DISTRIBUTION OF LAMPROITE PATHFINDERS IN SURFACE SOILS.

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INTRODUCTION

Using data from orientation surveys carried out in the monsoonal Kimberley Region of Western Australia at certain known lamproite localities (Fig.1), the limitations and potential of loam, anthill and geochemical sampling in diamond exploration are considered. Lamproites referred to occur in flat geomorphic settings and are described in detail in Jaques *et al.* (1986). From this limited study, some general conclusions about sampling surface materials can be drawn, but expanded surveys are needed to obtain a thorough understanding of the distribution of diamond pathfinders in the surface environment and establish sound guidelines for exploration practice.

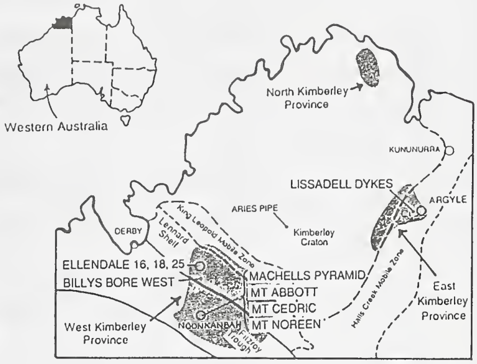

FIGURE 1 Location of Lamproites

ENVIRONMENTAL VARIABLES

In order to assess the effectiveness of loam and geochemical sampling, various agents that control the environment containing primary host rocks of diamond must be considered. Some of these factors may assist the survival and distribution of kimberlitic (i.e. any potentially diamond-bearing) material at the surface, whilst others have the opposite effect. In general, if degradation is occurring in the host terrain, a kimberlitic body is likely to be disintegrating and shedding debris into the overlying soil and local drainage. If aggradation is taking place, accumulation of alluvium may bury the body in such a fashion as to substantially reduce its surface expression. When burial is relatively rapid and/ or particularly deep the kimberlitic intrusive may be totally masked with scant mineralogical or geochemical expression in the upper soil horizon. Ant activity may, in certain cases, assist in maintaining detectable geological indicators at surface levels.

METHODS

Samples were collected from soil or anthills over lamproite bodies and at varying distances from their perimeters along traverse lines.

LOAM SAMPLES

The uppermost 1 cm of top-soil was collected for loam samples; where gravel debris was present samples were screened at 2 mm. The size of samples collected varied. Therefore, for comparative purposes, loam sample results in Table 1 have been standardized to "number of indicators per kg of sample screened at minus 2 mm". Where practical, samples were taken at sites with the minimum of obvious disturbance from prior exploratory excavation which may have unnaturally increased the indicator content at surface. Loam samples were reduced to their heavy mineral component by Wilfley Table, heavy liquid and magnetic separation treatment and then examined for kimberlite/ lamproite indicator mineral content.

ANTHILL SAMPLES

The largest available anthill was selected, assuming a relationship between size and depth of ant excavation. The uppermost, latest built part of the anthill was sampled, as well as some anthill "scree" around its base. Anthill samples were processed in the same manner as for loam samples.

GEOCHEMICAL SAMPLES

Geochemical analysis was performed on material from many of the loam sample sites (Table 1). Samples were analysed for a range of elements associated with lamproites and kimberlites, including incompatible elements and those of ultramafic affinity. Two samples from the Ellendale area were collected to assess the geochemical background.

RESULTS

Heavy mineral and geochemical analysis results are given in Table 1.

HEAVY MINERAL RESULTS

The dominant indicator minerals are chromite and phlogopite, the former having the most frequent occurrence in samples, i.e. the best overall dispersion. Pyrope occurs in some samples from Ellendale No.18, Mount Abbott, Mount Noreen and Mount Cedric. Some samples from Mount Noreen contain potassic richterite, lamproitic diopside and chrome diopside, the latter also occurring in a sample from Mount Abbott.

Where the 0.3-0.4mm size range was analysed in addition to the 0.4-2mm size, the recovery of indicator minerals is at least doubled in all cases where more than one indicator grain is present in the coarser fraction.

Ellendale No.25, with a sandy overburden of 7m, yielded no indicators in either loam or anthill sample. Ellendale No.18, under 6m overburden, yielded some chromite in both samples, but pyrope only in the anthill sample. By comparison to the loam sample, a relatively small proportion of phlogopite is present in the anthill sample from Ellendale No.16, though the chromite content is similar. At Billys Bore West the ants' haul of phlogopite is similarly low by comparison to the loam sample.

Mount Abbott, Mount Noreen and Mount Cedric yielded significant proportions of indicator minerals in central and peripheral zones over the bodies, with a rapid, steady tailing off of indicator content away from the margins. At Mount Noreen, however, there is a sudden increase in indicator levels 250m south of its margin, possibly due to a local concentrating effect or an underlying, undiscovered lamproite body.

Samples from Machells Pyramid and Lissadell Road Dykes yielded only trace quantities of indicators. A further 3 chromites were obtained from one Lissadell sample by examining the 0.1-0.3mm size range.

GEOCHEMISTRY RESULTS

Most lamproites in this study show anomalous Mg, P, Ti, Ni, Sr, Zr, Ba and La in the overlying or nearby soils. Elements K, Ca, Cu, Zn, Rb, Nb, Ce and Nd are anomalous at or near some bodies. Values of several times background are obtained for some samples. Li, Co, Sc, V, Cr, Y, Mo and Th give rare or more subtle variance from background. The dispersion halo of anomalous elements around the lamproites sampled is in no case extensive, distances from the periphery not exceeding the breadth of the body, in agreement with findings of Haebig & Jackson (1986). At Mount Noreen, anomalous values for most elements occur around 250m south of the known intrusion, at a point where indicator levels are also exceptionally high. As the extent of dispersion appears abnormal, the case for a concealed lamproite here is considerably strengthened.

DISCUSSION AND CONCLUSIONS

Remote sensing and geophysical techniques have serious limitations in that anomalous responses are unqualified. Additionally, the most broadly applied of these methods, magnetics, is relatively insensitive to pyroclastic phases and, when the host environment is strongly magnetic, to kimberlitic rocks in general. Some *conclusive* indication at surface of the presence of a concealed kimberlitic body is extremely important when prospecting for diamonds. Sampling of surface soils is thus a valuable prospecting tool. For optimum results, however, it must be applied with discrimination and sound understanding of environmental influences.

This limited survey has the following implications, which need substantiation by further investigations:-

1. Indicator mineral yield is increased significantly by examining the grain size range below 0.4mm.
2. Dispersion halos, even for large exposed bodies, and especially where overburden masks the intrusion, may extend only a few hundred metres beyond the margin. Therefore, when planning loam and geochemical sampling programmes, careful consideration should be given to choosing the appropriate sampling interval.
3. Anthill samples, in this study, did not yield higher quantities of indicators than loam samples. Total reliance on anthill samples alone is therefore inadvisable. Ants appear to selectively excavate certain minerals. This may be useful in certain cases and requires investigation.
4. Geochemical analysis of a broad selection of elements should increase the chance of detecting a concealed diamond host rock.

Particular indicators known to survive well in the soil horizon may be relatively uncommon in the host rock. Possible variations in source mineralogy that will have a bearing on the types and concentrations of indicators in associated soils should be considered when planning exploration surveys and assessing loam and geochemical results.

Correct selection of the type, size, spacing and treatment of surface samples for diamond exploration depends upon an understanding of the distribution of diamond pathfinders in regolith. Detailed, broad-based studies involving all known diamond lithologies and a variety of environmental settings are needed to determine reliable sampling methods for diamond exploration.

REFERENCES

Haebig, A.E., and Jackson, D.G. (1986) Geochemical expression of some West Australian kimberlites and lamproites. Fourth International Kimberlite Conference, Perth, Extended Abstracts Volume, Geological Society of Australia 16, 466-468.

Jaques, A.L., Lewis J.D., and Smith, C.B. (1986) The kimberlitic and lamproitic rocks of Western Australia. Bulletin of the Geological Survey of Western Australia 132, 268p.

TABLE 1 Loam and Geochemical Sample Results from Certain Lamproites from the Kimberley Region, Western Australia

LAMPROITE BODY	SAMPLE	WT-2	Chromites	Phlogopites	Other Minerals	Indicators / kg
ELLENDALE NO.18						
Olivine Lamproite 25.7ha	E18 centre	22.00	(26) 9	(0) 0		(1.59) 0.41
(6m sandy overburden)	E18 centre anthill	20.00	(20) 11	(0) 0	(2)+7 Py	(2.00) 0.90
ELLENDALE NO.25						
Leucite Lamproite 11.2ha	E25 centre	25.00	(0) 0	(0) 0		(0.00) 0.00
(7m sandy overburden)	E25 centre anthill	20.00	(0) 0	(0) 0		(0.00) 0.00
	E16 centre	21.00	(6) 23	(100) 50 *	* Estimated distribution	(8.52) 3.48
ELLENDALE NO.16	E16 centre anthill	23.00	(26) 15	(33) 17 *	* Estimated distribution	(3.96) 1.39
Olivine Lamproite 16.9ha	E16 centre	0.80	(?) 0	(?) 1		(?) 1.25
(3.5m sandy overburden)	E16 periphery N	0.90	(?) 0	(?) 0		(?) 0.00
	E16 outside 350 m	0.80	(?) 0	(?) 0		(?) 0.00
Soil from	Background (a)					
Ellendale area	Background (b)					
BILLYS BORE WEST						
Leucite Lamproite 1.6ha	BB centre	45.00	(4) 14	(200) 120		(7.51) 2.98
(Shallow overburden)	BB centre anthill	25.00	(1) 0	(30) 0		(1.24) 0.00
MOUNT ABBOTT	MA inside SE	2.80	(64) 20	(2) 0	(2) Py	(31.43) 7.14
Olivine Lamproite ~90a	MA inside SW	2.90	(Ab) 1776	(0) 0	(1)+3 Py; 2 CD	(>>615.00) 614.48
(Some surface exposure)	MA outside 300m E	3.30	(6) 5	(0) 0		(3.33) 1.52
	MN outside 45m N	3.20	(200) 53	(3) 0	(1) CD	(80.31) 16.56
	MN periphery N	2.80	(300) 175	(3) 2	(1) Py; (3) K-R; (21)+8 LD	(183.21) 66.07
MOUNT NOREEN	MN centre N	2.90	(Ab) 325	(11) 5	2 Py; (Ab) LD	(>>115.00) 114.48
Leucite / Olivine Lamproite	MN centre S	3.40	(Ab) 247	(Ab) 11	1 Py; (Ab)+6 LD	(>>78.00) 77.94
6.3ha	MN periphery S	2.90	(Few) 31	(0) 0	1 Py; (3) K-R; (2) LD	(>130.00) 11.03
(Shallow overburden;	MN outside 45m S	2.70	(3) 2	(0) 0		(1.85) 0.74
minor surface exposure)	MN outside 90m S	2.70	(0) 1	(0) 0		(0.37) 0.37
	MN outside 135m S	2.30	(3) 5	(0) 0	(2)+1 K-R	(4.78) 2.61
	MN outside 180m S	2.40	(3) 0	(0) 0		(1.25) 0.00
	MN outside 255m S	2.40	(120) 91	(10) 3	(7)+2 LD	(97.08) 40.00
	MC periphery S	2.60	(?) 20	(?) 0		(?) 7.69
	MC outside 30m S	3.30	(?) 10	(?) 0		(?) 3.03
	MC outside 60m S	3.20	(?) 24	(?) 0	2 Py	(?) 8.13
MOUNT CEDRIC	MC outside 90m S	3.30	(?) 9	(?) 0	2 Py	(?) 3.33
Leucite Lamproite 16.9ha	MC outside 120m S	3.30	(?) 8	(?) 0		(?) 2.42
(Protruding complex)	MC outside 150m S	2.50	(?) 4	(?) 0		(?) 1.60
	MC outside 180m S	2.40	(?) 1	(?) 0		(?) 0.42
	MC outside 210m S	2.80	(?) 1	(?) 0		(?) 0.36
	MC outside 240-330m S	1.25	(?) 0	(?) 0		(?) 0.00
MACHELLS PYRAMID	MP periphery E	0.51	(?) 1	(?) 0		(?) 1.96
Leucite Lamproite ~9ha	MP outside 90-180m E	0.67	(?) 0	(?) 0		(?) 0.00
(Protruding plug)	MP outside 210-270m E	0.52	(?) 0	(?) 0		(?) 0.00
	MP outside 300-360m E	0.53	(?) 1	(?) 0		(?) 1.89
LISSADELL RD DYKES	LD 1 trench	27.00	(0) 0	(0) 0		(0.00) 0.00
Olivine Lamproite	LD 2 nearby anthill	12.00	(1) 1	(0) 0	relatively high tourmaline	(0.16) 0.08
Few mm to 1-3m wide	LD 2 trench	25.00	(3) 0	(2) 0	3 chromite in 0.1-0.3 mm	(0.20) 0.00
(Slight surface exposure)	LD 3 trench	47.00	(1) 0	(0) 0		(0.02) 0.00

SAMPLE	TiO_2	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Ba	Li	Rb	Sr	Pb	Th	U	Zr	Nb	Y	La	Ce	Nd	Sc	V	Cr	Ni	Co	Cu	Zn	Mo	As	S	F	Cl	
	30	*20*	*20*	*70*	*70*	*600*	*200*	*5*	*2*	*5*	*1*	*5*	*10*	*1*	*5*	*10*	*1*	*5*	*15*	*20*	*1*	*2*	*10*	*10*	*5*	*5*	*5*	*20*	*2*	*50*	*15*	*20*	
E16 centre	5520	244	1300	2210	547	5260	1180	691	9	51	55	9	<10	<1	114	13	10	31	55	22	4	89	550	54	10	28	25	42	<2	<50	115	<20	#
E16 periphery N	5670	242	1020	2310	574	5600	723	515	8	43	46		<10		131	11	8	29	51	20	3	24	219	22	6	9	12	<20					
E16 outside 350 m	4520	210	792	1720	537	4000	586	405	8	29	41		<10		107	<10	9	19	36	<20	4	23	230	15	6	7	10	<20					
Background (a)	1840	152	441	663	204	1970	360	104	6	19	12	5	<10	<1	44	<10	6	11	25	<20	2	44	176	20	8	9	9	20	2	<50	49	23	#
Background (b)	2880	183	586	842	343	3230	272	119	9	28	16	5	<10	1	62	<10	9	16	31	<20	4	43	196	19	7	10	11	<20	2	<50	58	46	#
MA inside SE	8100	265	,1930	1030	1440	25100	322	554	11	78	54		14		215	12	17	44	82	35	5	69	160	21	<5	11	15	<20					
MA inside SW	11300	501	39500	22900	1470	36400	1440	2480	23	124	218		<10		236	32	10	68	112	40	6	79	269	211	19	24	34	<20					
MA outside 300m E	7660	360	2730	1630	1850	28900	306	562	11	84	62		16		245	10	22	57	108	47	6	62	143	12	<5	12	23	<20					
MN outside 45m N	12900	369	2970	1510	1700	36100	744	1130	10	91	70		32		296	14	24	96	183	80	6	50	210	27	6	11	24	<20					
MN periphery N	12800	306	11500	4510	1420	26800	902	1600	11	92	128		12		228	24	12	64	115	45	5	52	329	79	8	12	23	<20					
MN centre N	11400	333	11110	4380	1300	23000	989	1320	11	100	134	13	11	<1	203	22	11	53	95	37	3	46	330	83	10	17	29	<20	7	180	310	69	#
MN centre S	7030	248	4540	2170	1240	21100	697	783	11	77	83		<10		158	13	10	35	64	25	4	37	344	43	6	9	18	<20					
MN periphery S	5130	227	2510	1510	1190	17900	530	523	11	69	66		<10		106	11	9	24	45	<20	4	31	218	27	5	9	18	<20					
MN outside 45m S	6750	374	2970	1460	1570	19200	550	541	14	79	57		<10		146	12	13	33	66	27	6	46	200	30	9	11	21	<20					
MN outside 90m S	6870	354	2650	1080	1630	18800	276	480	20	77	52		<10		134	<10	14	35	67	28	7	53	168	22	8	10	18	<20					
MN outside 135m S	6440	251	2260	1090	1470	17600	329	468	14	77	50		<10		122	<10	11	28	55	22	5	43	181	16	5	10	18	<20					
MN outside 180m S	7800	349	3410	1300	1610	18700	286	466	22	85	57		<10		139	<10	15	33	63	27	8	61	126	15	7	11	19	<20					
MN outside 255m S	18400	458	25200	12900	1460	35800	1290	2140	26	136	195		13		395	46	18	110	178	70	10	97	264	225	19	29	34	<20					
MC periphery S	12200	330	3110	1240	1080	18900	599	747	15	72	64		21		276	15	21	73	138	59	6	74	167	27	5	12	18	<20					
MC outside 60m S	4610	175	1820	935	1030	15500	706	487	11	63	42	8	<10	2	92	<10	7	23	46	<20	3	68	146	27	8	7	17	<20	6	<50	99	23	#
MC outside 180m S	6890	563	4016	2400	1170	18800	592	501	23	86	47		<10		147	11	16	36	73	31	8	97	199	21	16	17	31	<20					
MC outside 240-330m S	5080	271	2110	1380	992	15600	408	386	14	68	43		<10		114	<10	11	24	50	20	5	88	175	26	8	12	19	<20					
MP periphery E	11900	257	3220	1560	1470	22000	546	938	9	71	75		12		275	15	17	49	90	37	5	69	225	35	<5	13	19	<20					
MP outside 90-180m E	6110	295	2180	1290	1830	22100	269	641	16	85	63		<10		139	<10	14	29	56	23	6	50	261	12	5	16	24	<20					
MP outside 210-270m E	7090	285	2340	1090	1750	22200	219	601	20	88	59		<10		145	11	15	34	66	28	7	52	215	16	7	17	24	<20					
MP outside 300-360m E	7660	439	2350	907	1350	21000	325	537	18	81	57		<10		154	10	17	37	75	31	7	50	163	13	9	18	25	<20					

KEY

Sample: Relation of sample site to lamproite body is indicated by centre = central position over body, periphery = marginal position over body or just outside, outside "x"m N,S etc. = "x"m in a north, south etc. direction away from the periphery of the body

WT-2: Weight of untreated minus 2mm sample.

Chromites, Phlogopites, Other Minerals, Indicators / kg: Within brackets = number of grains in 0.3-0.4mm size range; without brackets = number of grains in 0.4-2.0mm size range; Ab = abundant. Samples treated at Triad Minerals Laboratory, Perth, Western Australia.

Other Minerals: Py = pyrope garnet; CD = chrome diopside; LD = lamproitic diopside; K-R = potassic richterite

Indicators / kg: Proportion of combined indicator totals per kg of sample

Element columns: Small italicised number below each element or oxide symbol is the detection limit in ppm; assays tabled are in ppm. Determination was as follows (precision ±10% unless otherwise stated): Cl by precise titration instrumentation, precision ±5%; F by specific ion electrode analysis; S by Leco furnace analysis, accuracy ±10%; Ag, Ga, Pb, Rb, As, Sn by atomic absorbtion spectrophotometry (precision ±15% for As & Sn); U by fluorimetry; the remainder by inductively coupled plasma emission spectroscopy. Assays extremely high or low relative to background and/or overall traverse values are emboldened. # Ag, Ga, Sn below limit of detection. Samples treated at Resource Development Laboratories, Perth, Western Australia.