-	-	-	42.8	-	-
	<	<	<	-	-	-	5.03	-	-
	3.67	8.19	66.5	-	-	-	8.49	-	-
73	1.98	-	106.	-	-	-	396.	-	-
	<	<	30.7	-	-	-	46.1	-	-
	9.35	13.5	72.6	-	-	-	19.8	-	-
74	2.46	6.58	63.3	-	-	-	49.7	-	-
	<	<	<	-	-	-	6.42	-	-
	3.52	7.79	68.8	-	-	-	9.70	-	-

75	2.34	-	-	-	-	-	32.5	-	-
	<	<	<	-	-	-	3.56	-	-
	3.62	7.28	73.1	-	-	-	7.97	-	-
76	0.384	2.27	99.6	-	-	-	61.7	-	-
	<	<	27.8	-	-	-	7.15	-	-
	4.78	9.46	68.1	-	-	-	9.58	-	-
77	-	4.83	38.4	-	-	-	41.1	-	-
	<	<	<	-	-	-	5.59	-	-
	4.64	9.29	67.0	-	-	-	9.51	-	-
78	1.04	6.15	93.1	-	-	-	57.9	-	-
	<	<	33.7	-	-	-	7.15	-	-
	4.71	8.99	65.8	-	-	-	9.98	-	-
79	13.5	-	74.0	-	-	-	420.	-	-
	7.40	<	<	-	-	-	53.9	-	-
	10.1	13.5	76.2	-	-	-	21.4	-	-
80	2.23	-	67.5	-	-	-	62.3	-	-
	<	<	24.5	-	-	-	7.07	-	-
	4.22	8.96	65.2	-	-	-	9.60	-	-
81	2.17	3.04	38.8	-	-	-	36.7	-	-
	<	<	<	-	-	-	5.60	-	-
	4.18	8.93	68.1	-	-	-	8.65	-	-
82	1.86	1.39	77.6	-	-	-	56.0	-	-
	<	<	26.0	-	-	-	6.74	-	-
	4.59	9.49	67.8	-	-	-	10.1	-	-
83	0.851	5.40	27.2	-	-	-	93.4	-	-
	<	<	<	-	-	-	10.6	-	-
	5.30	8.73	65.9	-	-	-	11.1	-	-
84	6.14	-	59.7	-	-	-	380.	-	-
	<	<	<	-	-	-	43.8	-	-
	9.40	11.2	70.7	-	-	-	20.0	-	-
85	-	-	27.7	-	-	-	56.7	-	-
	<	<	<	-	-	-	6.14	-	-

	5.07	8.94	66.0	-	-	-	9.96	-	-
86	4.24	-	-	-	-	-	290.	-	-
	<	<	<	-	-	-	35.0	-	-
	8.68	12.0	74.4	-	-	-	18.1	-	-
87	1.67	1.48	48.4	-	-	-	64.3	-	-
	<	<	<	-	-	-	7.34	-	-
	4.77	10.1	75.5	-	-	-	10.1	-	-
88	6.93	12.3	96.8	-	-	-	665.	-	-
	<	<	37.9	-	-	-	84.8	-	-
	14.2	18.6	80.4	-	-	-	26.0	-	-
89	3.91	7.30	47.6	-	-	-	39.4	-	-
	<	<	<	-	-	-	4.17	-	-
	4.26	8.71	77.6	-	-	-	9.89	-	-
90	2.61	4.67	-	-	-	-	57.3	-	-
	<	<	<	-	-	-	7.90	-	-
	4.73	8.77	69.4	-	-	-	9.82	-	-
91	-	4.00	50.6	-	-	-	-	-	-
	<	<	<	-	-	-	<	-	-
	3.93	9.24	67.5	-	-	-	9.15	-	-
92	2.60	5.82	84.5	-	-	-	55.8	-	-
	<	<	27.4	-	-	-	6.60	-	-
	4.36	8.67	71.9	-	-	-	9.23	-	-
93	-	2.58	27.2	-	-	-	62.5	-	-
	<	<	<	-	-	-	8.43	-	-
	4.36	8.53	71.9	-	-	-	10.1	-	-
94	-	-	52.3	-	-	-	67.0	-	-
	<	<	<	-	-	-	8.95	-	-
	4.10	9.59	68.9	-	-	-	9.72	-	-
95	-	1.53	96.9	-	-	-	62.0	-	-
	<	<	34.4	-	-	-	7.88	-	-
	4.20	9.07	66.6	-	-	-	9.41	-	-
96	-	9.55	39.2	-	-	-	55.5	-	-

	<	3.40	<	-	-	-	6.46	-	-
	4.44	7.81	78.4	-	-	-	9.22	-	-
97	-	5.06	14.1	-	-	-	-	-	-
	<	<	<	-	-	-	<	-	-
	4.60	8.64	76.7	-	-	-	9.58	-	-
98	-	9.30	42.5	-	-	-	51.5	-	-
	<	4.17	<	-	-	-	6.26	-	-
	4.42	8.06	63.0	-	-	-	9.15	-	-
99	-	9.74	8.21	-	-	-	54.7	-	-
	<	3.52	<	-	-	-	7.11	-	-
	4.37	8.30	74.6	-	-	-	9.28	-	-
100	-	9.84	-	-	-	-	51.3	-	-
	<	2.84	<	-	-	-	7.29	-	-
	4.47	8.45	68.9	-	-	-	9.36	-	-
101	-	4.26	87.8	-	-	-	-	-	-
	<	<	27.6	-	-	-	<	-	-
	4.33	9.25	73.1	-	-	-	9.04	-	-
102	3.63	12.8	47.7	-	-	-	54.0	-	-
	<	4.04	<	-	-	-	5.62	-	-
	4.20	8.81	70.4	-	-	-	9.23	-	-
103	1.22	1.49	76.5	-	-	-	-	-	-
	<	<	27.0	-	-	-	<	-	-
	3.78	8.67	69.9	-	-	-	9.13	-	-
104	0.414	7.61	74.4	-	-	-	51.6	-	-
	<	<	32.2	-	-	-	8.50	-	-
	4.30	8.79	67.6	-	-	-	8.71	-	-
105	3.27	7.79	60.8	-	-	-	59.5	-	-
	<	<	<	-	-	-	8.62	-	-
	4.29	8.49	65.0	-	-	-	9.49	-	-
106	0.550	1.14	60.9	-	-	-	54.0	-	-
	<	<	<	-	-	-	6.50	-	-
	4.11	8.69	72.9	-	-	-	9.11	-	-

107	-	6.14	71.0	-	-	-	59.5	-	-
	<	<	<	-	-	-	7.86	-	-
	4.33	9.78	73.8	-	-	-	9.51	-	-
108	2.29	3.41	56.0	-	-	-	55.2	-	-
	<	<	<	-	-	-	5.96	-	-
	4.50	8.35	73.6	-	-	-	9.58	-	-
109	0.573	3.06	128.	-	-	-	61.2	-	-
	<	<	31.9	-	-	-	9.94	-	-
	4.05	8.46	73.4	-	-	-	9.74	-	-
110	-	3.82	21.4	-	-	-	56.9	-	-
	<	<	<	-	-	-	9.20	-	-
	4.75	8.98	74.5	-	-	-	9.59	-	-
111	0.564	0.688	44.9	-	-	-	42.7	-	-
	<	<	<	-	-	-	3.90	-	-
	3.24	8.76	79.4	-	-	-	8.00	-	-
112	1.41	3.68	43.2	-	-	-	37.7	-	-
	<	<	<	-	-	-	3.78	-	-
	3.97	8.64	67.4	-	-	-	8.25	-	-
113	0.304	5.87	-	-	-	-	45.9	-	-
	<	<	<	-	-	-	5.22	-	-
	3.63	7.68	65.6	-	-	-	8.36	-	-
114	1.86	5.09	83.5	-	-	-	44.7	-	-
	<	<	26.3	-	-	-	4.61	-	-
	3.52	8.39	69.7	-	-	-	8.57	-	-
115	0.212	-	48.7	-	-	-	46.8	-	-
	<	<	<	-	-	-	5.33	-	-
	4.30	9.21	77.8	-	-	-	8.89	-	-
116	3.14	-	24.6	-	-	-	35.7	-	-
	<	<	<	-	-	-	4.55	-	-
	4.32	8.61	67.0	-	-	-	8.56	-	-
117	4.11	7.67	63.8	-	-	-	92.2	-	-
	<	<	<	-	-	-	13.0	-	-
	5.17	9.53	77.4	-	-	-	11.3	-	-

118	-	8.73	85.4	-	-	-	65.5	-	-
	<	<	38.0	-	-	-	6.89	-	-
	4.22	9.10	69.9	-	-	-	9.80	-	-
119	2.710E-02	1.67	60.8	-	-	-	106.	-	-
	<	<	<	-	-	-	13.2	-	-
	5.52	10.6	71.8	-	-	-	11.3	-	-
120	2.60	4.26	13.7	-	-	-	62.0	-	-
	<	<	<	-	-	-	10.1	-	-
	3.80	7.96	77.2	-	-	-	9.40	-	-
	1.53	4.41	47.2	-	-	-	33.3	-	-
	0.123	0.258	2.17	-	-	-	0.459	-	-
	0.346	0.709	5.55	-	-	-	0.745	-	-
	1.47	3.97	50.1	-	-	-	84.6	-	-
	1.81	3.16	34.9	-	-	-	122.	-	-
	1.35	1.12	1.47	-	-	-	24.2	-	-
	Nb	Ag	Ba\K\	Ce\K\	Hf\L\	La\K\	Pb\L\	Sm\K\	Ta\L\

n/a not available (i.e. not fitted, or not in yield list)

Conc	Data		Norm	Scale		T(Ni)	Class
* 1	1/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_116_54632	Udachnaya	1.00	1.323E+03	+	55.4	-
2	2/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_117_54633		1.00	923.	+	41.2	-
3	3/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_118_54634		1.00	891.	+	39.7	-
4	4/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_119_54635		1.00	1.124E+03	+	44.8	-
5	5/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_120_54636		1.00	1.051E+03	+	41.0	-
6	6/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_121_54637		1.00	1.250E+03	+	53.1	-
7	7/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_122_54638		1.00		+		-
8	8/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_123_54639		1.00	1.331E+03	+	53.1	-
9	9/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_124_54640		1.00	750.	+	43.8	-
10	10/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_125_54641		1.00		+		-
11	11/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_126_54642		1.00	744.	+	55.3	-
12	12/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_127_54643		1.00		+		-
13	13/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_128_54644		1.00	789.	+	44.5	-
14	14/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_129_54645		1.00		+		-
15	15/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_130_54646		1.00	879.	+	47.1	-
16	16/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_131_54647		1.00		+		-
17	17/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_132_54648		1.00	1.144E+03	+	44.2	-
18	18/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_133_54649		1.00	1.251E+03	+	48.9	-
19	19/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_134_54650		1.00		+		-
20	20/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_135_54651		1.00	1.176E+03	+	46.0	-
21	21/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_136_54652		1.00	1.379E+03	+	57.7	-
22	22/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_137_54653		1.00		+		-
23	23/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_138_54654		1.00		+		-
24	24/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_139_54655		1.00	1.152E+03	+	45.1	-
25	25/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_140_54656		1.00	942.	+	40.0	-
26	26/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_141_54657		1.00		+		-
27	27/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_142_54658		1.00		+		-
28	28/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_143_54659	Rietfontein	0.944	811.	+	39.7	-
29	29/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_144_54660		0.837	772.	+	37.5	-
30	30/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_145_54661		0.780	841.	+	34.5	-
31	31/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_146_54662		0.699	795.	+	37.2	-
32	32/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_147_54663		0.696	1.015E+03	+	36.8	-
33	33/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_148_54664		0.930	857.	+	37.3	-
34	34/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_149_54665		0.826	867.	+	35.5	-
35	35/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_150_54666	Koffiefontein	0.751	1.004E+03	+	36.7	-
36	36/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_151_54667		0.784	1.049E+03	+	40.4	-
37	37/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_152_54668		0.783	1.076E+03	+	39.4	-
38	38/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_153_54669		0.907	761.	+	40.0	-
39	39/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_154_54670		0.781	1.062E+03	+	38.8	-
40	40/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_155_54671		0.818	889.	+	35.3	-
41	41/ [SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_156_54672		0.671	1.186E+03	+	43.3	-

42	42/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_157_54673	Koffiefontein	0.753	1.133E+03	+	44.3	-
43	43/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_158_54674		0.736	1.092E+03	+	44.3	-
44	44/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_159_54675		0.704	1.177E+03	+	43.8	-
45	45/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_160_54676		0.730	1.043E+03	+	39.3	-
46	46/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_161_54677		0.670	1.216E+03	+	48.9	-
47	47/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_162_54678		0.833	1.030E+03	+	41.0	-
48	48/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_163_54679		0.788	1.079E+03	+	42.8	-
49	49/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_164_54680		1.00	833.	+	44.1	-
50	50/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_165_54681		1.00	864.	+	38.4	-
51	51/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_166_54682		1.00	884.	+	41.3	-
52	52/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_167_54683		1.00	797.	+	47.0	-
53	53/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_168_54684		1.00	899.	+	36.3	-
54	54/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_169_54685		1.00	822.	+	37.6	-
55	55/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_171_54686		1.00		+		-
56	56/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_172_54687		1.00	895.	+	51.3	-
57	57/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_173_54690		1.00	1.157E+03	+	38.4	-
58	58/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_174_54691		1.00		+		-
59	59/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_175_54692	Roberts Victor	1.00	874.	+	44.1	-
60	60/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_176_54693		1.00	837.	+	37.0	-
61	61/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_177_54694		1.00	826.	+	53.3	-
62	62/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_178_54695		1.00	772.	+	62.4	-
63	63/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_179_54696		1.00	845.	+	37.0	-
64	64/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_180_54697		1.00	881.	+	42.9	-
65	65/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_181_54698		1.00	826.	+	37.2	-
66	66/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_182_54699		1.00	878.	+	36.6	-
67	67/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_183_54700		1.00	829.	+	38.0	-
68	68/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_184_54701		1.00	892.	+	42.4	-
69	69/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_185_54702		1.00	803.	+	49.9	-
70	70/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_186_54703		1.00	885.	+	48.6	-
71	71/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_187_54704		1.00	782.	+	58.2	-
72	72/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_188_54705		1.00	789.	+	39.3	-
73	73/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_189_54706		1.00	858.	+	43.3	-
74	74/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_190_54707		1.00	830.	+	37.5	-
75	75/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_191_54708		1.00		+		-
76	76/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_192_54709		1.00		+		-
77	77/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_193_54710		1.00	847.	+	39.5	-
78	78/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_194_54711	Riet-	1.00	1.197E+03	+	45.6	-
79	79/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_195_54712	fontein	1.00	1.227E+03	+	46.9	-
80	80/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_196_54713		1.00	1.248E+03	+	52.4	-
81	81/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_197_54714	Orapa	1.00	627.	+	69.4	-
82	82/	[SOEY.PROJECT_GARNET.PIXE]XLEAR1_PX1_198_54715		1.00	613.	+	112.	-

HIAF Proton Microprobe
CSIRO, Heavy Ion Analytical Facility.

GEO_TRACE 6.1
CSIRO, Australia.

Trace Element Summary: concentration (ppm or wt%), uncertainty (1 sigma) and MDL (99% confidence) 16-APR-93 11:47:50

	Ca	Ti	Cr	Mn	Fe	Ni	Cu	Zn	Rb	Sr	Y
1 XLear1_PX1.116	-	-	1.92 %	0.334 %	6.30 %	88.0	-	19.3	11.8	-	8.69
udach gud1	-	<	0.484 %	690.	0.991 %	10.4	<	2.02	4.22	<	2.14
	-	7.58 %	424.	99.0	35.9	12.0	7.13	5.28	3.58	3.85	3.86
2 XLear1_PX1.117	-	-	0.735 %	0.361 %	9.65 %	29.1	-	34.5	28.1	-	10.7
udach gud2	-	<	0.187 %	730.	1.52 %	4.61	<	3.07	10.6	<	2.86
	-	8.66 %	472.	111.	39.8	13.7	8.60	6.53	5.14	4.52	4.44
3 XLear1_PX1.118	-	-	1.16 %	0.358 %	8.06 %	25.7	1.93	28.1	19.7	-	17.8
udach gud3	-	<	0.293 %	720.	1.27 %	4.16	<	2.61	6.72	<	2.25
	-	8.52 %	470.	108.	38.1	12.5	7.87	5.89	4.09	3.54	3.50
4 XLear1_PX1.119	-	-	1.10 %	0.340 %	8.94 %	54.9	2.84	33.9	34.3	-	18.7
udach gud4	-	<	0.277 %	689.	1.41 %	6.87	<	3.21	9.94	<	2.74
	-	9.17 %	488.	112.	40.0	13.6	8.70	6.59	4.97	4.26	4.29
5 XLear1_PX1.120	-	-	0.248 %	0.332 %	7.85 %	44.6	3.50	25.9	19.5	-	9.27
udach gud5	-	<	666.	667.	1.23 %	5.69	<	2.46	5.59	<	1.93
	-	8.15 %	464.	103.	36.4	12.0	7.61	5.73	4.49	4.08	3.99
6 XLear1_PX1.121	-	-	1.66 %	0.304 %	7.78 %	75.1	0.769	23.4	16.0	-	22.3
udach gud6	-	<	0.420 %	627.	1.22 %	9.33	<	2.42	7.92	<	2.09
	-	7.97 %	441.	104.	37.6	12.9	8.14	5.97	4.41	3.98	3.83
7 XLear1_PX1.122	-	-	0.101 %	0.669 %	21.6 %	-	78.2	183.	149.	-	29.4
udach gud7	-	<	482.	0.134 %	3.40 %	<	14.9	16.8	48.9	<	19.3
	-	13.0 %	686.	153.	52.3	15.0	11.2	9.50	9.66	8.13	7.76
8 XLear1_PX1.123	-	-	2.65 %	0.402 %	7.36 %	89.5	0.619	24.2	6.45	-	18.8
udach gud8	-	<	0.669 %	812.	1.16 %	9.99	<	2.40	7.60	<	3.26
	-	8.28 %	454.	106.	38.6	12.9	7.68	5.77	4.16	3.72	3.68
9 XLear1_PX1.124	-	-	0.865 %	0.374 %	7.61 %	13.7	-	16.4	17.2	-	19.4
udach gud9	-	<	0.221 %	746.	1.20 %	3.26	<	2.30	5.56	<	2.49
	-	8.28 %	431.	100.	35.7	11.7	7.31	5.44	3.97	3.48	3.37
10 XLear1_PX1.125	-	-	266.	0.896 %	23.2 %	-	82.8	240.	186.	-	159.

udach gud10	-	<	<	0.179 %	3.66 %	<	14.9	20.2	60.8	<	28.1
	-	13.3 %	710.	158.	53.5	16.2	12.0	10.2	10.3	8.50	8.19
11 XLear1_PX1.126	-	-	0.154 %	0.400 %	10.8 %	13.3	-	40.2	43.0	-	-
udach gud11	-	<	547.	798.	1.69 %	<	<	3.74	12.4	<	<
	-	9.36 %	514.	114.	39.7	13.5	8.85	6.75	5.35	4.65	4.66
12 XLear1_PX1.127	-	-	0.121 %	0.707 %	23.1 %	-	85.6	197.	152.	-	28.0
udach gud12	-	<	586.	0.143 %	3.63 %	<	16.1	19.9	57.9	<	19.1
	-	13.5 %	699.	154.	53.1	15.9	11.8	10.1	10.8	9.19	8.65
13 XLear1_PX1.128	-	-	4.54 %	0.551 %	6.14 %	16.6	2.84	14.5	8.46	0.258	-
udach gud13	-	<	1.14 %	0.112 %	0.965 %	3.69	<	2.54	6.63	<	<
	-	8.26 %	458.	106.	37.3	11.8	7.32	5.51	4.20	3.73	3.64
14 XLear1_PX1.129	-	-	665.	0.779 %	23.3 %	-	89.7	199.	151.	-	60.4
udach gud14	-	<	<	0.156 %	3.67 %	<	15.1	18.2	58.9	<	20.0
	-	13.3 %	693.	154.	52.8	15.6	11.7	9.98	10.6	9.08	8.50
15 XLear1_PX1.130	-	-	3.38 %	0.398 %	5.80 %	24.5	2.27	15.3	6.97	-	-
udach gud15	-	<	0.850 %	808.	0.912 %	4.85	<	2.33	4.96	<	<
	-	7.37 %	384.	92.6	34.0	11.4	7.09	5.26	3.83	3.52	3.33
16 XLear1_PX1.131	-	-	766.	0.659 %	22.7 %	-	92.4	224.	174.	-	19.2
udach gud16	-	<	567.	0.132 %	3.57 %	<	17.5	20.1	58.5	<	17.6
	-	13.2 %	702.	156.	52.5	15.5	11.9	10.1	10.5	8.82	8.37
17 XLear1_PX1.132	-	-	3.20 %	0.422 %	6.72 %	58.0	-	16.3	6.95	-	5.22
udach gud17	-	<	0.806 %	848.	1.06 %	6.93	<	2.14	5.43	<	1.78
	-	8.13 %	436.	104.	37.8	12.6	7.75	5.72	4.24	3.81	3.80
18 XLear1_PX1.133	-	-	7.50 %	0.573 %	6.19 %	75.3	4.84	20.3	4.46	-	-
udach gud18	-	<	1.89 %	0.118 %	0.973 %	8.59	<	2.79	<	<	<
	-	7.79 %	470.	110.	39.8	12.7	7.54	5.73	4.62	4.32	4.19
19 XLear1_PX1.134	-	-	0.150 %	0.623 %	23.4 %	-	91.7	181.	142.	-	-
udach gud19	-	<	603.	0.125 %	3.68 %	<	15.0	15.8	53.6	<	<
	-	13.5 %	694.	154.	53.2	15.8	11.8	10.1	10.6	8.99	8.43
20 XLear1_PX1.135	-	-	1.36 %	0.402 %	8.01 %	62.9	-	23.7	11.2	-	24.2
udach gud20	-	<	0.343 %	803.	1.26 %	7.48	<	2.53	8.43	<	2.45
	-	8.69 %	468.	109.	39.2	13.3	7.90	5.89	4.29	3.85	3.80

21 XLear1_PX1.136	-	-	1.39 %	0.358 %	7.87 %	98.6	-	24.8	8.02	-	23.8
udach gud21	-	<	0.351 %	718.	1.24 %	11.2	<	2.74	8.45	<	2.07
	-	8.34 %	494.	112.	39.7	13.2	8.22	6.10	4.70	4.17	4.12
22 XLear1_PX1.137	-	-	0.143 %	0.758 %	23.1 %	-	88.7	218.	173.	-	46.9
udach gud22	-	<	584.	0.153 %	3.64 %	<	14.6	19.8	56.8	<	20.1
	-	13.6 %	708.	158.	53.8	16.1	12.2	10.3	10.8	9.17	8.64
23 XLear1_PX1.138	-	-	0.112 %	0.488 %	19.3 %	-	43.2	154.	106.	-	25.1
udach gud23	-	<	515.	980.	3.03 %	<	9.02	12.9	38.1	<	13.2
	-	12.0 %	633.	143.	49.8	15.1	10.9	9.09	8.79	7.48	6.98
24 XLear1_PX1.139	-	-	2.49 %	0.402 %	9.02 %	59.1	1.24	32.2	4.93	-	10.6
udach gud24	-	<	0.628 %	822.	1.42 %	7.14	<	2.88	8.47	<	2.84
	-	8.95 %	493.	115.	40.6	13.3	8.03	6.06	4.71	4.24	4.24
25 XLear1_PX1.140	-	-	1.19 %	0.369 %	8.08 %	31.2	2.32	24.1	20.6	-	14.7
udach gud25	-	<	0.301 %	739.	1.27 %	4.63	<	2.39	7.59	<	2.74
	-	8.53 %	453.	105.	37.6	12.7	7.90	5.94	4.49	3.99	3.94
26 XLear1_PX1.141	-	-	0.170 %	0.487 %	22.6 %	-	83.2	211.	165.	-	-
udach gud26	-	<	745.	0.100 %	3.55 %	<	14.4	18.8	67.9	<	<
	-	13.2 %	691.	156.	53.2	16.0	12.1	10.3	10.8	9.07	8.63
27 XLear1_PX1.142	-	-	793.	0.680 %	24.4 %	-	87.2	215.	155.	-	-
udach gud27	-	<	529.	0.136 %	3.84 %	<	18.2	20.4	64.5	<	<
	-	13.6 %	726.	164.	55.8	16.4	12.3	10.5	11.2	9.61	8.93
28 XLear1_PX1.143	-	-	5.71 %	0.506 %	5.69 %	18.4	0.723	22.9	5.60	-	40.7
~~koffie~~ gk3	-	<	1.43 %	0.103 %	0.895 %	3.46	<	2.83	4.64	<	2.62
Rietfontein	-	7.43 %	426.	100.	36.0	11.6	6.93	5.18	4.00	3.64	3.44
29 XLear1_PX1.144	-	-	1.24 %	0.298 %	5.72 %	15.3	0.146	13.9	8.55	-	8.27
~~koffie~~ gk7	-	<	0.314 %	598.	0.900 %	2.94	<	1.59	4.02	<	2.08
Rietfontein	-	6.56 %	366.	84.5	30.0	9.83	5.86	4.36	3.23	2.89	2.85
30 XLear1_PX1.145	-	-	2.42 %	0.330 %	4.60 %	21.0	-	10.5	2.71	-	14.6
~~koffie~~ gk13	-	<	0.610 %	668.	0.724 %	3.21	<	1.33	<	<	1.45
Rietfontein	-	5.75 %	337.	79.0	28.3	9.14	5.49	4.06	3.18	2.94	2.59
31 XLear1_PX1.146	-	-	0.708 %	0.248 %	4.55 %	17.1	-	10.1	7.72	-	12.5
~~koffie~~ gk14	-	<	0.180 %	495.	0.715 %	3.10	<	1.31	2.47	<	1.17
Rietfontein	-	5.38 %	289.	67.3	24.3	8.06	4.65	3.42	2.50	2.27	2.27

32 XLear1_PX1.147	-	-	0.257 %	0.162 %	5.62 %	39.9	-	18.9	11.6	-	-
~~koffie~~ gk15	-	<	686.	326.	0.883 %	4.82	<	1.89	5.35	<	<
Rietfontein	-	5.70 %	306.	70.9	25.6	9.04	5.74	4.21	3.11	2.76	2.51
33 XLear1_PX1.148	-	-	4.99 %	0.460 %	4.81 %	22.4	-	11.8	2.52	3.92	-
~~koffie~~ gk26	-	<	1.25 %	959.	0.757 %	3.62	<	1.56	<	1.14	<
Rietfontein	-	7.36 %	413.	96.8	34.2	10.8	6.63	4.88	3.63	3.28	3.19
34 XLear1_PX1.149	-	-	1.17 %	0.276 %	5.26 %	23.3	-	16.3	9.74	-	7.69
~~koffie~~ gk27	-	<	0.294 %	553.	0.828 %	3.52	<	1.96	3.48	<	1.75
Rietfontein	-	6.52 %	341.	79.9	28.8	9.65	5.97	4.38	3.36	3.08	2.82
35 XLear1_PX1.150	-	-	2.46 %	0.289 %	4.41 %	38.5	-	10.1	6.75	-	10.5
~~riet~~ gr2	-	<	0.619 %	591.	0.693 %	4.72	<	1.32	3.33	<	1.55
Koffiefontein	-	5.44 %	313.	74.7	27.3	9.16	5.63	4.13	3.13	2.91	2.88
36 XLear1_PX1.151	-	-	3.13 %	0.321 %	4.49 %	44.3	-	13.6	4.97	-	9.17
~~riet~~ gr3	-	<	0.788 %	688.	0.706 %	5.58	<	1.59	3.58	<	1.17
Koffiefontein	-	6.07 %	349.	81.7	29.2	9.34	5.57	4.12	2.99	2.76	2.85
37 XLear1_PX1.152	-	-	1.27 %	0.278 %	5.71 %	48.0	0.275	20.4	8.39	-	8.06
~~riet~~ gr4	-	<	0.321 %	566.	0.897 %	5.65	<	2.07	4.14	<	1.59
Koffiefontein	-	6.65 %	368.	85.1	30.1	9.41	5.62	4.20	3.34	3.08	2.96
38 XLear1_PX1.153	-	-	4.04 %	0.440 %	5.51 %	14.6	0.378	13.4	6.41	-	10.9
~~riet~~ gr5	-	<	1.02 %	890.	0.867 %	3.05	<	1.62	4.15	<	1.74
Koffiefontein	-	7.20 %	409.	95.1	33.9	10.7	6.65	4.89	3.77	3.55	3.56
39 XLear1_PX1.154	-	-	2.59 %	0.306 %	4.46 %	46.0	1.62	14.8	8.67	-	11.2
~~riet~~ gr8	-	<	0.652 %	622.	0.702 %	5.46	<	1.72	3.31	<	1.56
Koffiefontein	-	5.99 %	335.	79.0	28.6	9.43	5.57	4.15	3.15	2.86	2.76
40 XLear1_PX1.155	-	-	3.30 %	0.311 %	4.54 %	25.5	0.267	10.9	6.36	-	7.16
~~riet~~ gr11	-	<	0.830 %	638.	0.714 %	3.67	<	1.49	2.60	<	1.43
Koffiefontein	-	6.24 %	342.	81.5	29.5	9.66	5.96	4.40	3.24	3.01	3.00
41 XLear1_PX1.156	-	-	1.15 %	0.192 %	4.28 %	64.6	7.499E-02	11.8	4.32	-	11.3
~~riet~~ gr14	-	<	0.291 %	388.	0.672 %	7.11	<	1.62	2.37	<	1.39
Koffiefontein	-	5.01 %	282.	66.3	23.8	8.11	4.89	3.61	2.60	2.37	2.39
42 XLear1_PX1.157	-	-	1.52 %	0.260 %	5.05 %	56.3	7.045E-02	15.7	4.30	-	10.8
~~riet~~ gr15	-	<	0.383 %	545.	0.794 %	6.85	<	1.82	3.83	<	1.44
Koffiefontein											

	-	5.81 %	324.	76.2	27.6	9.28	5.74	4.21	3.15	2.93	2.83
43 XLear1_PX1.158	-	-	1.03 %	0.230 %	5.81 %	50.2	2.07	19.8	16.6	-	13.0
~~riet~~ gr16	-	<	0.261 %	463.	0.913 %	6.52	<	1.91	4.28	<	2.34
Koffiefontein	-	6.28 %	344.	79.6	28.7	9.78	6.06	4.51	3.34	2.98	2.89
44 XLear1_PX1.159	-	-	1.24 %	0.209 %	4.42 %	63.1	-	13.5	8.46	-	10.1
~~riet~~ gr18	-	<	0.314 %	424.	0.695 %	7.12	<	1.43	2.99	<	1.15
Koffiefontein	-	5.39 %	314.	73.5	26.4	8.72	5.10	3.79	2.94	2.73	2.58
45 XLear1_PX1.160	-	-	1.38 %	0.235 %	4.87 %	43.5	0.782	11.1	9.55	-	6.59
~~riet~~ gr20	-	<	0.347 %	477.	0.765 %	5.38	<	1.36	3.91	<	1.11
Koffiefontein	-	5.74 %	297.	71.4	26.5	9.09	5.53	4.10	3.11	2.87	2.78
46 XLear1_PX1.161	-	-	1.22 %	0.198 %	4.17 %	69.4	0.187	13.9	7.38	-	10.6
~~riet~~ gr21	-	<	0.308 %	404.	0.655 %	8.31	<	1.45	1.74	<	1.78
Koffiefontein	-	4.99 %	272.	64.9	23.8	7.98	4.69	3.51	2.69	2.55	2.36
47 XLear1_PX1.162	-	-	2.09 %	0.322 %	5.57 %	41.8	0.430	15.1	5.52	-	2.38
~~riet~~ gr22	-	<	0.530 %	646.	0.875 %	5.51	<	2.14	4.28	<	<
Koffiefontein	-	7.05 %	381.	89.0	31.7	10.3	6.06	4.55	3.48	3.20	3.20
48 XLear1_PX1.163	-	-	4.07 %	0.357 %	4.80 %	48.5	1.27	15.8	7.85	0.658	5.62
~~riet~~ gr24	-	<	1.02 %	766.	0.755 %	6.18	<	1.72	3.07	<	1.63
Koffiefontein	-	6.57 %	350.	83.7	30.6	10.1	5.83	4.39	3.34	3.07	3.09
49 XLear1_PX1.164	-	-	2.57 %	0.445 %	6.85 %	20.2	-	12.1	0.669	0.366	22.7
robv grv1	-	<	0.648 %	893.	1.08 %	4.07	<	1.47	<	<	1.87
	-	6.82 %	420.	98.4	34.6	10.7	5.95	4.24	2.39	2.82	2.94
50 XLear1_PX1.165	-	-	3.60 %	0.520 %	6.12 %	23.0	0.663	9.64	-	1.38	27.7
robv grv2	-	<	0.905 %	0.104 %	0.963 %	3.79	<	1.35	<	<	2.22
	-	7.33 %	405.	95.1	33.8	10.7	6.29	4.38	2.54	3.03	3.20
51 XLear1_PX1.166	-	-	2.25 %	0.428 %	6.92 %	25.0	-	10.1	0.763	-	26.6
robv grv3	-	<	0.566 %	862.	1.09 %	4.27	<	1.58	<	<	1.54
	-	7.57 %	428.	98.6	34.4	10.2	6.20	4.40	2.58	3.04	3.21
52 XLear1_PX1.167	-	-	1.50 %	0.394 %	7.71 %	17.3	1.67	11.6	-	0.792	21.0
robv grv4	-	<	0.379 %	799.	1.21 %	4.00	<	1.47	<	<	1.79
	-	7.93 %	442.	101.	35.6	11.2	6.33	4.46	2.50	2.84	3.22
53 XLear1_PX1.168	-	-	3.24 %	0.446 %	6.60 %	26.5	-	13.3	-	1.34	22.2

robv grv5	-	<	0.817 %	941.	1.04 %	3.85	<	1.54	<	<	2.29
	-	7.79 %	433.	99.6	34.6	10.3	6.03	4.30	2.56	2.91	2.98
54 XLear1_PX1.169	-	-	4.42 %	0.489 %	6.15 %	19.3	1.14	10.6	1.39	-	19.2
robv grv6	-	<	1.11 %	0.103 %	0.967 %	3.36	<	1.41	<	<	1.97
	-	7.19 %	381.	91.7	33.2	10.7	6.28	4.43	2.60	3.02	3.15
55 XLear1_PX1.171	-	-	4.07 %	455. %	39.3 %	0.727 %	-	-	1.64	-	22.1
robv grv7	-	<	1.02 %	90.0 %	6.17 %	796.	<	<	<	<	2.61
	-	8.22 %	511.	119.	42.1	13.5	7.72	5.41	3.21	3.34	3.49
56 XLear1_PX1.172	-	-	3.97 %	0.511 %	6.98 %	26.1	1.28	12.1	7.542E-02	1.37	14.0
robv grv8	-	<	0.998 %	0.106 %	1.10 %	5.48	<	1.47	<	<	1.19
	-	7.91 %	432.	101.	35.4	10.5	5.90	4.28	2.65	3.09	3.17
57 XLear1_PX1.173	-	-	50.0 %	-	1.361E+07	59.9	28.8 %	-	2.33	-	9.44
robv grv9	-	<	12.6 %	<	214. %	6.10	2.39 %	<	<	<	1.33
	-	7.57 %	424.	99.2	34.7	10.6	6.16	4.39	2.45	2.89	3.14
58 XLear1_PX1.174	-	-	5.46 %	315. %	84.0 %	313. %	-	-	2.83	16.6	-
robv grv10	-	<	6.05 %	109. %	37.1 %	31.9 %	<	<	<	0.284	<
	-	9.73 %	572.	129.	44.0	13.3	7.81	5.57	3.01	3.21	3.45
59 XLear1_PX1.175	-	-	1.81 %	0.398 %	7.22 %	24.0	-	11.4	0.237	7.41	17.6
robv grv11	-	<	0.458 %	821.	1.14 %	4.48	<	1.42	<	0.980	1.54
	-	7.68 %	428.	98.8	34.7	10.8	5.97	4.23	2.40	2.90	3.28
60 XLear1_PX1.176	-	-	3.25 %	0.430 %	6.88 %	20.6	-	8.04	4.096E-02	0.650	22.4
robv grv12	-	<	0.821 %	898.	1.08 %	3.43	<	1.28	<	<	1.49
	-	7.77 %	443.	103.	35.4	10.7	6.21	4.42	2.58	2.86	2.78
61 XLear1_PX1.177	-	-	1.90 %	0.466 %	7.62 %	19.7	-	13.4	0.829	0.169	21.6
robv grv13	-	<	0.478 %	929.	1.20 %	4.91	<	1.55	<	<	1.97
	-	7.85 %	443.	102.	35.5	10.8	6.16	4.38	2.51	2.98	3.21
62 XLear1_PX1.178	-	-	2.75 %	0.438 %	6.60 %	15.3	2.88	11.2	-	-	24.8
robv grv14	-	<	0.691 %	883.	1.04 %	5.07	<	1.43	<	<	2.07
	-	7.45 %	403.	94.6	33.7	10.7	6.10	4.34	2.39	2.86	3.04
63 XLear1_PX1.179	-	-	4.06 %	0.497 %	6.15 %	21.3	-	8.55	1.79	2.05	12.8
robv grv15	-	<	1.02 %	0.105 %	0.967 %	3.49	<	1.36	<	<	1.19
	-	7.14 %	398.	94.8	34.1	10.9	6.08	4.34	2.38	2.72	2.89

64	XLear1_PX1.180	-	-	3.64 %	0.476 %	6.64 %	24.7	3.00	11.3	-	1.03	12.4
	robv grv17	-	<	0.915 %	983.	1.05 %	4.42	<	1.46	<	<	1.39
		-	6.94 %	426.	99.1	34.8	10.7	6.19	4.42	2.62	3.11	3.31
65	XLear1_PX1.181	-	-	2.54 %	0.442 %	7.16 %	19.7	1.78	14.6	0.129	-	26.0
	robv grv18	-	<	0.639 %	914.	1.13 %	3.36	<	1.73	<	<	2.06
		-	7.65 %	428.	98.7	34.9	10.8	5.73	4.17	2.58	2.98	3.04
66	XLear1_PX1.182	-	-	3.44 %	0.488 %	6.42 %	24.4	-	12.6	-	1.90	31.1
	robv grv19	-	<	0.866 %	0.102 %	1.01 %	3.72	<	1.50	<	<	2.76
		-	7.11 %	440.	102.	35.7	10.7	6.03	4.35	2.29	2.73	3.22
67	XLear1_PX1.183	-	-	3.89 %	0.518 %	6.98 %	19.9	-	8.98	-	1.97	21.6
	robv grv20	-	<	0.979 %	0.109 %	1.10 %	3.46	<	1.38	<	<	1.42
		-	7.95 %	439.	103.	36.5	11.3	6.48	4.60	2.70	3.13	3.21
68	XLear1_PX1.184	-	-	3.22 %	0.519 %	7.26 %	25.8	-	9.75	0.862	1.10	18.4
	robv grv21	-	<	0.811 %	0.105 %	1.14 %	4.47	<	1.66	<	<	1.67
		-	8.04 %	462.	107.	37.1	11.3	6.39	4.54	2.75	3.16	3.18
69	XLear1_PX1.185	-	-	3.72 %	0.498 %	7.29 %	17.8	2.02	11.5	-	1.39	21.1
	robv grv22	-	<	0.936 %	0.103 %	1.15 %	4.33	<	2.12	<	<	1.45
		-	7.90 %	422.	99.7	35.8	11.4	6.66	4.70	2.73	3.22	3.35
70	XLear1_PX1.186	-	-	3.62 %	0.521 %	6.73 %	25.1	1.59	11.9	-	0.723	28.7
	robv grv23	-	<	0.915 %	0.104 %	1.06 %	5.08	<	1.93	<	<	1.68
		-	7.23 %	383.	91.9	32.9	10.2	5.95	4.30	2.59	2.98	2.99
71	XLear1_PX1.187	-	-	3.64 %	0.503 %	6.29 %	16.0	0.537	8.54	0.575	-	17.2
	robv grv24	-	<	0.918 %	0.107 %	0.989 %	4.81	<	1.50	<	<	1.30
		-	7.14 %	413.	96.2	34.2	10.6	6.31	4.45	2.56	3.02	3.20
72	XLear1_PX1.188	-	-	3.35 %	0.492 %	7.00 %	16.6	0.997	8.94	0.744	1.04	28.9
	robv grv25	-	<	0.849 %	0.106 %	1.10 %	3.24	<	1.35	<	<	1.93
		-	7.70 %	444.	103.	36.1	11.3	6.40	4.56	2.75	3.21	3.30
73	XLear1_PX1.189	-	-	2.53 %	0.441 %	7.22 %	22.5	-	13.4	0.704	0.324	26.6
	robv grv26	-	<	0.638 %	903.	1.14 %	4.25	<	1.55	<	<	2.06
		-	7.74 %	442.	101.	35.4	10.9	6.09	4.37	2.40	2.72	3.08
74	XLear1_PX1.190	-	-	2.99 %	0.494 %	7.11 %	20.0	0.233	11.2	-	0.382	22.8
	robv grv27	-	<	0.752 %	0.100 %	1.12 %	3.41	<	1.45	<	<	2.06
		-	7.99 %	443.	104.	36.2	10.9	6.36	4.50	2.55	3.08	3.21

75 XLear1_PX1.191	-	-	83.1 %	-	1.250E+07	-	-	13.4	0.531	-	18.8
robv grv28	-	<	20.9 %	<	196. %	<	<	1.56	<	<	1.43
	-	7.61 %	428.	101.	35.2	10.6	6.20	4.42	2.85	2.96	2.97
76 XLear1_PX1.192	-	-	32.7 %	-	4.006E+07	1.70 %	-	2.57	-	1.85	36.8
robv grv29	-	<	8.20 %	<	630. %	0.173 %	<	<	<	<	1.77
	-	5.88 %	387.	93.0	33.6	11.2	6.36	4.48	2.64	2.65	2.81
77 XLear1_PX1.193	-	-	2.47 %	0.448 %	7.75 %	21.5	-	11.9	1.59	1.12	25.4
robv grv30	-	<	0.624 %	899.	1.22 %	3.76	<	1.48	<	<	2.12
	-	7.10 %	436.	102.	36.4	11.3	6.22	4.46	2.72	3.11	3.08
78 XLear1_PX1.194	-	-	3.42 %	0.359 %	6.31 %	66.2	0.208	13.8	-	-	22.1
riet gr2	-	<	0.860 %	797.	0.992 %	7.59	<	1.67	<	<	1.86
	-	7.85 %	449.	103.	36.3	11.4	6.66	4.72	2.63	3.10	3.27
79 XLear1_PX1.195	-	-	4.26 %	0.359 %	6.05 %	71.2	2.25	16.4	0.452	0.817	15.1
riet gr3	-	<	1.07 %	786.	0.951 %	8.05	<	1.85	<	<	1.27
	-	7.74 %	426.	101.	36.4	11.3	6.32	4.56	2.75	3.16	3.25
80 XLear1_PX1.196	-	-	1.75 %	0.328 %	7.70 %	74.9	-	17.9	-	2.14	19.1
riet gr4	-	<	0.442 %	678.	1.21 %	9.19	<	1.83	<	<	1.71
	-	7.36 %	446.	101.	36.1	11.5	6.48	4.59	2.57	3.04	3.17
81 XLear1_PX1.197	-	-	0.149 %	1.46 %	34.4 %	6.79	-	10.9	-	-	17.8
orap gor27	-	<	707.	0.291 %	5.41 %	<	<	1.66	<	<	2.59
	-	14.8 %	785.	170.	55.8	15.1	8.53	5.80	4.34	4.45	4.57
82 XLear1_PX1.198	-	-	0.163 %	0.391 %	33.5 %	6.17	2.05	9.26	-	3.07	28.3
orap gor29	-	<	815.	859.	5.27 %	<	<	1.60	<	<	2.38
	-	14.7 %	771.	164.	54.1	15.3	8.58	5.84	4.39	4.47	4.53
Weighted average	-	-	0.201 %	0.339 %	6.15 %	26.1	1.41	13.6	2.76	5.28	15.9
Weighted error	-	<	138.	84.2	0.118 %	0.542	0.251	0.205	5.483E-02	0.144	0.211
Weighted MDL	-	0.828 %	46.3	10.8	3.84	1.23	0.735	0.537	0.354	0.367	0.369
Arith. mean Conc	-	-	4.18 %	9.81 %	90.9 %	3.85 %	0.352 %	37.7	24.3	0.680	18.4
Stand. deviation	-	-	10.9 %	60.7 %	482. %	34.6 %	3.18 %	62.6	50.3	2.08	19.3
Std. dev./ error	-	-	87.2	796.	452.	7.048E+04	1.401E+04	33.7	101.	1.60	10.1
	Ca	Ti	Cr	Mn	Fe	Ni	Cu	Zn	Rb	Sr	Y

n/a not available (i.e. not fitted, or not in yield list)

Continued on next page ...

Trace Element Summary: concentration (ppm or wt%), uncertainty (1 sigma) and MDL (99% confidence) 16-APR-93 11:47:50

	Zr	Nb	Ag	La\K\	Ce\K\	Sm\K\	Hf	Ta	Ba\K\	Hf\L\	Pb\L\	Ta\L\
1	30.8	3.14	-	-	-	-	-	-	24.6	-	35.7	-
	1.91	<	<	-	-	-	-	-	<	-	4.55	-
	3.98	4.32	8.61	-	-	-	-	-	67.0	-	8.56	-
2	58.7	4.11	7.67	-	-	-	-	-	63.8	-	92.2	-
	3.36	<	<	-	-	-	-	-	<	-	13.0	-
	4.80	5.17	9.53	-	-	-	-	-	77.4	-	11.3	-
3	40.7	-	8.73	-	-	-	-	-	85.4	-	65.5	-
	4.20	<	<	-	-	-	-	-	38.0	-	6.89	-
	3.89	4.22	9.10	-	-	-	-	-	69.9	-	9.80	-
4	116.	2.710E-02	1.67	-	-	-	-	-	60.8	-	106.	-
	7.51	<	<	-	-	-	-	-	<	-	13.2	-
	4.92	5.52	10.6	-	-	-	-	-	71.8	-	11.3	-
5	45.2	2.60	4.26	-	-	-	-	-	13.7	-	62.0	-
	4.27	<	<	-	-	-	-	-	<	-	10.1	-
	3.79	3.80	7.96	-	-	-	-	-	77.2	-	9.40	-
6	102.	0.643	9.10	-	-	-	-	-	29.2	-	56.8	-
	4.30	<	3.45	-	-	-	-	-	<	-	6.10	-
	4.10	4.61	8.77	-	-	-	-	-	67.0	-	9.55	-
7	1.77	-	0.705	-	-	-	-	-	28.1	-	437.	-
	<	<	<	-	-	-	-	-	<	-	53.6	-
	8.79	9.98	13.8	-	-	-	-	-	63.2	-	21.1	-
8	39.2	-	3.05	-	-	-	-	-	79.8	-	-	-
	4.77	<	<	-	-	-	-	-	26.6	-	<	-
	4.00	4.48	9.13	-	-	-	-	-	71.5	-	9.59	-
9	35.9	3.63	-	-	-	-	-	-	-	-	48.6	-
	2.23	1.58	<	-	-	-	-	-	<	-	5.41	-
	3.27	3.63	9.33	-	-	-	-	-	72.0	-	8.87	-
10	-	-	-	-	-	-	-	-	80.3	-	548.	-

	<	<	<	-	-	-	-	-	28.7	-	66.4	-
	9.16	10.3	15.1	-	-	-	-	-	79.6	-	22.4	-
11	95.2	3.56	5.58	-	-	-	-	-	56.5	-	121.	-
	8.49	<	<	-	-	-	-	-	<	-	11.5	-
	5.15	5.58	9.98	-	-	-	-	-	77.7	-	12.1	-
12	-	4.23	-	-	-	-	-	-	-	-	525.	-
	<	<	<	-	-	-	-	-	<	-	65.1	-
	9.56	10.8	15.5	-	-	-	-	-	82.6	-	22.8	-
13	3.28	2.71	6.61	-	-	-	-	-	82.0	-	39.5	-
	<	<	<	-	-	-	-	-	27.3	-	4.87	-
	3.70	3.79	9.13	-	-	-	-	-	73.3	-	9.31	-
14	11.4	3.99	9.86	-	-	-	-	-	-	-	502.	-
	14.5	<	<	-	-	-	-	-	<	-	62.7	-
	9.27	10.3	12.8	-	-	-	-	-	72.1	-	22.3	-
15	0.325	1.53	3.81	-	-	-	-	-	43.5	-	33.0	-
	<	<	<	-	-	-	-	-	<	-	5.84	-
	3.56	3.85	8.75	-	-	-	-	-	66.2	-	8.37	-
16	-	6.49	21.0	-	-	-	-	-	-	-	541.	-
	<	<	6.14	-	-	-	-	-	<	-	69.5	-
	9.62	11.0	13.9	-	-	-	-	-	74.3	-	23.0	-
17	26.8	0.433	-	-	-	-	-	-	83.7	-	-	-
	4.59	<	<	-	-	-	-	-	28.6	-	<	-
	4.10	4.45	9.18	-	-	-	-	-	78.4	-	9.18	-
18	12.2	2.89	2.27	-	-	-	-	-	61.6	-	29.5	-
	1.68	<	<	-	-	-	-	-	<	-	4.02	-
	4.34	4.66	9.27	-	-	-	-	-	65.8	-	9.81	-
19	-	6.16	8.19	-	-	-	-	-	68.0	-	500.	-
	<	<	<	-	-	-	-	-	<	-	63.2	-
	9.49	10.7	13.2	-	-	-	-	-	70.8	-	22.6	-
20	55.2	2.33	8.79	-	-	-	-	-	50.4	-	-	-
	5.79	<	2.89	-	-	-	-	-	<	-	<	-
	4.08	4.34	7.68	-	-	-	-	-	78.3	-	9.86	-

21	51.2	-	3.91	-	-	-	-	-	61.4	-	-	-
	5.13	<	<	-	-	-	-	-	<	-	<	-
	4.55	4.96	9.72	-	-	-	-	-	77.4	-	10.0	-
22	-	2.03	-	-	-	-	-	-	-	-	515.	-
	<	<	<	-	-	-	-	-	<	-	73.5	-
	9.55	10.7	15.2	-	-	-	-	-	77.9	-	22.9	-
23	4.63	-	3.76	-	-	-	-	-	56.5	-	341.	-
	<	<	<	-	-	-	-	-	<	-	42.0	-
	7.84	8.84	12.2	-	-	-	-	-	74.7	-	19.0	-
24	44.4	-	-	-	-	-	-	-	24.3	-	-	-
	6.57	<	<	-	-	-	-	-	<	-	<	-
	4.49	4.85	8.62	-	-	-	-	-	73.0	-	10.2	-
25	44.5	2.47	5.10	-	-	-	-	-	128.	-	67.6	-
	4.43	<	<	-	-	-	-	-	29.5	-	9.78	-
	4.29	4.65	8.94	-	-	-	-	-	67.4	-	10.1	-
26	-	6.39	-	-	-	-	-	-	119.	-	506.	-
	<	<	<	-	-	-	-	-	29.7	-	68.7	-
	9.45	10.8	13.6	-	-	-	-	-	69.4	-	22.8	-
27	-	4.30	-	-	-	-	-	-	70.9	-	533.	-
	<	<	<	-	-	-	-	-	<	-	71.1	-
	9.74	10.8	14.3	-	-	-	-	-	81.1	-	23.4	-
28	46.6	1.43	-	-	-	-	-	-	40.9	-	36.7	-
	2.84	<	<	-	-	-	-	-	<	-	4.64	-
	3.61	4.07	8.11	-	-	-	-	-	66.5	-	8.72	-
29	0.933	0.252	5.63	-	-	-	-	-	70.3	-	31.4	-
	<	<	<	-	-	-	-	-	22.4	-	5.09	-
	3.18	3.59	5.65	-	-	-	-	-	58.2	-	7.13	-
30	15.4	0.115	0.725	-	-	-	-	-	54.3	-	-	-
	1.47	<	<	-	-	-	-	-	24.5	-	<	-
	2.60	3.06	7.01	-	-	-	-	-	53.7	-	6.63	-
31	28.0	1.19	2.80	-	-	-	-	-	46.4	-	26.6	-
	2.87	<	<	-	-	-	-	-	<	-	4.60	-
	2.36	2.67	6.08	-	-	-	-	-	46.5	-	5.49	-

32	4.87	2.34	4.16	-	-	-	-	-	33.6	-	40.4	-
	1.93	<	<	-	-	-	-	-	<	-	5.61	-
	2.61	2.98	5.92	-	-	-	-	-	54.0	-	6.70	-
33	2.32	2.17	7.10	-	-	-	-	-	-	-	20.1	-
	<	<	2.18	-	-	-	-	-	<	-	4.57	-
	3.21	3.58	6.60	-	-	-	-	-	72.8	-	7.78	-
34	28.9	0.747	7.79	-	-	-	-	-	44.9	-	39.5	-
	3.57	<	2.57	-	-	-	-	-	<	-	4.75	-
	2.98	3.36	6.31	-	-	-	-	-	64.9	-	7.12	-
35	25.3	0.606	-	-	-	-	-	-	8.74	-	23.3	-
	2.28	<	<	-	-	-	-	-	<	-	4.22	-
	2.94	3.30	6.62	-	-	-	-	-	57.9	-	6.58	-
36	36.1	0.686	5.17	-	-	-	-	-	15.0	-	21.2	-
	2.91	<	<	-	-	-	-	-	<	-	3.23	-
	3.11	3.33	6.71	-	-	-	-	-	46.7	-	6.64	-
37	35.2	2.64	5.29	-	-	-	-	-	-	-	33.1	-
	2.02	<	<	-	-	-	-	-	<	-	5.01	-
	2.80	2.75	6.60	-	-	-	-	-	51.4	-	7.03	-
38	47.4	-	6.60	-	-	-	-	-	49.4	-	27.5	-
	3.38	<	<	-	-	-	-	-	<	-	4.76	-
	3.81	4.06	7.18	-	-	-	-	-	62.1	-	7.97	-
39	50.0	1.60	2.86	-	-	-	-	-	30.4	-	28.4	-
	2.60	<	<	-	-	-	-	-	<	-	3.50	-
	3.10	3.32	6.71	-	-	-	-	-	51.5	-	6.67	-
40	29.8	-	6.63	-	-	-	-	-	29.8	-	22.2	-
	2.69	<	<	-	-	-	-	-	<	-	2.97	-
	3.18	3.50	6.96	-	-	-	-	-	59.6	-	7.05	-
41	38.5	1.43	6.10	-	-	-	-	-	36.5	-	-	-
	2.53	<	2.14	-	-	-	-	-	<	-	<	-
	2.46	2.69	5.52	-	-	-	-	-	44.1	-	5.60	-
42	47.6	2.51	6.45	-	-	-	-	-	42.4	-	-	-
	4.27	<	<	-	-	-	-	-	<	-	<	-

	3.07	3.16	6.90	-	-	-	-	-	55.9	-	6.58	-
43	47.2	1.57	0.884	-	-	-	-	-	48.9	-	44.7	-
	3.64	<	<	-	-	-	-	-	<	-	4.85	-
	3.08	3.28	6.87	-	-	-	-	-	54.4	-	7.37	-
44	34.1	1.25	5.07	-	-	-	-	-	47.0	-	32.4	-
	2.75	<	<	-	-	-	-	-	<	-	3.73	-
	2.74	3.06	5.99	-	-	-	-	-	50.5	-	6.17	-
45	17.7	1.58	3.28	-	-	-	-	-	106.	-	31.3	-
	1.31	<	<	-	-	-	-	-	25.7	-	4.63	-
	2.89	3.29	6.90	-	-	-	-	-	49.5	-	6.59	-
46	18.4	-	-	-	-	-	-	-	22.7	-	25.2	-
	2.11	<	<	-	-	-	-	-	<	-	3.40	-
	2.41	2.83	5.21	-	-	-	-	-	46.9	-	5.72	-
47	10.6	1.38	-	-	-	-	-	-	70.0	-	32.1	-
	1.23	<	<	-	-	-	-	-	24.1	-	5.36	-
	3.29	3.55	7.52	-	-	-	-	-	66.2	-	7.53	-
48	22.8	3.11	7.37	-	-	-	-	-	39.0	-	21.9	-
	2.86	<	3.05	-	-	-	-	-	<	-	4.87	-
	3.21	3.36	7.19	-	-	-	-	-	55.8	-	7.21	-
49	35.2	-	6.66	-	-	-	-	-	16.4	-	-	-
	3.60	<	<	-	-	-	-	-	<	-	<	-
	3.26	3.62	7.91	-	-	-	-	-	66.2	-	6.07	-
50	56.3	-	5.50	-	-	-	-	-	40.7	-	2.78	-
	2.31	<	<	-	-	-	-	-	<	-	<	-
	3.46	3.76	7.04	-	-	-	-	-	66.1	-	5.95	-
51	22.1	-	4.46	-	-	-	-	-	24.2	-	-	-
	1.68	<	<	-	-	-	-	-	<	-	<	-
	3.41	3.74	7.91	-	-	-	-	-	69.9	-	6.13	-
52	195.	-	7.81	-	-	-	-	-	36.2	-	-	-
	5.23	<	3.16	-	-	-	-	-	<	-	<	-
	3.53	3.75	7.52	-	-	-	-	-	74.2	-	6.10	-
53	34.9	-	4.95	-	-	-	-	-	-	-	0.155	-

	1.92	<	<	-	-	-	-	-	<	-	<	-
	3.15	3.49	7.76	-	-	-	-	-	70.0	-	5.88	-
54	77.6	-	-	-	-	-	-	-	44.8	-	1.59	-
	2.68	<	<	-	-	-	-	-	<	-	<	-
	3.39	3.68	8.30	-	-	-	-	-	73.5	-	6.03	-
55	73.9	2.64	-	-	-	-	-	-	-	-	-	-
	6.38	<	<	-	-	-	-	-	<	-	<	-
	3.74	4.09	8.58	-	-	-	-	-	69.9	-	7.42	-
56	34.0	-	2.56	-	-	-	-	-	-	-	0.745	-
	2.30	<	<	-	-	-	-	-	<	-	<	-
	3.24	3.36	8.03	-	-	-	-	-	58.3	-	6.19	-
57	40.3	1.27	5.41	-	-	-	-	-	-	-	23.8	-
	4.21	<	<	-	-	-	-	-	<	-	0.927	-
	3.37	3.63	7.75	-	-	-	-	-	62.8	-	6.05	-
58	83.1	16.2	26.0 %	-	-	-	-	-	195.	-	1.83 %	-
	1.05	0.178	0.128 %	-	-	-	-	-	30.5	-	714.	-
	3.80	4.22	9.15	-	-	-	-	-	74.6	-	7.56	-
59	27.9	-	5.40	-	-	-	-	-	56.1	-	2.34	-
	2.70	<	<	-	-	-	-	-	<	-	<	-
	3.61	3.88	8.06	-	-	-	-	-	68.0	-	5.86	-
60	24.7	-	6.52	-	-	-	-	-	47.5	-	1.94	-
	2.50	<	<	-	-	-	-	-	<	-	<	-
	2.96	3.51	7.53	-	-	-	-	-	66.6	-	6.16	-
61	29.1	0.342	8.96	-	-	-	-	-	42.4	-	0.504	-
	2.56	<	2.69	-	-	-	-	-	<	-	<	-
	3.30	3.52	7.96	-	-	-	-	-	71.8	-	6.13	-
62	69.0	-	8.13	-	-	-	-	-	18.3	-	-	-
	4.08	<	2.47	-	-	-	-	-	<	-	<	-
	3.25	3.59	7.54	-	-	-	-	-	70.7	-	5.98	-
63	71.0	-	0.891	-	-	-	-	-	-	-	6.88	-
	2.57	<	<	-	-	-	-	-	<	-	2.28	-
	3.32	3.77	7.99	-	-	-	-	-	61.9	-	6.10	-

64	50.9	1.615E-02	3.91	-	-	-	-	-	70.0	-	-	-
	2.17	<	<	-	-	-	-	-	22.9	-	<	-
	3.54	3.67	8.17	-	-	-	-	-	59.0	-	6.10	-
65	33.8	-	4.14	-	-	-	-	-	-	-	-	-
	2.18	<	<	-	-	-	-	-	<	-	<	-
	3.28	3.69	6.91	-	-	-	-	-	66.7	-	6.04	-
66	48.3	-	3.05	-	-	-	-	-	48.4	-	3.68	-
	3.54	<	<	-	-	-	-	-	<	-	<	-
	3.64	4.06	7.69	-	-	-	-	-	71.1	-	6.28	-
67	44.0	1.46	10.4	-	-	-	-	-	-	-	0.850	-
	2.40	<	2.68	-	-	-	-	-	<	-	<	-
	3.20	3.41	7.80	-	-	-	-	-	68.8	-	6.40	-
68	72.2	1.75	-	-	-	-	-	-	30.5	-	-	-
	4.32	<	<	-	-	-	-	-	<	-	<	-
	3.26	3.70	7.45	-	-	-	-	-	75.7	-	6.42	-
69	29.2	-	5.36	-	-	-	-	-	73.2	-	1.13	-
	2.81	<	<	-	-	-	-	-	<	-	<	-
	3.40	3.52	7.56	-	-	-	-	-	74.7	-	6.51	-
70	33.2	2.868E-03	7.44	-	-	-	-	-	-	-	-	-
	2.55	<	<	-	-	-	-	-	<	-	<	-
	3.19	3.43	8.29	-	-	-	-	-	73.9	-	6.19	-
71	47.6	-	6.959E-02	-	-	-	-	-	34.1	-	-	-
	2.82	<	<	-	-	-	-	-	<	-	<	-
	3.44	3.65	8.31	-	-	-	-	-	68.6	-	6.20	-
72	45.2	-	9.59	-	-	-	-	-	74.6	-	1.47	-
	2.69	<	2.63	-	-	-	-	-	25.5	-	<	-
	3.41	3.69	8.13	-	-	-	-	-	60.9	-	6.36	-
73	44.9	-	8.50	-	-	-	-	-	36.3	-	4.21	-
	2.70	<	2.68	-	-	-	-	-	<	-	<	-
	3.40	3.70	7.46	-	-	-	-	-	65.2	-	6.21	-
74	33.4	1.77	-	-	-	-	-	-	-	-	-	-
	2.29	<	<	-	-	-	-	-	<	-	<	-
	3.32	3.56	8.05	-	-	-	-	-	68.8	-	6.23	-

	Zr	Nb	Ag	La\K\	Ce\K\	Sm\K\	Hf	Ta	Ba\K\	Hf\L\	Pb\L\	Ta\L\
75	11.5	3.14	4.06	-	-	-	-	-	87.2	-	1.74	-
	1.18	<	<	-	-	-	-	-	25.8	-	<	-
	2.98	3.20	8.26	-	-	-	-	-	60.4	-	6.07	-
76	121.	-	1.75	-	-	-	-	-	31.6	-	-	-
	8.15	<	<	-	-	-	-	-	<	-	<	-
	3.17	3.43	7.82	-	-	-	-	-	64.7	-	6.37	-
77	46.9	0.955	6.18	-	-	-	-	-	-	-	-	-
	2.16	<	<	-	-	-	-	-	<	-	<	-
	3.06	3.36	7.72	-	-	-	-	-	65.9	-	6.33	-
78	39.5	-	-	-	-	-	-	-	-	-	-	-
	2.72	<	<	-	-	-	-	-	<	-	<	-
	3.55	3.83	7.66	-	-	-	-	-	73.1	-	6.47	-
79	48.3	1.77	4.95	-	-	-	-	-	70.5	-	1.05	-
	3.41	<	<	-	-	-	-	-	<	-	<	-
	3.37	3.74	8.10	-	-	-	-	-	71.6	-	6.54	-
80	51.3	-	7.86	-	-	-	-	-	49.2	-	0.753	-
	2.86	<	2.47	-	-	-	-	-	<	-	<	-
	3.21	3.28	7.70	-	-	-	-	-	73.6	-	6.32	-
81	11.0	-	0.142	-	-	-	-	-	72.5	-	-	-
	2.20	<	<	-	-	-	-	-	22.8	-	<	-
	4.79	5.00	9.00	-	-	-	-	-	60.8	-	7.69	-
82	15.2	-	9.92	-	-	-	-	-	-	-	-	-
	2.11	<	2.71	-	-	-	-	-	<	-	<	-
	4.69	4.75	8.57	-	-	-	-	-	76.4	-	8.46	-
	30.0	8.84	4.97	-	-	-	-	-	47.8	-	11.7	-
	0.269	0.125	0.318	-	-	-	-	-	2.94	-	0.383	-
	0.390	0.426	0.875	-	-	-	-	-	7.14	-	0.813	-
	37.9	1.48	0.317 %	-	-	-	-	-	41.5	-	300.	-
	31.8	2.31	2.87 %	-	-	-	-	-	35.3	-	0.202 %	-
	13.1	2.04	9.963E+03	-	-	-	-	-	1.33	-	584.	-
	Zr	Nb	Ag	La\K\	Ce\K\	Sm\K\	Hf	Ta	Ba\K\	Hf\L\	Pb\L\	Ta\L\

n/a **not available (i.e. not fitted, or not in yield list)**

	A	B	C	D	E
1	**Kimberlite name**	**Location with respect to craton**	**Average grade (in carots per 100 tonnes)**	**Grade estimate using major elements**	**Grade estimate using Nickel-geothermometer**
2					
3	Roberts Victor	On craton	41	Uneconomic	Uneconomic
4	Koffiefontein	On craton	10	Medium	Medium
5	Rietfontein	Edge of craton	Zero	Medium-High	Uneconomic
6	Nouzee	Off craton	Zero	Uneconomic	Medium-high
7	Mothae	Edge of craton	2	Uneconomic	Uneconomic
8	Orapa	On craton	69	High	No data available as all garnets are eclogitic
9	Zarnitsa	On craton	100-150	low/uneconomic	High
10	Leningradskaya	On craton	100-150	Uneconomic	High
11	Udachnaya	On craton	100-150	High	High
12					
13					
14			**Please note: one carot = 0.2 grams**		
15					
16					