AN INTEGRATED EXPLORATION CASE HISTORY FOR DIAMONDS, HARDY LAKE PROJECT, NWT

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INTRODUCTION

The Hardy Lake property lies near the geographic center of the Slave Geological Province (SGP) of the Northwestern Canadian Shield (Figure 1) in the Northwest Territories (NWT). The SGP is a stable Archean craton that contains some of the oldest rocks in the world, and possibly a deep lithospheric keel (Anderson *et al.*, 1992). The SGP is therefore an ideal structural setting for the location of diamondiferous kimberlite pipes.

The area is covered by glacial deposits. In a glacial environment, the exposed kimberlite bedrock is eroded by the movement of basal ice. The kimberlite minerals then form a small contribution to the local glacial deposits. The dispersion of these mineral grains down-ice from a single kimberlite may be from a few hundred metres up to several tens of kilometres. A typical cluster of kimberlites may extend over several tens of kilometres and indicator minerals may be detected a few hundreds of kilometres from the source.

Exploration for kimberlites in a glaciated terrain involves the recovery of kimberlitic indicator minerals (pyrope garnets, ilmenite, spinel and chrome diopside) from surficial sediments (Muggeridge, 1995). Diamonds and olivine are other possible pathfinder minerals and trace element geochemical surveys can be used but are frequently less effective. The sediment sampling will identify kimberlite clusters at the reconnaissance stage and dispersion trains from individual kimberlites after detailed sampling. Chemical analysis of the mineral grains can be used to determine the diamond potential of the source kimberlite.

Geophysics has been widely used to identify and quantify kimberlite bodies and several reviews have been published (e.g., Gerryts, 1970; Kamara, 1981; Macnae, 1979, 1995). Airborne magnetic and airborne electromagnetic (EM) surveys are the most common reconnaissance methods (Reed and Sinclair, 1991; Smith *et al.*, 1995; Aerodat, 1993; Macnae, 1979; and Buckle, 1993). Ground magnetic, electromagnetic (time domain, and frequency domain) and gravimetric surveys are typically used in detailed investigations.

A combination of sediment sampling, mineral geochemistry and geophysics is generally more effective in locating kimberlites in a glaciated terrain than any one technique. This paper provides details of the integrated use of these techniques during prospecting of the Hardy Lake area for diamondiferous kimberlites.

THE HARDY LAKE PROPERTY

The property is centered on Hardy Lake which is located approximately 350 km north-northeast of Yellowknife in the barrenlands of NWT. The area is remote and is covered by many shallow lakes. Access is by fixed wing aircraft, helicopter, or winter road.

Bedrock geology

The SGP is a late Archean granite-greenstone terrane in which predominantly metasedimentary supracrustal rocks, assigned to the Yellowknife Supergroup, occupy approximately half of the surface area (Fyson and Helmsteadt, 1988). An east-west trending supracrustal belt straddles the Hardy Lake area; it is composed of greywacke, sandstone and phyllite. Quartz diorite crops out north of the belt, and granite and quartz monzonite with associated pegmatite dykes occur to the south (Lord and Barnes, 1954). Four swarms of Proterozoic diabase dykes are recognized: the dominant north-northwest trending Mackenzie swarm (1.27 Ga); the northerly trending Lac de Gras swarm (2.02 Ga); the east trending MacKay dykes (2.21 Ga); and the northeast trending Malley dykes (2.23 Ga) (LeCheminant and van Breeman, 1994).

Surficial geology

The surficial geology of the SGP has been primarily influenced by the Keewatin sector of the Laurentide Ice Sheet (Shilts and Aylsworth, 1989).

Till is the most extensive glacial deposit in the Hardy Lake area and only one stratigraphic unit has been recognized. The till consists of a matrix-supported diamicton, with the matrix ranging from a silty-sand to sand (Dredge *et al.*, 1994a). Till derived from the granitoid rocks is sandier than that derived from the Yellowknife Supergroup. Glaciofluvial deposits in the form of eskers and related kames, and felsenmeer are also found on the property.

In the Hardy Lake area the earliest direction of ice transport was to the southwest; it was followed by a westerly flow and then by a flow to the northwest (Dredge *et al.*, 1994a). The dominant direction is to the northwest which is an extremely important factor in interpreting dispersal trains from potential kimberlite targets.

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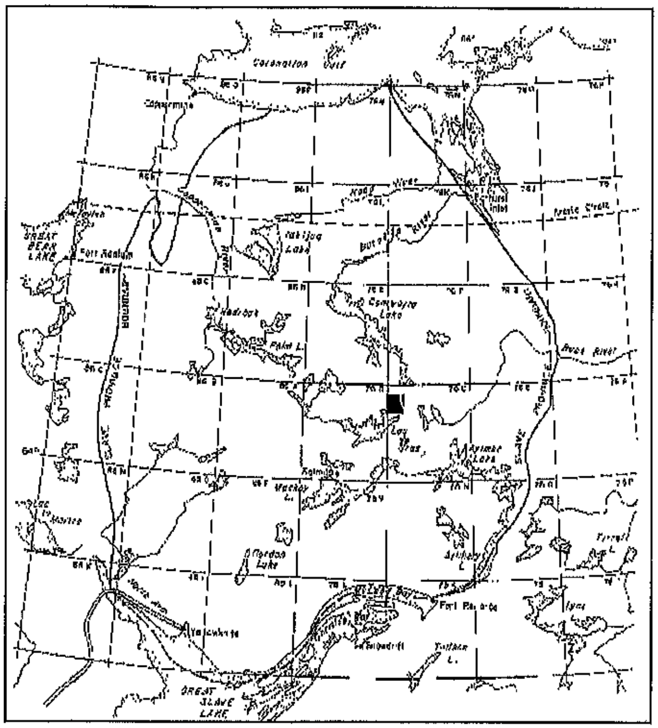


Figure 1: *Location of Hardy Lake claims.*

PROSPECTING TECHNIQUES

Airborne geophysics

The combined time domain electromagnetic (TDEM) and magnetic fixed wind system is described by Smith *et al.* (1995). For this survey the aircraft terrain clearance was 100 m and the centres of each for the off-time windows 6 through 12 were 217, 362, 507, 651, 796, 941, and 1086 microseconds (seconds after transmitter switch-off) respectively. The base frequency of the transmitter was increased to 270 Hz to optimize the system toward detection of weakly conducting kimberlite in a highly resistive host rock. Flight lines were flown at 250 m intervals.

The helicopter-borne frequency domain electromagnetic (FDEM) and magnetic gradiometer system is described by Aerodat (1993). The EM bird was towed at approximately 30 m mean terrain clearance and the magnetic gradiometer 15 m higher. The flight lines were flown at 50 m intervals.

Ground geophysics

The ground magnetometer data was collected along lines at 50 m intervals and stations every 10 m and was corrected for diurnal variations. The ground EM system used the Slingram method in horizontal coplanar loop mode, with a coil separation of 100 m and stations every 20 m. Data for five frequencies (880, 1760, 3520, 7040 and 14080 Hz) were collected. The gravity data was collected using a Lacoste Romberg Model D gravimeter for selected lines on the grid, at 40 m station intervals. The data was corrected for drift, latitude, free-air and Bouguer corrections.

Sample collection

Reconnaissance sediment sampling of glaciofluvial can detect kimberlite indicator grains from a source area that may be hundreds or even thousands of square kilometers in size. Follow-up sampling of glacial till can further define the dispersal train such that the source area for a single kimberlite may be reduced to tens of square kilometers.

Glacial drift samples weighing 22 to 30 kg were collected and transported to a washing station where the samples were de-slimed (the clay size fraction was removed) and wet screened into size fractions that vary from 0.3 mm to 2.0 mm. Heavy mineral concentrates were produced from each sample. The concentrates were sent to mineral sorting laboratories where they were sorted for kimberlitic indicator minerals.

Mineral chemistry

Kimberlitic indicator minerals (mainly garnet, chrome diopside, ilmenite and lesser chromite) were analyzed at Anglo American Research Laboratories in Johannesburg using an SEMQ microprobe to determine the major trace element abundances.

The low calcium, chrome-pyrope variety of garnet (so-called G10 garnets of Dawson and Stephens, 1975) are usually associated kimberlites which have the potential to be diamondiferous (Sobolev, 1977). Ilmenites are not directly associated with diamonds, however they can be used to assess the redox conditions of the kimberlite magma and thus predict the likelihood of any diamonds incorporated in the kimberlite being preserved at surface (Gurney and Moore, 1991). The Cr and Ti oxide content of chromites can be used to predict the depth of the mantle source of the grains and therefore if the grains are derived from the diamond stability field.

Drilling

A Longyear 38 wire-line drill was used to recover NQ (45.1 mm) size core. Drill locations were spotted initially by navigating to the site using a GPS (undifferentiated), surveying short lines with a magnetometer and siting the drill collar based on the magnetometer readings. Later a real-time GPS system was used to provide very accurate drill collar positioning, without the need for additional ground geophysical surveys.

EXPLORATION

Advanced reconnaissance prospecting—1991/1992

Reconnaissance surficial sediment sampling was undertaken by during the summer of 1991 and seven samples were collected in the Hardy Lake Area. The samples collected were from beaches and eskers.

In two beach samples and an esker sample, a total of 114 garnets, 4 ilmenites and 6 chrome diopsides was recovered (Figure 2). Many of the G10 garnets were very subcalcic and had fresh surface textures on the grains, which suggested that at least one potentially diamondiferous kimberlite was nearby. The original Hardy Lake claims were then staked in the fall/winter of 1991/1992.

A fixed wing TDEM and magnetic test geophysical survey was performed over the area of the anomalous beach samples. The magnetic

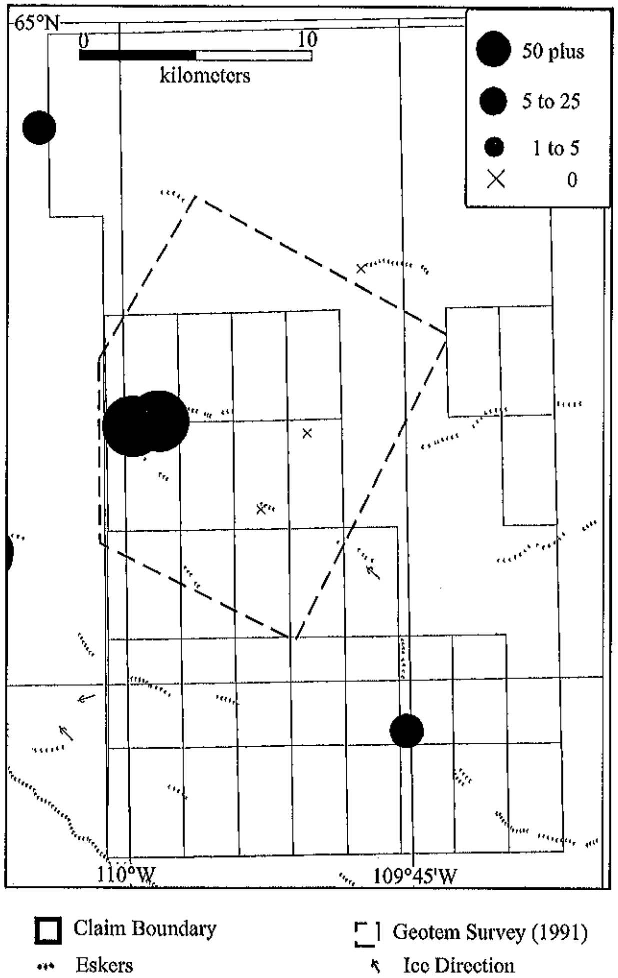


Figure 2: *Sediment sampling and airborne geophysics, Spring 1992; Hardy Lake, NWT.*

response (presented in Figures 3 and 4) shows numerous linear positive magnetic anomalies which were interpreted as dykes. The magnetic background is generally quiet, except for about 25% of the area. The quiet background is interpreted as granite and metasediments, and the active background as granodiorite or diorite bedrock.

Nine magnetic anomalies were interpreted as kimberlite targets, five were over lakes or swamps (for example, positive polarity anomaly 25 and negative polarity anomaly 9), and four were located over granite outcrop or felsenmeer (e.g., positive polarity anomaly 7).

The off-time EM data (Figures 3 and 5) contains only two weak anomalies, both observed on a single flight line, and both decay very rapidly. Anomaly 5, over a small lake, is observed only in the earliest EM channel. Anomaly 6, in a larger lake, has decayed to zero by channel 8. Comparison with computer generated responses from a horizontal plate model suggest a conductivity-thickness of 1 S and a depth to top of 15–25 m. The coincident magnetic data shows unremarkable subtle disturbances of the local magnetic field.

Follow-up prospecting 1992/1993

A detailed sampling programme in 1992 consisted of 50 till, 42 glaciofluvial and 2 modern beach samples collected at a density of one sample per 5 to 10 km^2 along lines perpendicular to the known glacial ice movement.

Three till samples yielded 337 garnets, 10 chrome diopsides and 9 spinels, however most other samples contained less than 10 indicators. Ilmenites were not recovered in significant quantities. Surface textures were observed which resembled those of grains freshly liberated from a kimberlite. Abundant high interest G10 garnets were present. Four of the spinels containing high Cr_2O_3 and MgO values have similar composition to the diamond inclusion type spinels, reinforcing the high interest potential of the kimberlite source.

A helicopter borne combined FDEM and magnetic survey was performed over five anomalies within the area of the high interest indicator minerals. Anomaly 5 and 6 both have significant responses at high frequencies (Figure 5). The low frequency response is subtle and the quadrature is significant suggesting the presence of weak conductors. The EM responses of these targets are anomalous in comparison with the EM background of adjacent lakes, and represent isolated circular anomalies with subtle negative magnetic anomaly associations. Anomaly 9, a distinct negative polarity magnetic anomaly, has a weak EM response at 32 kHz not previously observed (Figure 5). The two positive polarity magnetic anomalies flown do not have EM responses (e.g., anomaly 10). All of these anomalies occur over lakes.

A drill programme tested geophysical anomalies 5, 6 and 9. Kimberlite was intersected in anomaly 6. The main target for anomaly 9 was missed, however a nearby 2 m wide kimberlite dyke was intersected.

The results of the drill programme were encouraging and the rest of the Hardy Lake claim block was flown using the fixed-wing TDEM system. A total 43 anomalies were selected from the TDEM surveys, which included 3 coincident magnetic and EM targets, 3 EM anomalies, and 25 magnetic anomalies (18 positive polarity and 7 negative polarity). The anomalies were evenly distributed throughout the claims.

Detailed prospecting 1993/1994

To more fully define individual dispersion trains, an additional 114 samples were collected during the summer of 1993 at 1 km intervals (Figure 6). Four new indicator mineral anomalies, defined by broad dispersion trains, were delineated in the southern part of the claim block. In one dispersion train two till samples contained a total of 465 garnets, 13 chrome diopsides, and 124 spinel grains. Spinels, however, were generally limited to a few grains in other anomalous samples. Many of the indicator grains were coarse, and displayed very little glacial abrasion of the garnets and chrome diopsides, suggesting a proximal source. Background counts were generally less than 10 indicators. The differences in mineralogy and mineral chemistry of the sampled areas led to the identification of six possible sources.

The indicator mineral results were used to prioritize the geophysical anomalies and a detailed helicopter geophysical FDEM and magnetic survey was flown over the geophysical anomalies within the area of anomalous indicator minerals. Thirteen geophysical anomalies were then selected and defined by ground geophysical surveys (Figure 7). Drilling of these anomalies resulted in the discovery of five more kimberlites.

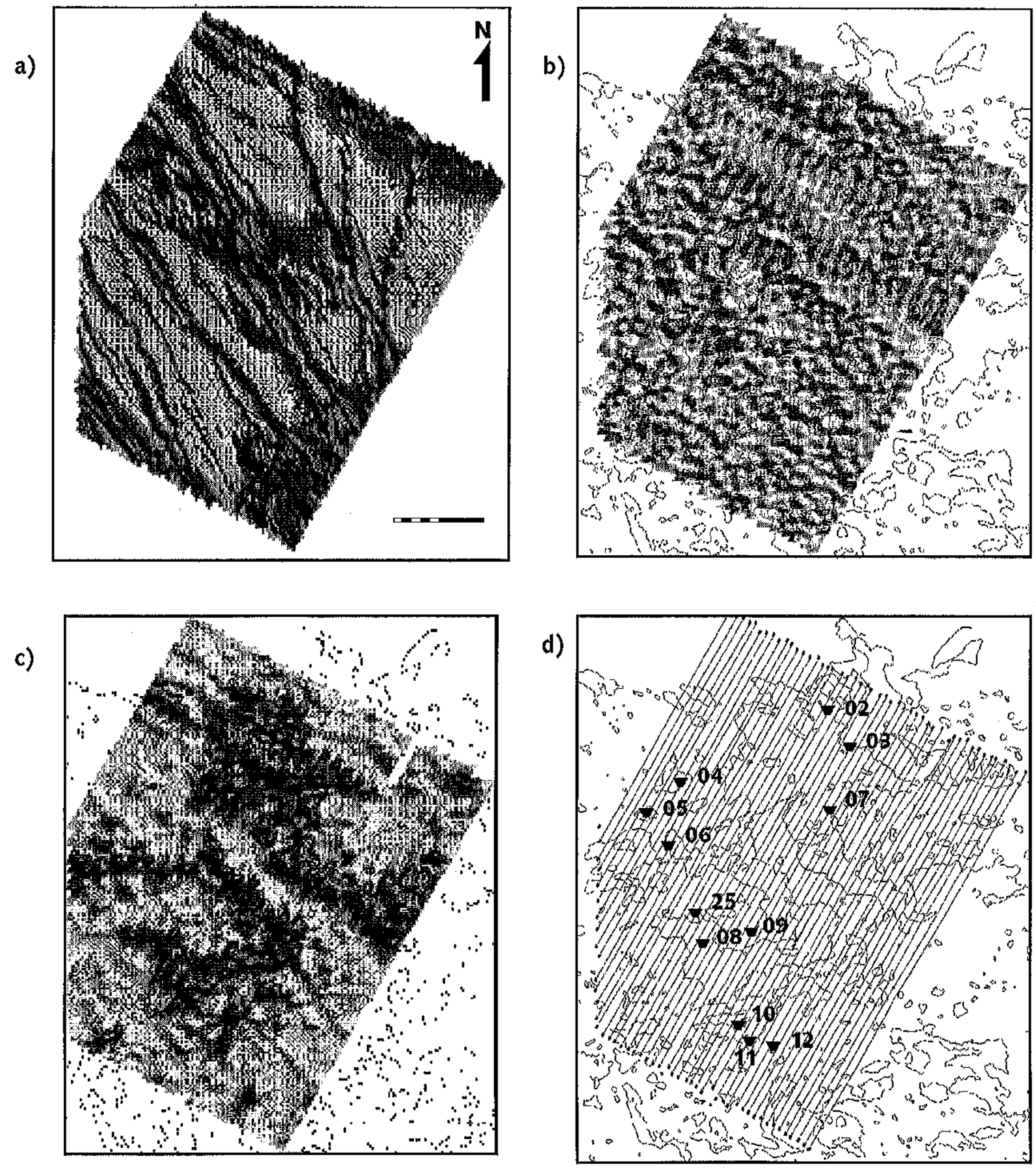


Figure 3: *Combined time-domain electromagnetic and magnetic survey, Hardy Lake, 1992.*
(a) Total magnetic intensity, sun shaded from the north east;
(b) EM channel 6 amplitude and lakes;
(c) apparent conductivity and lakes;
(d) flight path, lakes and geophysical anomalies.

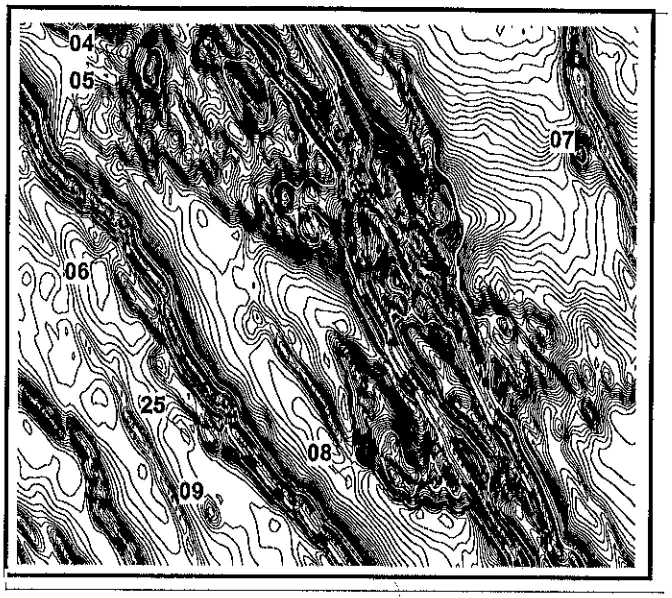


Figure 4: *Contoured total magnetic intensity for a part of the 1992 fixed-wing EM and magnetic survey. Anomalies referred to in the text are*

GEOLOGY OF THE KIMBERLITES

The seven kimberlite bodies form two contrasting groups, each with distinct textural characteristics:

1. the larger bodies are infilled with inhomogeneous, partly bedded, crater-facies kimberlite, and
2. the smaller bodies are composed of internally uniform hypabyssal kimberlite.

Group A includes the two most northerly bodies, Hardy Lake-01 and Hardy Lake-02, which contain typical mantle-derived garnets. These bodies contain only volcanoclastic rocks. The rocks can be described as matrix supported fine to coarse grained olivine tuffs but there is a suggestion that reworking may have been an important process in their final deposition. Juvenile lapilli are present, but only in the coarser grained kimberlite. No hypabyssal or diatreme-facies kimberlites (according to Clement and Skinner, 1985) were intersected by the limited core drilling programmes that have been carried out. Breccias and microbreccias are present. Xenoliths present include granite similar to that observed in the adjacent country rock and, commonly, shale. Shale occurs as xenoliths derived from the since eroded upper country rock and is also incorporated into the fine mud-like matrices of the crater facies kimberlites.

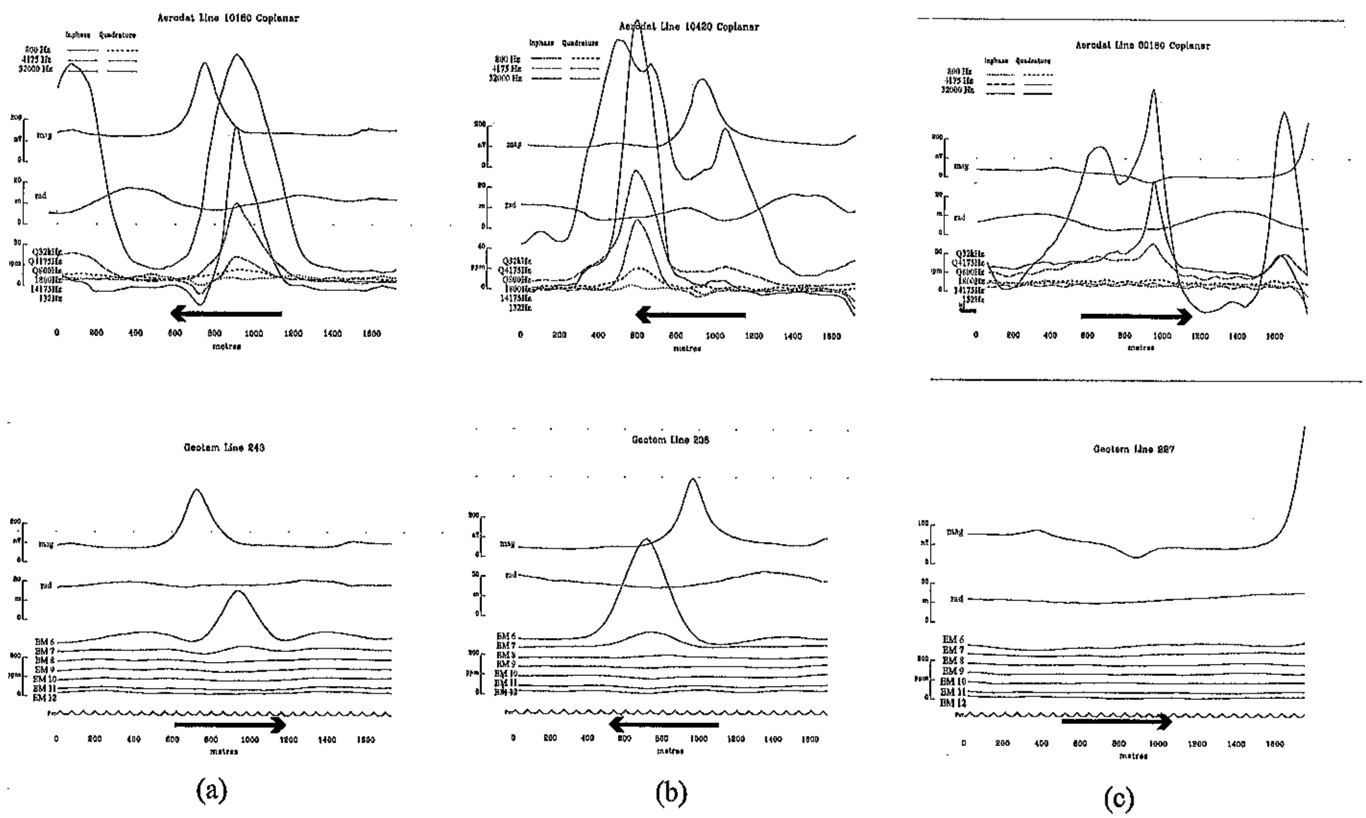
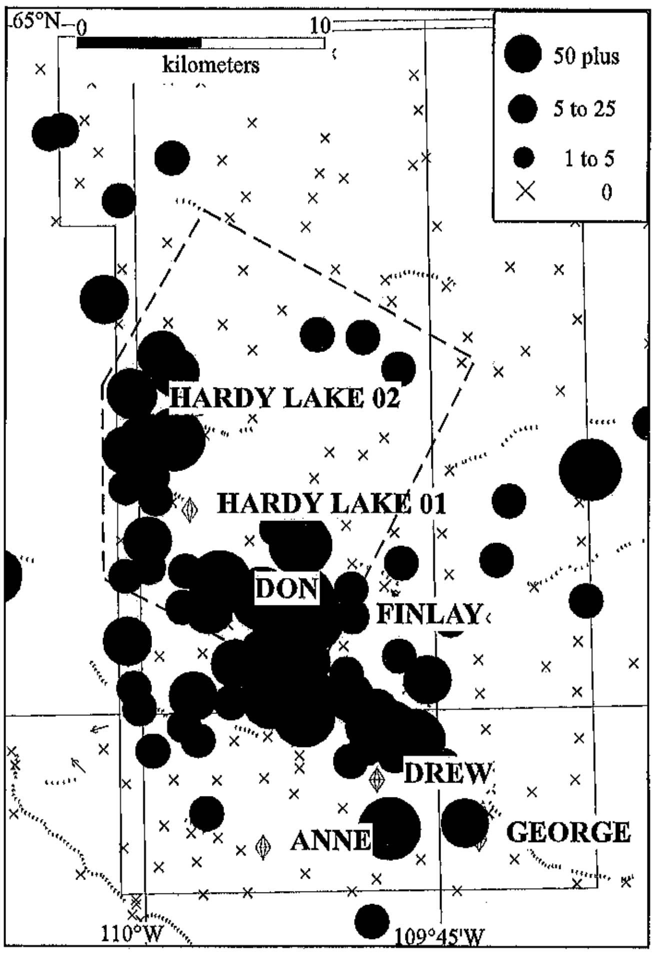


Figure 5: *Electromagnetic data from fixed-wing time-domain survey (lower panels) and the rotary-wing frequency-domain survey (upper panels) for the three targets in the Hardy Lake area. The flight direction for each panel is shown by the arrow at the panel bottom. Magnetometer (upper profile) and radar altimeter (middle profile) data are also shown.* ***(a)*** *Anomaly 5;* ***(b)*** *Anomaly 6; and* ***(c)*** *Anomaly 9.*

Some fossil wood is also present. The two bodies display several contrasting characteristics such as fresh versus altered olivine, abundant versus rare garnet, abundant versus less common xenoliths. Microdiamonds have been recovered from both bodies.

The other kimberlites (Group B) range from small sheet-like intrusions to larger plug-like bodies. The rocks forming these bodies are typically characteristic Group (I) hypabyssal kimberlites composed of two generations of olivine set in a fine grained groundmass. The primary groundmass minerals include; spinel, monticellite, perovskite, phlogopite, serpentine, and carbonate. The textures in the kimberlites vary from macrocryst-poor to macrocrystic (or from finer to coarser grained olivine). Garnet, although present in variable proportions, dominates the mantle-derived xenocryst or 'indicator' mineral suites after olivine. Xenoliths of granite less than 1cm can be common and some rocks can be termed microbreccias. Interestingly, a few of these hypabyssal kimberlites also contain sedimentary xenoliths, although such inclusions are rare. Some of these kimberlites contain significant quantities of microdiamonds.



Claim Boundary
Eskers
Geotem Survey (1991)
Kimberlites
Ice Direction

Figure 6: *Sediment sampling and airborne geophysics, March 1994; Hardy Lake, NWT.*

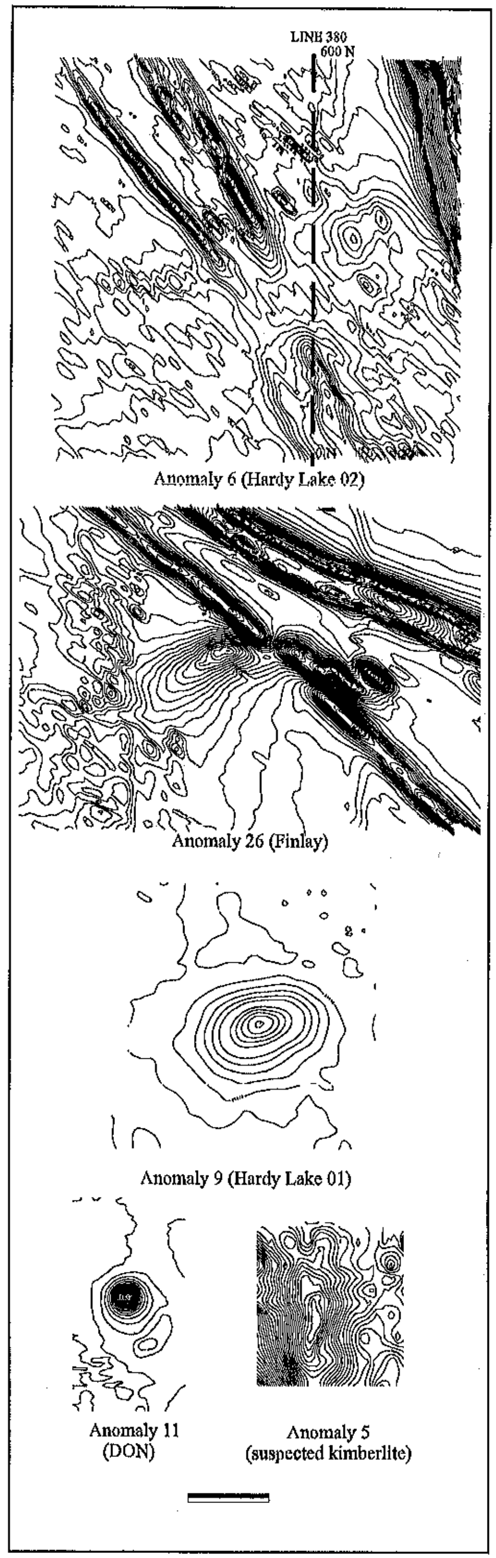


Figure 7: *Contours of the total magnetic intensity from ground surveys, 1994. Anomalies 6, 9, 11, and 26 are kimberlites, anomaly 5 has not been confirmed. Negative polarity anomalies are observed in all cases. Note the subtle response from anomaly 6.*

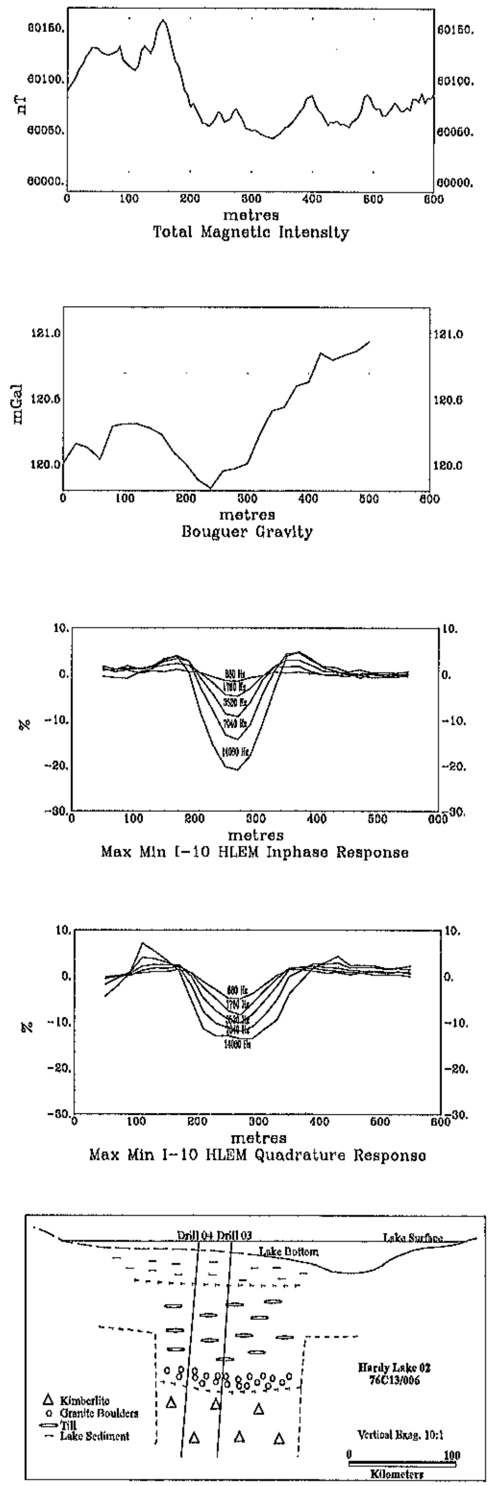


Figure 8: *Total magnetic intensity, gravimetric and HLEM data from line 380 for the Hardy Lake 02 kimberlite (anomaly 6). A proposed geological section from drilling and lake depth surveys is shown for comparison. All geological boundaries are inferred from drill projected data onto the section.*

Table 1: ***Results of NRM and susceptibility measurements from selected drill core.***

Sample #	NRM Intensity x 10^{-9} T	Susceptibility x 10^{-3} SI	IND Intensity x 10^{-9} T	Q	Rock type
HL-1-1/1	514.2	3.87	232	2.2	Kimb. Dyke
HL-1-1/2	519.2	3.87	232	2.2	Kimb. Dyke
HL-2-1/1	1395.0	7.21	433	3.2	Kimberlite
HL-2-2/1	545.6	6.25	375	1.5	Kimberlite
HL-2-3/1	251.4	4.82	290	0.9	Kimberlite
HL-2-4/1	235.1	3.09	186	1.3	Kimberlite
HL-2-5/1	92.4	2.93	176	0.5	Kimberlite
HL-2-6/1	47.6	1.38	83	0.6	Kimberlite
HL-2-7/1	4790	45.68	2742	1.8	mafic dyke
HL-2-7/2	2062	45.68	2742	0.75	mafic dyke
HL-2-8/2	0.109	.302	18	0.006	granite
HL-2-8/2	0.315	.302	18	0.002	granite

Palynological data for sedimentary xenoliths (performed by S. De Gasparis of Palynex) in both groups suggests a maximum age for the emplacement of the kimberlites of 70-80 Ma. These data also show that the Great Western Interior Seaway extended to this area during the Cretaceous.

DISCUSSION OF RESULTS

Analyses from the Hardy Lake garnets indicate they are pyropes and are peridotitic in origin. The majority are calcium saturated (G9) garnets from lherzolites and calcium under-saturated (G10) garnets from harzburgites (Dawson and Stephens, 1975; Gurney, 1994). A few garnets are probably derived from wherlites. Many of the harzburgitic garnets are highly subcalcic and have compositions similar to diamond inclusion type grains.

The majority of the ilmenites from the Hardy lake area have moderate to high Cr values and high Mg values. A small population of ilmenites from low chrome megacrysts contains moderate Mg values. The high Mg and low Fe values from the ilmenites suggest a reducing environment within the kimberlite and thus, good diamond preservation potential according to Gurney and Moore (1991).

In the Hardy Lake area, three populations of chromites exist. There are chromites with high Cr and high Ti signatures similar to chromites from kimberlite sources, there are chromites with high Cr and low Ti signatures similar to chromites from diamond inclusions, and there is a small population of chromites with low Cr, low Mg and high Al signatures from shallow mantle sources (Fipke *et al.*, 1995).

The chrome diopsides analysed have Cr_2O_3 values ranging from 0.4 to 4 weight percent and the majority contain 1 to 2 weight percent Al_2O_3.

Overall, the composition of the garnets and chromites from a number of the Hardy Lake bodies therefore indicate that the kimberlite sources are likely to be diamondiferous and this has been confirmed by micro-diamond analysis.

Two kimberlites (Drew and Finlay) have down-ice indicator mineral dispersion trains. The chemistry of the indicators from these kimberlites and from their respective mineral trains are very similar. Five kimberlites did not have well-developed associated mineral dispersion trains and were found by geophysical methods (Hardy Lake-01, Hardy Lake-02, Anne, Don, and George). The sizes of the Hardy Lake kimberlites have not been determined but all are thought to be small bodies. A variety of factors may be responsible for the lack of indicator dispersion trains from some of the kimberlites, including topography, size of the kimberlite, and the density of sediment samples. There remains unexplained dispersion trains which will be followed up in the future.

The ground geophysical surveys over the Hardy Lake-02 kimberlite (anomaly 6), included magnetic, frequency domain horizontal loop EM (HLEM), and gravimetric methods. Some of the data is presented in Figure 8. The magnetic data does not reveal a single anomaly but a small weak low to the north and a break in the linear anomalies to the south. This implies that the kimberlite postdates the linear magnetic anomalies. A measured susceptibility contrast of 0.35×10^{-3} SI would produce an positive anomaly of 100 nT at ground level for a typical sized body. Therefore the observed magnetic data cannot be explained solely by induced magnetisation (IND). The natural remanent magnetisation (NRM) of several core samples was determined and a significant remanent magnetization was found. The values are listed in Table 1 and presented in Figure 9. Since the core was orientated downward only, the results are presented relative to the drill hole axis and the range of declinations for the NRM vector is represented in three dimensions by a cone, or as an ellipse on the stereonets.

For the Hardy Lake 02 kimberlite averaged values of the NRM intensity and the magnetic susceptibility were used to calculate models of the magnetic response for various declinations and inclinations of the NRM. Typically, the calculated anomaly is positive, with some dipolar character, except in the single case when the NRM direction is at 180° to the current geomagnetic pole direction. If the Koenigsberger ratio (ratio of NRM to IND) is 1, no discernible anomaly is produced. This would explain the near absence of an observed magnetic response in this case.

The HLEM data from the Hardy Lake 02 kimberlite (anomaly 6) was interpreted by comparison with model curves and characteristic curves from Ketola and Puranen (1967). A vertical conductor with a conductivity thickness product (CTP) of 1.1 S and a depth to top of which is 15 to 20 m below the lake surface was interpreted. A cross-section through the Hardy Lake 02 body (Figure 8) shows the geophysics and drilling results and the kimberlite contacts inferred from the geophysical data. The cross-section suggests the kimberlite has been scoured out and infilled with a thin layer of boulders, tills and lake bottom sediments. The depth estimates of 15 to 20 m suggest that the top of the conductor coincides with top of the infill material and not the lake bottom.

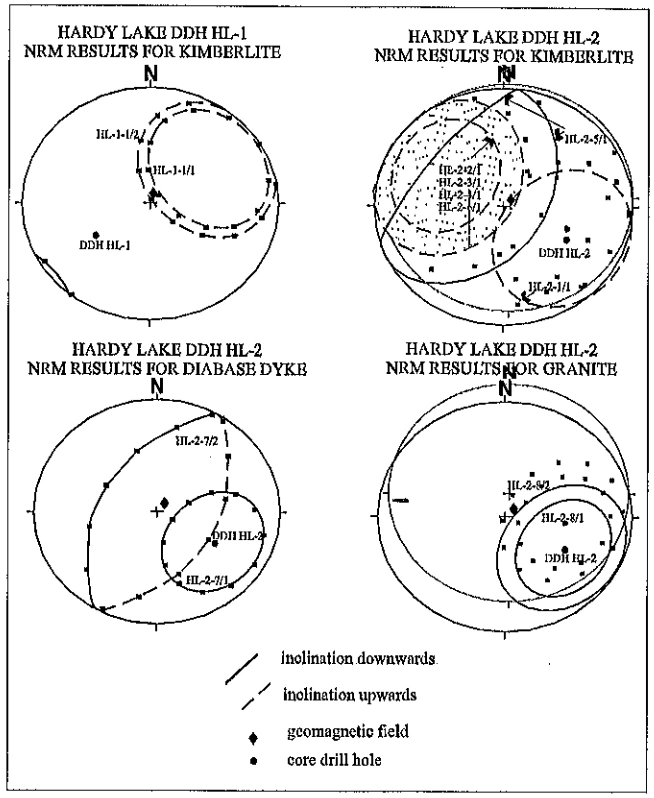


Figure 9: *NRM directions of 12 rock specimens obtained from drill core in the Hardy Lake area. Drill cores were only oriented along one axis and therefore the NRM declination could not be determined (see text for details). Numerical results are presented in Table 1.*

CONCLUSIONS

Seven kimberlites were found on the Hardy Lake property, some of which are diamondiferous. The kimberlites are thought, on the available evidence, to be small bodies. Two of the kimberlites discovered on the property are crater facies and five are hypabyssal facies. Mineral grains unrelated to the known kimberlites on the property suggest that more kimberlites are present in the area. The exploration methods used to find the known kimberlites include studies of regional geology, sediment sampling to recover indicator minerals, the study of the local surficial geology including ice flow directions, geophysical surveys over favourable target areas, and the chemical analysis of indicator minerals.

Two of the seven kimberlites have well-developed indicator dispersion trains, although they all have well-defined geophysical signatures. Many targets with geophysical signatures similar to that of the known kimberlites have been identified across the property but some of these anomalies have been followed up without success. It was essential to use all exploration methods and analytical tools in order to maximize success.

Variations in indicator mineral compositions across the property indicated at an early stage that a number of potential sources were present and allowed prioritization of follow up work by qualitatively rating the diamond potential of different sources. Fresh surface textures on the indicator grains indicated proximal kimberlite sources.

Six of the seven kimberlites have negative polarity magnetic anomalies. The two kimberlites interpreted as crater facies (Hardy Lake-01 and 02) have EM signatures as well, only one of which is a negative polarity anomaly. Therefore a negative magnetic response is not necessarily diagnostic of crater facies kimberlites in this area. The negative magnetic response can be explained by remanent magnetisation which may result in a zero magnetic response requiring EM methods to detect such bodies.

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REFERENCES

"Aerodat", 1993, Case history: kimberlite exploration, NWT Canada, Aerodat.

Anderson, D.L., Tanimoto, T., and Zhang, Y., 1992, Plate tectonics and hot spots: The third dimension. Science, 256 1645-1651.

Buckle, J., 1993, Detection of kimberlite pipes in the Lac de Gras area with helicopter borne electromagnetics and magnetics, Brochure, Dighem Surveys and Processing Inc., Toronto.

Clement, C.R., and Skinner, E.M.W., 1985, A textural genetic classification of kimberlites: Trans. Geol. Soc. S. Afr.,88, 403-409.

Dawson, J.B., and Stephens, W.E., 1975, Statistical classification of garnets from kimberlite and associated xenoliths: Journal of Geology, 83, 589-607.

Dredge, L.A., Ward, B.C., and Kerr, D.E., 1994, Glacial geology and implications for drift prospecting in the Lac de Gras, Winter Lake and Aylmer Lake map areas (NTS 76D, 86A, 76C), central Slave Province, Northwest Territories. Terrain Sciences Division Project 920072 *in*Geological Survey of Canada, Current Research 1994-A.

Fipke, C.E., Gurney, J.J., and Moore, R.O., 1995, Diamond exploration techniques emphasising indicator mineral geochemistry and Canadian examples: G.S.C Bulletin 423.

Fyson, W.K., and Helmsteadt, H., 1988, Structural patterns and tectonic evolution of surpracrustal domains in the Archean Slave Province, Canada: Canadian Journal of Earth Science,25, 301-315.

Gerryts, E., 1970, Diamond Prospecting by geophysical methods: a review of current practice: Geol. Surv. Can. Econ. Geol. Rep.,26, 439-446.

Gurney,J.J., 1984. A correlation between garnets and diamonds in kimberlites. Kimberlite Occurrence and Origin: A basis for conceptual models in exploration, J. E. Glover and P. G. Harris, eds., Geology Department and University Extension, University of Western Australia, Publication 8, 143-166.

Gurney, J.J. and Moore, R.O, Geochemical Correlation between Kimberlitic Indicator Minerals and Diamonds as Applied to Exploration. Extended Abstract, In Fifth International Kimberlite Conference, Brazil, 1991, Comphania de Pequisa de Recursos Minerais, Special Publication 2/91, 125-126.

Kamara, A.Y.S., 1981, Review: geophysical methods for kimberlite prospecting: Aust. Soc. Explor. Geophys., Bull.,12, 43-51.

Ketola, M., and Puranen, M., 1967, Type curves for the interpretation of slingram (horizontal loop) anomalies over tabular bodies: Geol. Surv. Finland, Rept. of Investigations 1.

LeCheminant, A.N., and van Breeman, O., 1994, U-Pb ages of Proterozoic dyke swarms, Lac de Gras area, NWT: Evidence for progressive break-up of an Archean supercontinent. GAC-MAC Program with Abstracts, 19, A62.

Lord, C.S., and Barnes, F.Q., 1954, Aylmer Lake, District of Mackenzie, Northwest Territories; Geological Survey of Canada, Map 1031A, scale 1:253 440.

Macnae, J.C., 1979, Kimberlite and exploration geophysics: Geophysics,44, 1395-1416.

Macnae, J.C., 1995, Applications of geophysics for the detection and exploration of kimberlites and lamproites: Journal of Geochemical Exploration, 53 213-243.

Muggeridge, M.T., 1995, Pathfinder sampling techniques for locating primary sources of diamond: Recovery of indicator minerals, diamonds and geochemical signatures: Journal of Geochemical Exploration53, 183-204.

Reed, L.E., and Sinclair, I.G.L., 1991, The search for kimberlite in the James Bay Lowland of Ontario: CIM, 84, 132-139.

Shilts, W.W. and Aylsworth, J.M., 1989, Glacial features around the Keewatin Ice Divide: Districts of Mackenzie and Keewatin; Geological Survey of Canada, Paper 88-24.

Smith, R.S., Annan, A.P., Lemieux, J. and Pedersen, R.N., 1995, Application of modified Geotem® system to reconnaissance exploration for kimberlites in the Point Lake Area, N.W.T., Canada: Geophysics, 61, 82-92.

Sobolev, N.V., 1977, Deep Seated Inclusion in Kimberlites and the Problems of the Composition of the Upper Mantle: American Geophysical Union, Washington, 279.