REPORT: Minor & Major Element Discrimination of Legend Cr-Spinels

Introduction

In order to improve the discrimination of diamond indicator Cr-Spinel from Cr-Spinel of crustal magmatic origin high precision microprobe analyses were conducted at RSES, ANU, Canberra.

Beam conditions for the analyses were set at 100nA specimen current and 15kV accelerating voltage. Old carbon-coats were removed and the mounts re-coated. However, despite cleaning and recoating, good totals for the oxides could not be achieved in some cases, although the cation totals are acceptable. Poor totals are due to grain alteration and weathering causing pitting and cracking and hence poor surface quality. Analyses of the New Caledonian Cr-spinel standard are acceptable. The detection limits and analytical precision (based on 37 analyses of the New Caledonian standard) for the minor elements are given in Table 1. Analytical precision for the key discriminating elements Ti and V is particularly good. A number of grains (17) were not analysed because of difficulties in locating them on the grain mounts; these analyses will be repeated at a later date. A total of 191 Cr-spinel analyses are reported on here.

Table 1. Minor element precision and detection limits

	detection limit	standard average	1sd	%precision
Al(ppm)	150	51759	892	1.7
Si(ppm)	110	344	114	33.1
Ni(ppm)	110	1509	212	14.0
Zn(ppm)	190	560	354	63.2
Ca(ppm)	70	108	46	42.6
Ti(ppm)	60	749	69	9.2
V(ppm)	65	639	58	9.1
Mn(ppm)	150	650	383	58.9

Grain Assessment

Detailed discrimination assessments have been made for each composition using a variety of discrimination methods. Grain scores between 0 and 6 have been assigned (4 to 6 = high-scoring indicator; 1 to 3 = low-scoring indicator; 0 = crustal grain, no interest). This treatment, based on both major and minor elements, gives a much higher level of confidence in assigning a grain provenance compared to using only major elements from SEM analyses. In general around 20 to 50% of grains from sample areas have been reassigned (upgraded or downgraded) compared to the SEM analyses of the same grains. Where results of minor element microprobe analyses are unavailable, particularly for samples processed in November-December 2009, interpretation of SEM data has been considered below and plotted on the summary maps in conjunction with the minor element data. The SEM data is of lesser quality and therefore the interpretation is less robust.

A number of categories, listed in Table 2, have been assigned using the minor element data. Particular attention has been paid to identification of grains having a metamorphic overprint (i.e. Zn and/or Mn plus Fe enriched compositions). Approx. 50% of the analysed grains have a metamorphic overprint consistent with having experienced greenschist facies metamorphic conditions. Most of these grains are likely to have been derived from mafic/ultramafic units within the McArthur Basin basement (or Mt Isa basement for the Barr Creek project). It should be noted that about 10% of the analysed grains from the McArthur Basin area are indicator compositions with a Zn and/or Mn overprint. The majority of these grains would have acquired their overprint during regional metamorphism , although overprints can develop, rarely, by hydrothermal processes in a kimberlite pipe. The occurrence of such indicators suggest the presence of older Proterozoic age kimberlites in the area. This is consistent with the occurrence of significant diamond populations with brown (i.e. annealed at >400^{o}C) radiation spots known from some alluvial sites such as Wilkinson Creek. Proterozoic age kimberlites are, however, likely to be eroded and difficult to find particularly if indicator minerals have been recycled into and are now being dispersed from secondary sedimentary rock sources. Such older kimberlites must therefore represent targets of lower priority compared to Merlin "look-a-like" targets. Unequivocal overprinted indicators have not yet been found at the Barr Creek prospect (Queensland).

Grains of most interest belong to the "Indicator-HS" and "Indicator-LS" categories (see Table 2). Results for each project area are discussed in detail below. Some data from Merlin area historical samples has been included in the summary maps.

Table 2. Grain Assessment Categories based on Minor Elements

Category	Description	Grain Count	%
Indicator-?	possible indicator	8	4.2
Indicator-?OP	possible indicator with metamorphic overprint	16	8.4
Indicator-HS	high-scoring indicator (4 to 6)	14	7.3
Indicator-HSOP	high-scoring indicator (4 to 6) with metamorphic overprint	5	2.6
Indicator-LS	low-scoring indicator (1 to 3)	15	7.9
Indicator-LSOP	low-scoring indicator (1 to 3) with metamorphic overprint	13	6.8
Magmatic	crustal magmatic origin	59	30.9
Metamorphic	crustal magmatic origin with metamorphic overprint	21	11
Ophiolitic	ophiolite origin	20	10.5
Unclass	unclassified	11	5.8
Unclass-OP	unclassified with metamorphic overprint	8	4.2
Unresolved-OP	unresolved grain with metamorphic overprint due to chemical-morphological mismatch	1	0.5
Total		191	100

Note the Cr-spinel compositional types in the following discussion: MC = magnesiochromite; MAC = magnesian aluminous chromite; TMAC =titaniferous magnesian aluminous chromite, TMC = titaniferous magnesiochromite; CH = chromite; TCH = titaniferous chromite.

1. Abner South Results

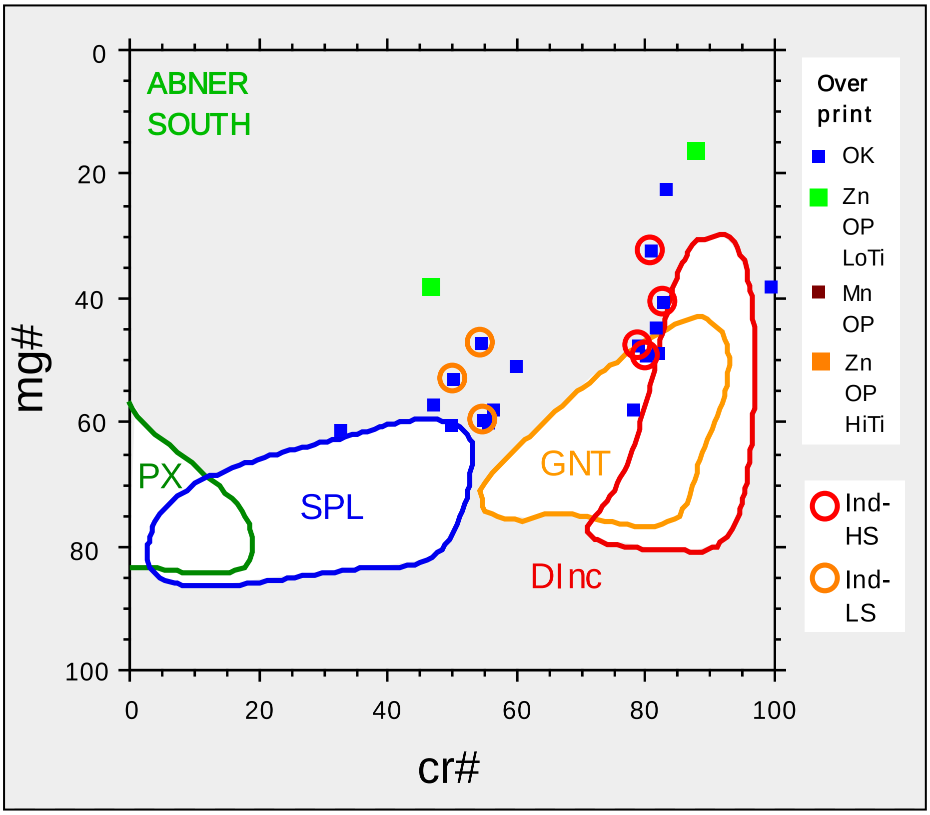

Fig.1.1 Most of the grains show Fe-enrichment trends, however, only two grains are Zn overprinted.

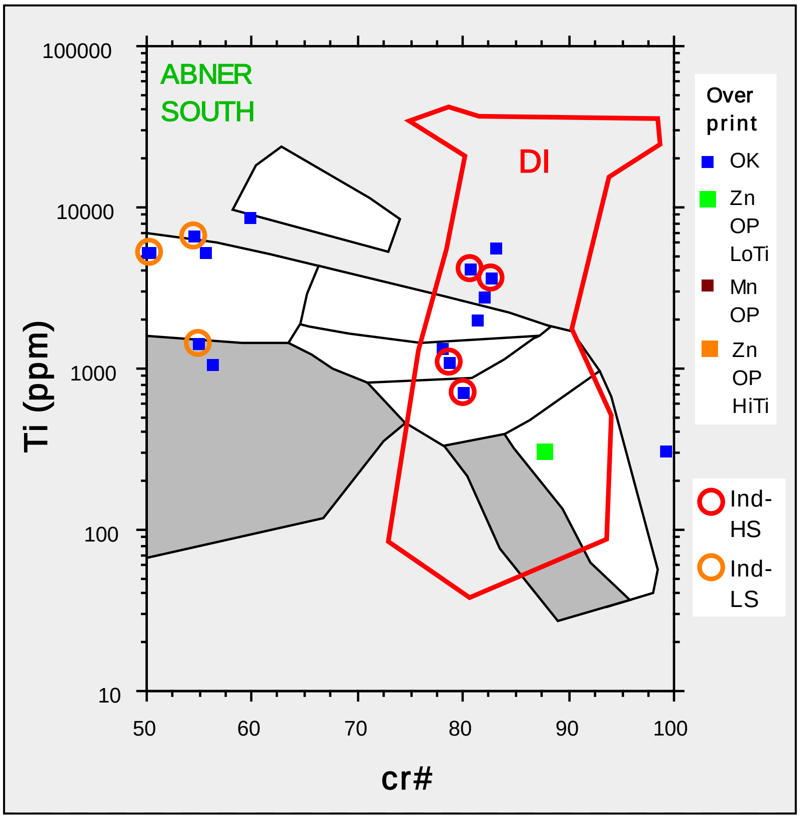

Fig.2.1 The vertical trends within the DI field are consistent with a dominance of indicator compositions.

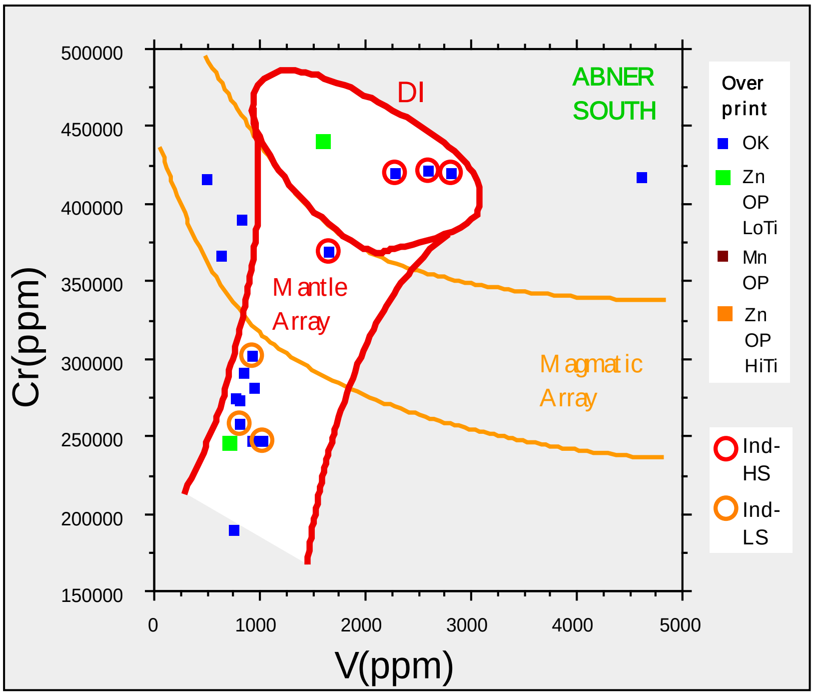

Fig.3.1 Three Indicator-HS compositions plot within the DI field (MC grains from ABS23 and 24). Many of the other grains plot within the mantle array, however, some of these have high Ni-Zn-Mn temperatures (>1250 °C) so have not been flagged as indicators.

Abner South Cr-Spinel Types

	Total Count	CH Count	MAC Count	MC Count	TAC Count	TMAC Count
Indicator-?	3	1	1	1	0	0
Indicator-HS	4	1	0	3	0	0
Indicator-LS	3	0	2	0	0	1
Indicator-LSOP	1	0	0	0	1	0
Magmatic	6	0	4	2	0	0
Ophiolitic	1	1	0	0	0	0
Unclass	2	1	0	0	0	1
Total	20	4	7	6	1	2

Table.1.1 Summary: Approx. 50% of grains are from mantle sources; there are four high-score indicators and three low-score indicators. Only one grain is titaniferous (a TMAC from sample ABS23).

Abner South Indicators

	Total Count	ABR024 Count	ABS149 Count	ABS22 Count	ABS23 Count
Indicator-HS	4	1	0	1	2
Indicator-LS	3	1	1	0	1
Total	7	2	1	1	3

Table.2.1

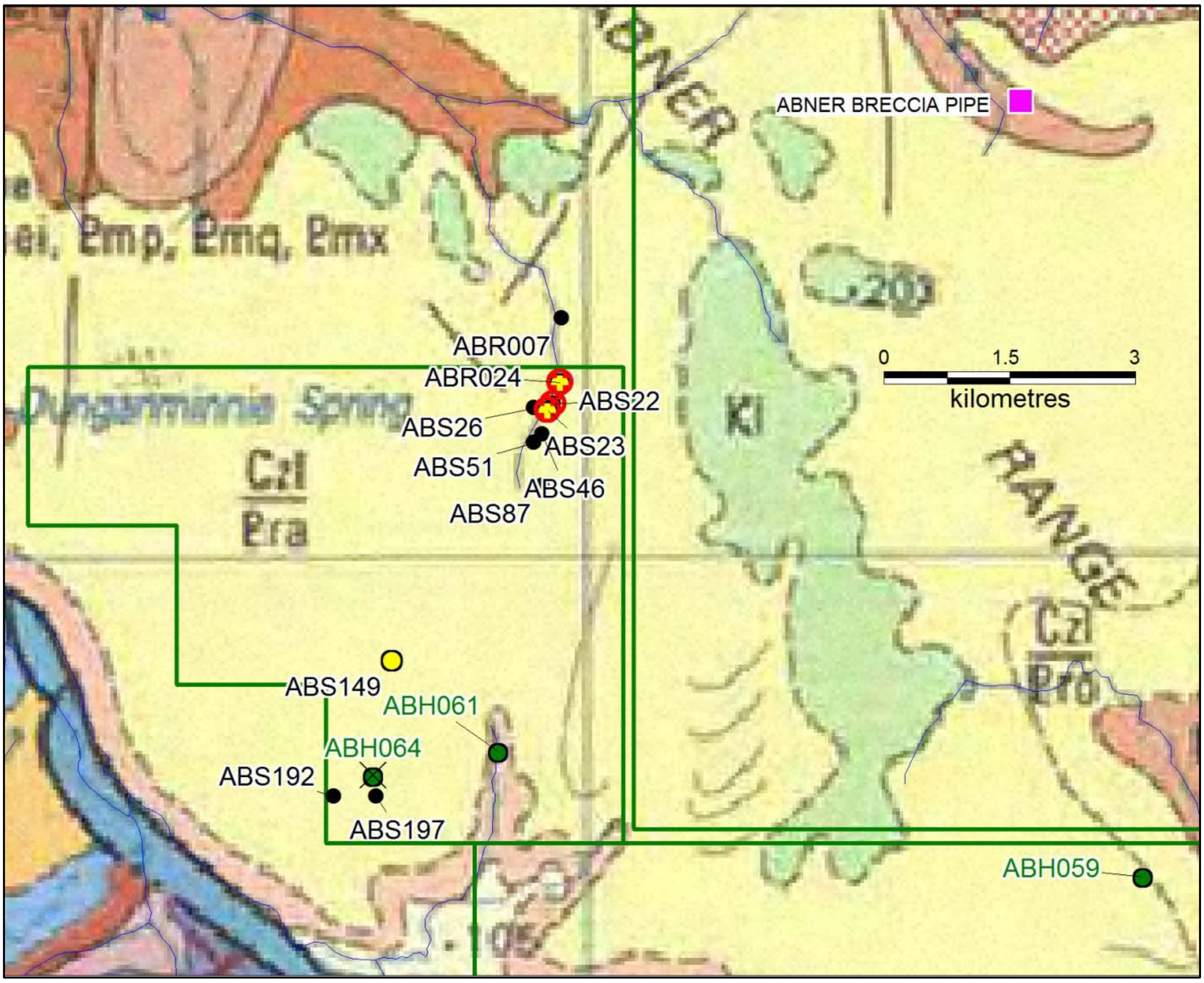

Fig.4.1 Red dots with cross= Indicator-HS; yellow-dots or internal cross = Indicator-LS; black dots = sample point without Cr-spinel of interest; green dots= sample points where only SEM analytical data is available. Black cross = unresolved grain. KI = Cretaceous sediment outcrop.

<u>Recommended Priority Follow-up samples/areas:</u> ABR024 (one 4-score CH, one 3-score MAC), ABS22 (one 5-score MC), ABS23 (one 6-score MC, one 5-score MC, one 3-score TMAC), ABS149 (one 3-score MAC). Traditional follow-up would be a grid loaming exercise for indicator recovery.

<u>Potential Problems</u>: The erosion of Cretaceous sediments (KI) containing recycled Abner breccia pipe grains could disperse indicators into the adjacent drainages. The nearest Cretaceous outcrop is located approx. 1.5 km east of the main positive sample sites. This possibility could be tested by sampling the creek that drains north across the KI outcrop.

6. Abner North Results

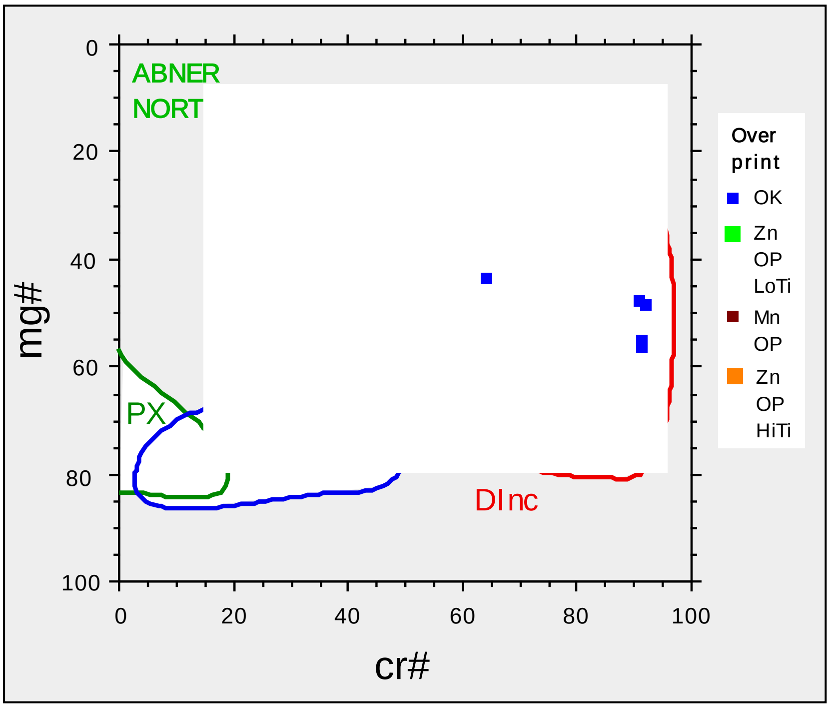

Fig.1.6 Four grains appear to be DI TMC compositions. There are no metamorphic overprints.

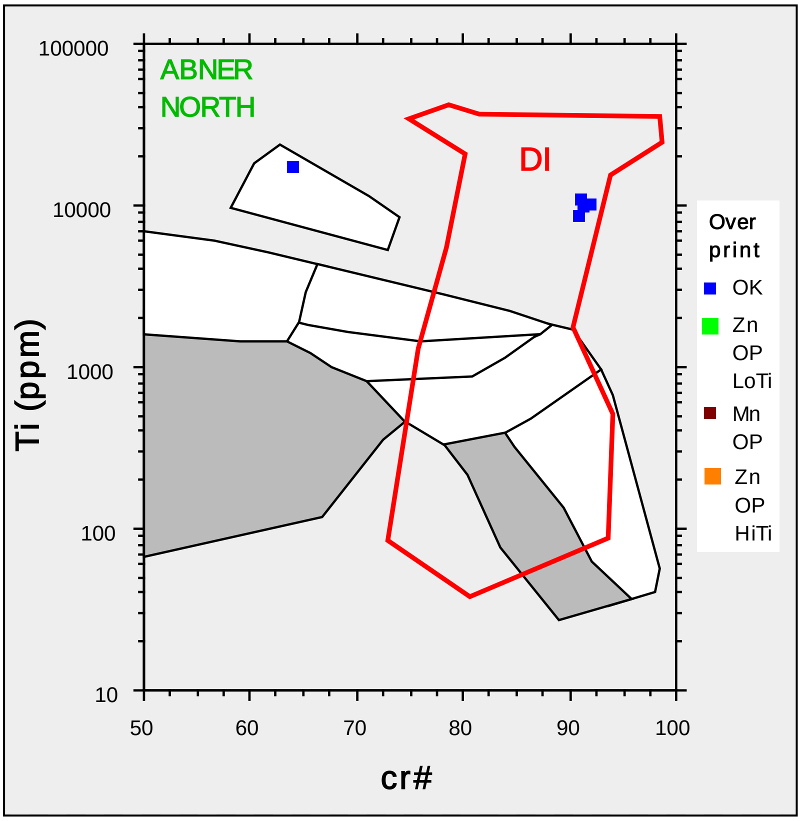

Fig.2.6 One grain (upper left hand side) is consistent with derivation from an alkali basalt (this agrees with laboratory morphology assessment).

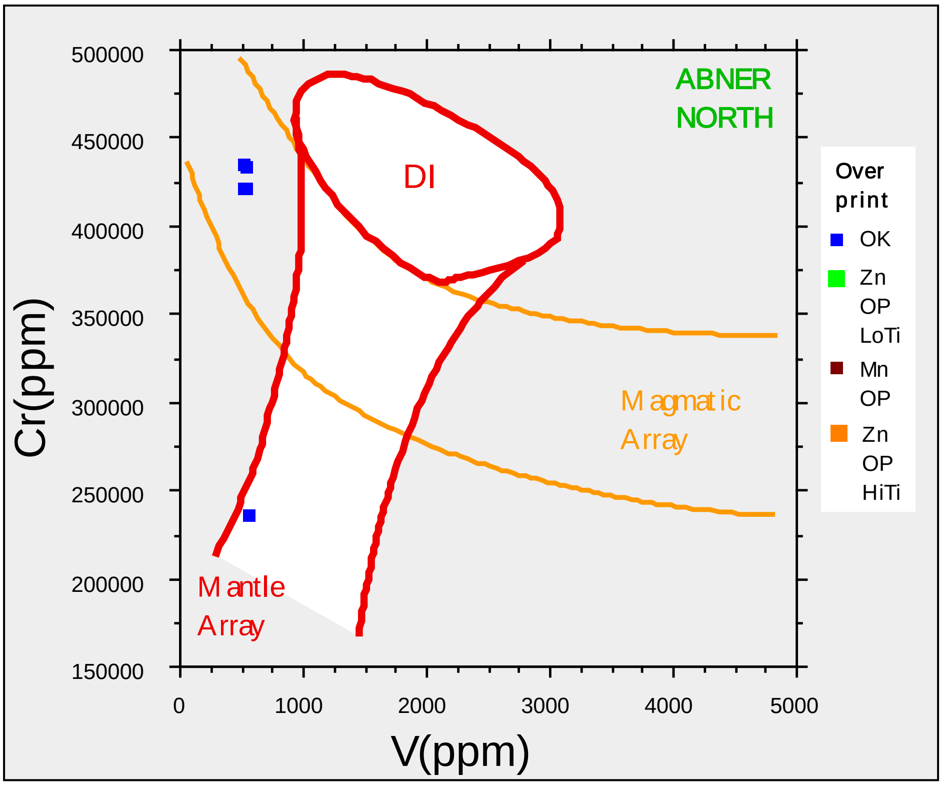

Fig.3.6 The TMC grains have low V contents and plot on the magmatic array unlike any known diamond indicators. This result is unusual for TMC composition grains.

Abner North Cr-Spinel Type

	Total Count	TMC Count
Unclass	5	5
Total	5	5

Table.1.6

<u>Recommended Follow-up samples/areas:</u> Further investigations are required to establish the provenance of these TMC grains. At this stage they appear to be related to alkali basalts rather than kimberlite. But the occurrence and chemistry is unusual.