Kimberlite and Diamond Indicator Minerals in Northeastern British Columbia: A Reconnaissance Survey

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KEYWORDS: diamond, kimberlite, lamproite, indicator minerals, exploration potential, G10, G11, G12, garnet, Cr-spinel, Cr-diopside, ilmenite, olivine

EXECUTIVE SUMMARY

Northeastern British Columbia is underlain by Precambrian basement that belongs to the North American craton (Fig. 1). It has diamond exploration potential, particularly if the modified 'diamondiferous mantle root model' is considered (Simandl, 2004). This heavy mineral reconnaissance project expands on an earlier study, which was restricted to kimberlite indicator minerals (KIMs) present in Late Pleistocene glaciofluvial sands and gravels sampled in the Fort Nelson region (Levson *et al.*, 2004; Simandl *et al.*, 2005). A variety of media were sampled and tested during this study, including bedrock and regolith of partially consolidated conglomerates of the Dunvegan Formation, active river or stream sediments, and glaciofluvial or glaciolacustrine deposits. Of the 58 samples processed, 38 contain KIMs, such as purple pyrope garnet, Cr-diopside, olivine, ilmenite or spinel. In contrast with the earlier study, no eclogitic garnets were recovered. At least a portion of the KIMs recovered from these samples may be derived from local igneous sources or from secondary or tertiary sources that originated by weathering, transportation and natural preconcentration of protolith-derived constituents. The fact that the Dunvegan Formation contains Cr-spinel, but no other indicator minerals, is noteworthy. The chemical composition of some of these spinels is suggestive of a lamproite/kimberlite provenance.

Concentrations of KIMs located east of the maximum extent of the Laurentide glaciation, as delineated by Mathews (1980; Fig. 2), may have been locally derived and reworked or brought into the region from the Northwest Territories and Alberta by Late Pleistocene glacial and/or glaciofluvial systems. Samples from the Etsho Plateau area yield a wide spectrum and relatively high concentration of potential kimberlite indicator minerals. Follow-up sampling in this area is warranted.

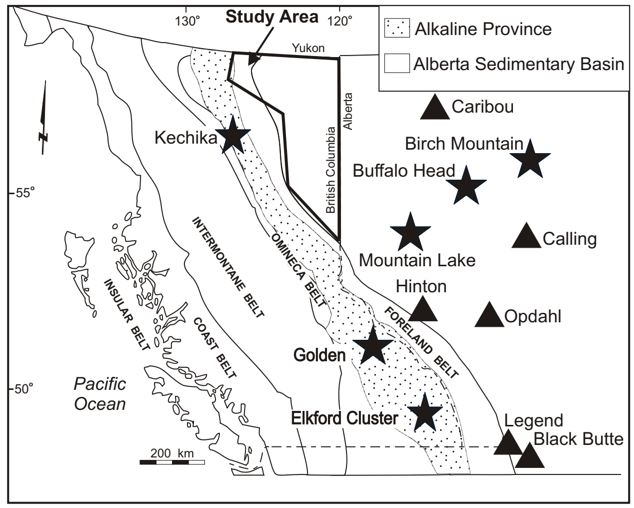

Figure 1. Location of the study area; corresponds approximately to BC's portion of the Western Canada Basin. Known primary (star) and secondary (triangle) diamond occurrences in BC and Alberta are also shown. The Crossing Creek diatreme, within the Elkford Cluster, is the only confirmed kimberlite in BC (*modified from* Simandl, 2004).

Samples NEBC-1, 7, 23, 43 and 44 are noteworthy because of their high concentrations of Cr-spinels (chromites). Some of these spinels have the same chemical characteristics as chromites that plot within the diamond inclusion field. Samples NEBC-1 and 7 are active river sediments, and upstream prospecting is justified.

An intriguing, but problematic, aspect of this study is the recovery of a diamond during the processing of sample NEBC-11, which did not contain any indicator minerals. This stone is a clear diamond nearly 0.8 mm in size (Fig. 3). Because of its size and colourless nature, the diamond may have been lodged within the screen during the processing for an unspecified number of samples without being detected by the laboratory personnel. If the diamond did not belong to sample NEBC-11, as suggested by a lack of associated KIMs, it may have come from any of the samples that were processed prior to it, or from samples belonging to the previous client. Ten BC Geological Survey samples, numbered NEBC-1 to 10, were processed before sample NEBC-11. Several of these samples did contain KIMs.

BACKGROUND

Northeastern BC is an underexplored portion of the North American continent with respect to diamonds, other

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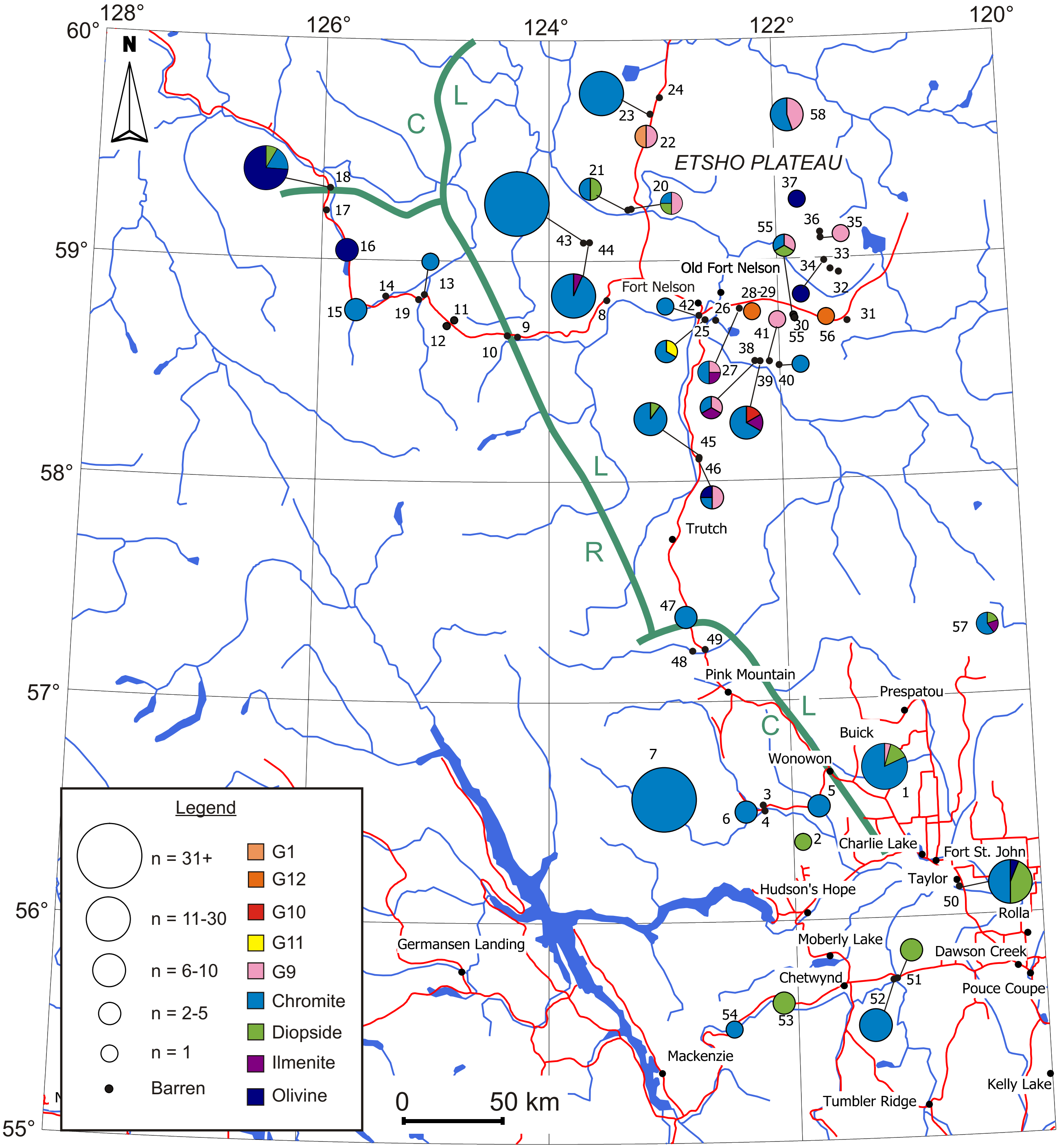

Figure 2. Location of glaciofluvial, stream sediment and bedrock samples. The circle diameter is proportional to the number of indicator mineral grains. Colours correspond to specific kimberlite indicator minerals (KIMs). The green line separates the glacial systems: L - Laurentide glacial system; C - Cordilleran glacial system; R - Rocky Mountain glacial system.

gemstones and non-energy minerals. It is characterized by low relief and has a rapidly developing infrastructure, which supports the oil and gas industry. High-quality diamonds are presently mined within the Slave Craton of the Northwest Territories (Carlson *et al.*, 1999; Lockhart *et al.*, 2004), approximately 600 km northeast of Fort Nelson. Diamond deposits have also been discovered in the Buffalo Head Terrane in neighbouring Alberta (Eccles *et al.*, 2004; Hood and McCandless, 2004), approximately 400 km southeast of the Fort Nelson area. Several alluvial diamond occurrences have also been reported in the Northwest Territories and in Alberta (Simandl, 2004). There are reports of diamond occurrences within the BC Alkaline Province (Northcote, 1983a, b; Anonymous, 1994; McCallum, 1994; Pell, 1994; Allan, 1999, 2002; Roberts, 2002). Recent dating (Simandl and Davis, 2005) indicates that Precambrian crystalline basement similar in age to the Buffalo Head Terrane extends farther west than previously ex-

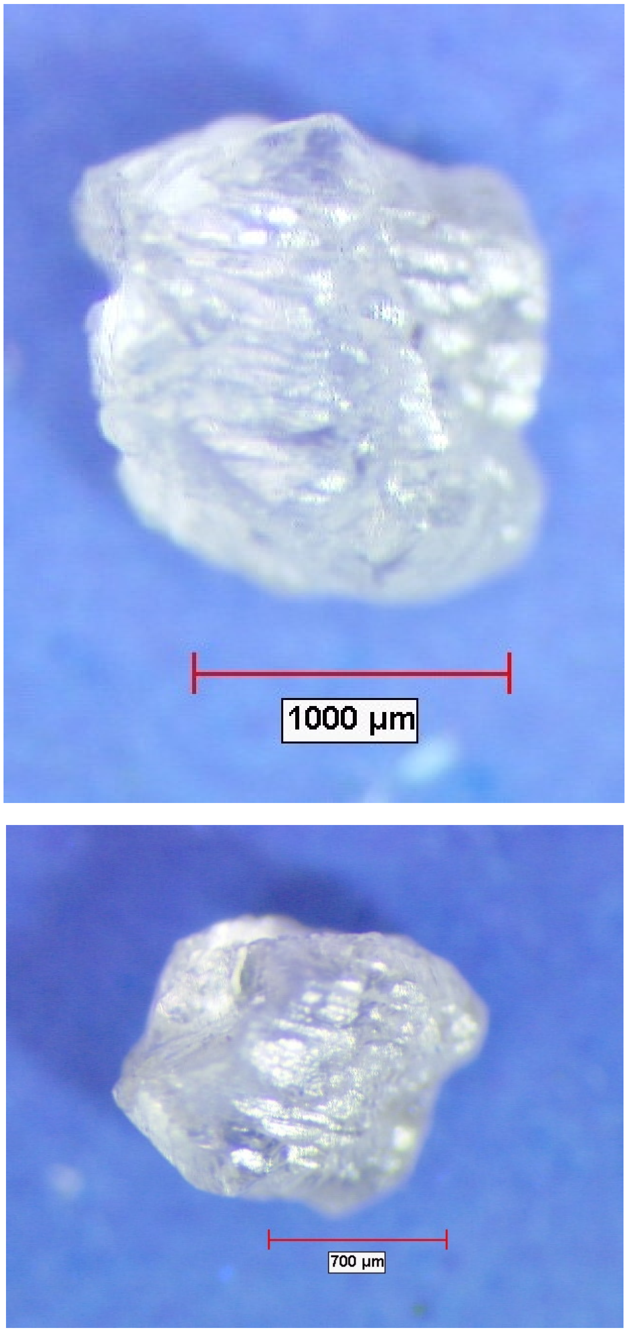

Figure 3: Colourless diamond identified in the heavy mineral concentrate of sample NEBC-11. There is a distinct possibility that this diamond was derived from samples processed prior to sample NEBC-11 or may have come from samples belonging to a previous client (contamination). See sections “Diamond and Fluorite” and “Discussion and Recommendations” for possible implications of this find on diamond exploration in northeastern BC.

pected, supporting the hypothesis that northeastern BC may have been underlain by a thick cold lithosphere prior to rifting of the Rodinia Supercontinent. The diamondiferous root, as described by Haggerty (1986) and Mitchell (1991), may have been destroyed after the diamonds were brought to the surface by kimberlites, lamproites or other diamond elevators (Simandl, 2004). The results of this heavy mineral reconnaissance/orientation survey, when considered in conjunction with the findings of a previous KIM study (Simandl *et al.*, 2005), provide support for the use of the diamondiferous mantle root exploration model in northeastern BC.

BEDROCK GEOLOGY, POTENTIAL DIAMOND ELEVATORS AND THEIR AGE

Northeastern BC is underlain by a Precambrian basement that belongs to the North American craton (Hoffman, 1988, 1989, 1991; Ross *et al.*, 1991, 1995; Villeneuve *et al.*, 1993; Simandl and Davis, 2005). Traditionally, northeastern BC was regarded as being ‘too close to the edge’ of the continent to apply the diamondiferous mantle root concept; however, recent dating indicates that Precambrian crystalline basement of similar age as the Buffalo Head Terrane extends farther west than was previously thought (Simandl and Davis, 2005).

The Precambrian basement in northeastern BC is overlain by a thick sedimentary sequence. Outcropping in the study area are major stratigraphic elements of this sedimentary package: the Toad and Grayling formations (Triassic, 208–245 Ma) the Wapiti Formation (Upper Cretaceous, 65–97 Ma), the Fort St. John Group or Smokey Group (Cretaceous, 65–145.6 Ma), the Dunvegan Formation (Upper Cretaceous, 65–97 Ma), the Sikanni Formation of the Fort St. John Group (Cretaceous, 65–145.6 Ma) and Kotaneelee Formation (Upper Cretaceous, 65–97 Ma), in a compilation by Massey *et al.* (2005). The Fort Nelson area is underlain predominantly by marine shales of the Shaftsbury Formation, part of the Lower Cretaceous Fort St. John Group. These shales are interpreted to have been deposited in a prodelta or shelf environment during a transgression of an embayment in the Cretaceous (Thompson, 1977).

Directly overlying the Fort St. John Group and forming the resistive cap of the Etsho Plateau are sandstones of the Dunvegan Formation of the Upper Cretaceous Smokey Group. These sandstones are part of an assemblage of clastic rocks that range texturally from clay-rich shales and mudstones to boulder conglomerates. The contact between the Dunvegan and Shaftsbury formations is gradational and consists of sandy siltstones and fine-grained sandstones interbedded with silty shales (Thompson, 1977; Stott, 1982). The stratigraphy and sedimentology of the Dunvegan Formation have been discussed in detail by Plint *et al.* (2001), Plint (2002) and Plint and Wadsworth (2003).

There are no known kimberlite or lamproite occurrences in the study area. The closest examples of extensive alkaline volcanic activity are in the Lac de Gras area (Northwest Territories), the Buffalo Head Hills area (Alberta) and BC’s Alkaline Province. Most kimberlite pipes in the Northwest Territories were emplaced between 45 and 75 Ma (Lockhart *et al.*, 2004). In northern Alberta, the radiometric ages of kimberlite emplacement range from 70.3 ±1.6 to 88 ±5 Ma (Eccles *et al.,* 2004). The known radiometric ages of lamprophyres, lamproites and kimberlites within BC’s Alkaline Province vary from 391 ±12 Ma for the HP pipe to 240 to 250 Ma for the Cross kimberlite (Smith *et al.*,1988; Pell, 1994) and are older than sedimentary rocks that outcrop in northeastern BC. It is possible that pipes of similar ages to those of the Lac de Gras and Buffalo Head Hills areas cut sedimentary units of comparable or older ages in northeastern BC. It is also possible that the pyroclastic material ejected from craters or eroded from the pipes was incorporated into the sedimentary sequence.

This is the first report substantiating that indicator minerals may occur in the sedimentary rocks of northeastern BC. The presence of indicator minerals within the outcropping sedimentary sequence may complicate the interpretation of KIM anomalies in surficial materials; however, if confirmed, this report will provide invaluable information for the exploration of possible secondary (placer) diamond targets.

SURFICIAL GEOLOGY

Quaternary History

A recent account of the glacial history of the North American continent is provided by Dyke (2004). For detailed information regarding the Quaternary geology of portions of northeastern BC and the surrounding areas, the reader is referred to Smith *et al.* (1988), Bednarski (1999, 2000, 2001), Levson *et al.* (2004) and Plouffe *et al.* (2004). The text that follows is a simplified glacial history of northeastern BC, with emphasis on aspects directly related to diamond exploration using glacial or glaciofluvial deposits.

According to Mathews (1980), three glacial systems (*i.e.*, the Laurentide, Rocky Mountain and Cordilleran) coexisted in northeastern BC during the last glaciation. During the Late Pleistocene, the Laurentide ice sheet advanced westward up the regional slope into northeastern BC. Its western boundary with the Rocky Mountain and Cordilleran glacial systems is approximated on Figure 2. Most, if not all, of the region was covered by ice during the last glacial maximum. The configuration of late glacial ice fronts and lobes is indicated by cross-cutting relationships observed in large-scale landforms (*e.g.*, flutes, crag and tails, recessional moraines, etc.). Although the Laurentide ice sheet generally moved into the region from the east and northeast, its advance was not uniform. Differing orientations of these landforms suggest that multiple ice-flow events occurred in the region during the Late Wisconsinan and that ice lobes were active during the later stages of glaciation. During the eastward retreat of the Laurentide ice sheet, numerous meltwater channels, flowing towards the west, incised the landscape. Glacial lakes commonly developed along the ice margin, as drainage down the regional slope to the east was blocked by ice (Mathews, 1980).

Based on clast lithologies, glacial deposits within the study area can be divided into three groups. The first group of deposits were those affected by the Laurentide system during the last glacial advance, east of Mathews' line (Fig. 2). These deposits contain a variety of rock types and are characterized by the presence of pink granitic and gneissic clasts that originated within the Canadian Shield. Deposits affected by the Cordilleran system, west of Mathews' line, are characterized by grey granite fragments, quartzite/sandstone pebbles and boulders, and schist and slate clasts. The deposits that were affected by the Rocky Mountain system are characterized by fragments and pebbles of locally derived sedimentary rocks including chert, quartzite, limestone, dolomite, shale and minor diabase. These areas are devoid of pebbles of either Cordilleran or shield-derived plutonic rocks (Mathews, 1980).

SAMPLE LOCATION AND COLLECTION

The 58 samples analyzed for this study were collected across northeastern BC, from as far as 200 km west of Muncho Lake Park to 350 km south of Dawson Creek (Fig. 2). These samples were collected during the 2004 field season and included material from modern stream and river deposits, and glaciofluvial sand and gravel deposits.

The spatial distribution of the glaciofluvial samples was affected by the scarcity of glaciofluvial material in the region and accessibility constraints. This material was collected from vertical exposures in gravel pits, trenches and roadcuts. Samples of modern stream or river sediments were, in most cases, collected upstream from bridges or where river valleys were easily accessed from nearby roads. Sample weights typically ranged from 15 to 30 kg, but some samples were over 40 kg. The samples were sieved in the field to exclude clasts greater than 4 mm. Sample depths were typically 20 to 50 cm below surface and samples were collected from undisturbed material.

Samples from modern river and stream sediments were collected from fluvial systems that drain significant basins. These systems may have incorporated indicator minerals from primary diamond deposits, till, glaciofluvial and glaciolacustrine deposits, or sedimentary bedrock. In samples where KIMs are present, it is expected that river and stream sediment samples will have higher counts of KIMs relative to till samples, as flowing water will tend to naturally preconcentrate heavy minerals. Modern stream or river sediments are particularly useful sample media for assessing the potential of inaccessible areas within well-defined topography and catchment areas.

Information on the samples collected for this study is summarized in Table 1. Clast lithologies are provided for samples that contained pebble and cobble-sized clasts only. This information is important to establish the provenance of the sediments that host the KIMs. The clasts were invariably well-rounded, with the exception of clasts of shales or locally derived sediments. Samples that did not contain any clasts are described as sand-sized or clay-rich material. The table also lists the type and frequency of grains that were confirmed to be potential KIMs, based on their chemical composition.

Samples NEBC-23 and 43 must be considered separately. The former was sampled from a regolith derived from a conglomerate facies of the Dunvegan Formation, whereas the latter was sampled from lithified Dunvegan Formation conglomerate.

Figure 4 summarizes the sample processing procedure. A 500 g sample split was taken from the original sample and archived prior to processing by SGS Lakefield Research Limited's laboratory. Each sample was then wet-screened at 20 and 60 mesh. The +20 mesh material and approximately 500 g of the -60 mesh material were dried and stored. The -20+60 mesh fraction was further concentrated using the Wilfley table and the tail fractions were dried and stored. The concentrates were subjected to heavy liquid separation (methylene iodide at 3.1 g/cm^3) followed by dry screening (35 mesh) and magnetic separation by hand-magnet and Frantz electromagnetic separator.

Using a binocular microscope, the mineral concentrates were picked for diamond indicator mineral species. All picked indicator minerals were put into standard 1-inch polished grain mounts and returned to the BC Ministry of

TABLE 1. SAMPLE DESCRIPTION, LOCATION AND KIMBERLITE INDICATOR MINERAL (KIM) SUMMARY. KEY: DIOP=DIOPSIDE, ILM=ILMENITE, CHR=CHROMITE, OL=OLIVINE, GN=GNEISS, GR=GRANITE, SH=SHALE, LS=LIMESTONE, SS=SANDSTONE, CL=CLAY, CONGL=CONGLOMERATE, UMF=ULTRAMAFIC, CB=CRYSTALLINE BASEMENT, SED=SEDIMENTARY, QTZ=QUARTZITE, CH=CHERT, SI=SILTSTONE, IS=IRONSTONE, MAF=MAFIC, (P)=PINK, (G)=GREY, >=GREATER THAN, >=MUCH GREATER THAN, COMMAS INDICATE SIMILAR ABUNDANCES.

									KIMs					
Sample Number	UTM - Northing	UTM - Easting	Composition of Clasts	Sample Type	G10	G9	G11	G1	G12	Cr Diop	Ilm	Chr	Ol	Total
NEBC-01	6282870	608712	ss/si > gr (p), gn (p), ls, is	River		1				3		18		22
NEBC-02	6264810	575052	ss > sh > gr > gr gn > umf > ch > maf	River						1				1
NEBC-03	6262791	546990	sand-sized material	River										0
NEBC-04	6262536	547022	ss > ls > sh > is	River										0
NEBC-05	6265576	573653	ss >> ls, sh > is > gr	Stream								4		4
NEBC-06	6297889	522801	mainly sed	Stream								2		2
NEBC-07	6304336	520920	ss >> sh, ls > ch, congl	River								71		71
NEBC-08	6520367	471424	ss, si > gr > sh > ch, gn	Pit										0
NEBC-09	6502598	426083	ss >> ls > congl	River										0
NEBC-10	6503318	420959	ss >> ls > sh, ch	Pit										0
NEBC-11	6508859	390131	ls > ss > ch > sh	Pit										0
NEBC-12	6501947	400528	ls > ss > ch	Pit										0
NEBC-13	6524807	379408	ls, ss, sh > qtz > ch > maf	Pit								1		1
NEBC-14	6524322	359904	ls >> sh, ch, ss > congl, qtz	Flood Plain										0
NEBC-15	6518192	344777	ls >> maf, ss, sh, (g)	Pit								2		2
NEBC-16	6548532	340361	ls >> ss, qtz, ch	Pit									5	5
NEBC-17	6568296	330650	cl (clay-rich)	River										0
NEBC-18	6579659	332851	ls >> ss, si, sh > gr	River						2		4	17	23
NEBC-19	6522313	376458	ls > qtz > sh, gn > ch > maf	Flood Plain (River)										0
NEBC-20	6566238	484386	gn >> maf > qtz, sh	Pit		2				1		1		4
NEBC-21	6565844	482724	gr gn >> qtz, ss > is	Pit						1		1		2
NEBC-22	6603120	492464	qtz, ss, gn	Pit		1		1						2
NEBC-23	6614075	494595	congl, ls, ss, sh >> qtz > gn	pit, Dunvegan Fm, regolith								25		25
NEBC-24	6622371	499465	ss, sh > gr gn > qtz	Pit										0
NEBC-25	6510030	520870	gn (p) > qtz > gr > ch	Pit			1					2		3
NEBC-26	6509616	526229	gr gn >> qtz > sh	Stream										0
NEBC-27	6515567	538244	gn > qtz > sh, ss	Roadcut		1					1	2		4
NEBC-28	6514501	544774	ss, cb (p)	Pit					1					1
NEBC-29	6514501	544774	ss, cb (p)	Pit										0
NEBC-30	6512127	565471	gn (p), qtz > maf, umf	Pit										0
NEBC-31	6509051	592514	cb (p)	Trench										0
NEBC-32	6533569	588526	gr gn >> qtz	Pit										0
NEBC-33	6535231	584300	cl (clay-rich)	Surface										0
NEBC-34	6539551	581206	cb (p) > sh	Pit									1	1
NEBC-35	6551005	579502	sand-sized material	Stream		1								1
NEBC-36	6553888	578755	cb (p)	Stream										0
NEBC-37	6570249	567872	cb (p)	Small Pit									1	1
NEBC-38	6489088	545698	gr (p) > qtz > maf	Pit		1					1	1		3
NEBC-39	6488921	548332	cb (p)	Esker	1						1	4		6
NEBC-40	6486881	557911	sand-sized material	Pit								1		1
NEBC-41	6488850	553059	cb (p)	Pit		1								1
NEBC-42	6512245	517785	cb (p)	Pit								1		1
NEBC-43	6549892	460825	ch, congl, ss > qtz	pit, Dunvegan Fm, hard rock								37		37
NEBC-44	6549887	461981	congl, sh > 70% >> cb (p)	Stream							2	25		27
NEBC-45	6440574	516839	gn (p) > gn (g) > ss > maf, sh > is, congl	Stream						1		9		10
NEBC-46	6439810	516735	cb (p) > ss	Pit		2						1	1	4
NEBC-47	6360037	509264	ss, ls > sh > gr gn >> maf	River								3		3
NEBC-48	6342957	512200	ls+sh > 97%	Pit										0
NEBC-49	6343737	518469	ss >> is	River										0
NEBC-50	6222613	645018	ss > sh > qtz > is > gr gn (p)	Stream						7		8	1	16
NEBC-51	6176752	613163	qtz/ss >> 70% > congl, is > gr	Pit						2				2
NEBC-52	6176129	611299	ss, sh > is > maf >> gr (p)	River								8		8
NEBC-53	6165753	556133	ss > sh > ls, congl >> is	River						2				2
NEBC-54	6152653	530479	qtz > ls >> sh, is, maf	Stream								1		1
NEBC-55	6510906	565930	gr (p), qtz	Pit		1				1	1			3
NEBC-56	6539487	581232	gr (p), qtz	Pit					1					1
NEBC-57	6354768	661877	gr (p), qtz	Pit						1	1	3		5
NEBC-58	6612910	564017	gr (p), qtz	Pit		4						5		9
Total Indicators					1	15	1	1	2	22	7	240	26	315

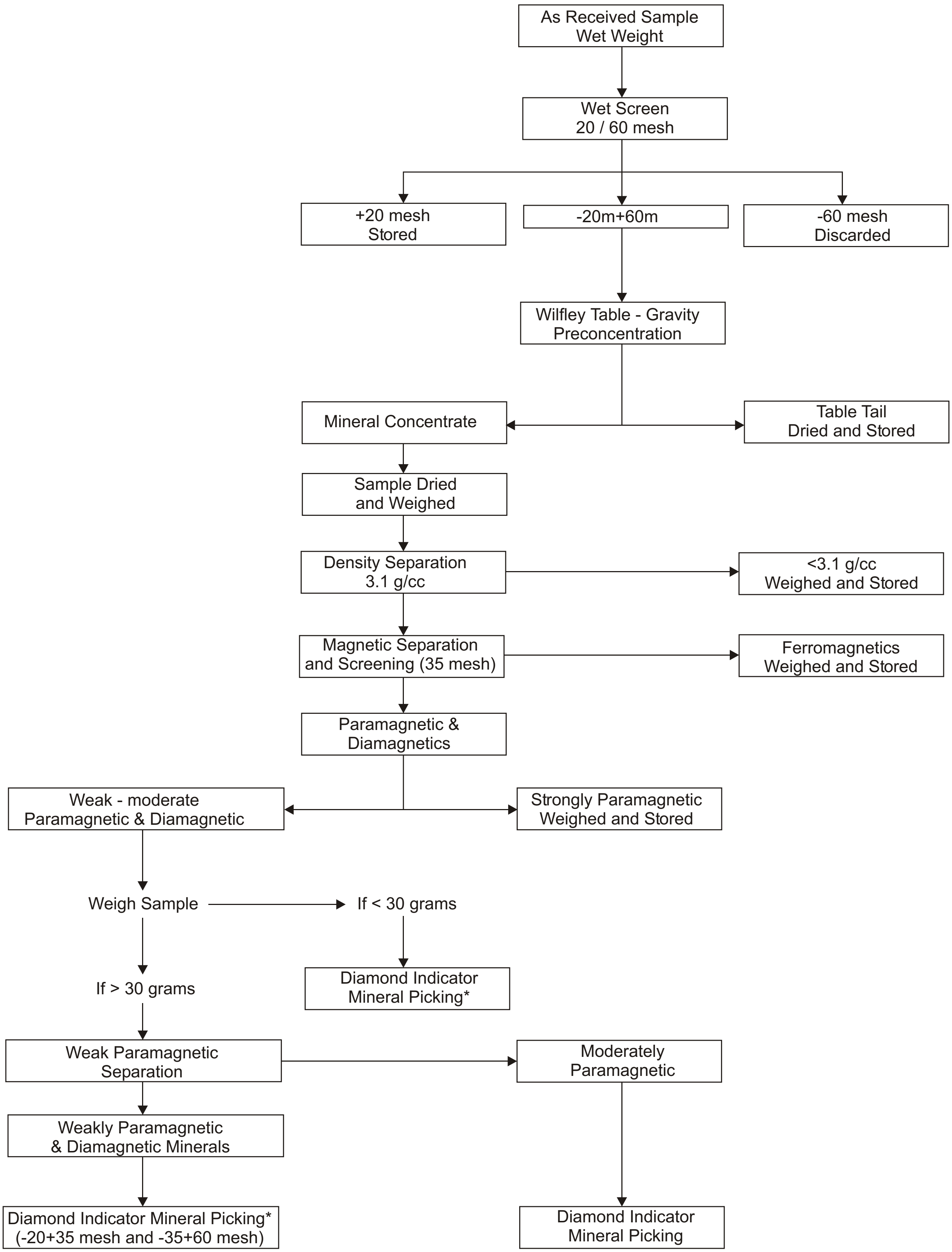

Figure 4. Diamond indicator mineral extraction flow sheet. * indicates primary diamond indicator mineral fraction. Source: SGS Lakefield Research Limited.

Energy, Mines and Petroleum Resources. Microprobe analyses were then conducted on these mounts by M. Raudsepp at the University of British Columbia to determine the major element composition of the visually picked mineral grains. Chemical composition of mineral grains is required to determine if a mineral is a diamond or kimberlite indicator.

In total, 381 mineral grains were subjected to microprobe analyses. Of these, 315 grains were identified as potential KIMs. The locations of sample sites and number of KIM grains at each site are provided in Figure 2 and Table 1.

INTERPRETATION OF MICROPROBE ANALYSES

Interpretation of the data from northeastern BC is more complex than from areas such as Lac de Gras (NWT) or Buffalo Head Hills because sediments in northeastern BC contain clinopyroxenes, olivines and chromites with chemical compositions that may not be unique to kimberlites or lamproites. For example Cr-spinel can be also derived from Alaskan intrusions, ophiolites, boninites, xenoliths within alkali basalts, or from other lithologies typical of BC's Alkaline Province. Of the 58 samples collected for this study, 38 contain potential KIMs. Of these, 28 contain more than one indicator mineral variety and often more than one grain of each. The following section presents microprobe data on visually picked minerals and includes a discussion of the KIMs identified in this study.

Garnet

Mantle-derived garnet is considered to be the most important kimberlite and diamond indicator mineral. The two most recent studies on garnet classification and interpretation are those of Schulze (2003) and Grütter *et al.* (2004). Methods presented in these studies are very effective in distinguishing pyrope, eclogitic and crustal garnets. The key elements used to identify and interpret mantle-derived garnets, and to estimate the diamond potential of an area or individual pipe, are Cr, Ca, Mg, Fe, Ti and Na.

In this paper, different garnet species are classified in accordance with the method described by Grütter *et al.* (2004). This scheme divides garnets into 12 categories (G1 to G12). Of these, harzburgitic (G10), lherzolitic (G9), pyroxenitic, websteritic and eclogitic garnets (G4, G5 and G3) are commonly associated with diamonds. Wehrlitic garnets are referred to as G12, low-chromium megacrysts as G1, and titanium-rich peridotitic varieties as G11. The garnets that do not fit any of the 12 categories, including crustal garnets, are referred to as G0. The scheme is in part empirical; it was tested on a large dataset and is robust.

The results of the microprobe analyses of the hand-picked garnets, using the classification method outlined by Grütter *et al.* (2004), are provided in Table 2. The locations of garnet-bearing samples identified in this study are presented in Figure 2. Of the 21 garnets visually picked and analyzed, at least 20 can be considered as KIMs. There is one G10 garnet (sample NEBC-39). Fifteen of the mantle-derived garnets are lherzolitic (G9), two are wehrlitic (G12), one is a G11 and one is a G1 garnet (Fig. 5). Eclogitic (G3) garnets were previously reported from this area by Simandl *et al.* (2005); however, no eclogitic garnets were picked in this study. Follow-up picking is required to confirm the lack of eclogitic garnets. Kelyphitic rims were not observed on any of the visually picked garnets, and some garnets did have an orange-peel texture, suggesting that they were subject to some degree of transport, or at least local reworking, after being liberated from their host rock.

Clinopyroxene

Chrome-bearing, green to bright green clinopyroxenes are typically easy to visually identify in heavy mineral concentrates and can be associated with diamonds. For these reasons, clinopyroxenes are considered effective KIMs. Unfortunately, clinopyroxenes with similar characteristics to those present in kimberlitic rocks are also found in a variety of ultramafic rocks, such as ophiolitic-layered intrusions, Alaskan-type intrusions and basalt-hosted xenoliths. Consequently, microprobe analyses are required to differentiate kimberlite-related clinopyroxene grains from those associated with other lithologies, and clinopyroxene is therefore considered a less significant KIM than garnet or ilmenite. The chemical compositions of the 24 clinopyroxene grains that were visually picked from concentrates are provided in Table 3.

All of the clinopyroxenes, except one (a clinoenstatite), plot within the kimberlite indicator field on the Quirt (2004) Wo-En-Fs diagram. The Mg numbers $[100*Mg^{2+}/(Mg^{2+}+Fe^{2+})]$ of these clinopyroxenes vary from 85.42 to 93.33 with an average higher than 90 (Table 3). Cr-diopside grains with an Mg number greater than 88 are likely to be from mantle peridotite, particularly if they have elevated Cr_2O_3 levels (> 0.5 wt %), as do most of the grains analyzed.

The Cr_2O_3-Al_2O_3 discrimination plot of Ramsey and Tompkins (1994) and the Cr_2O_3-CaO plot of Fipke *et al.* (1989) were used to further refine this interpretation. Globally, most clinopyroxenes found as solid inclusions or intergrowths in and/or with diamond, plot in the on-craton garnet-peridotite field seen in Figure 6, but clinopyroxenes plotting in the off-craton garnet peridotite and spinel peridotite field are also recovered from kimberlite concentrates. On the Cr_2O_3-CaO plot (Fig. 7), with the exception of three grains, all the clinopyroxenes visually picked from heavy mineral concentrates plot within the field representative of diopsides found as inclusions in diamonds. If the Cr-Al-Na ternary diagram of Morris *et al.* (2002) is consid-

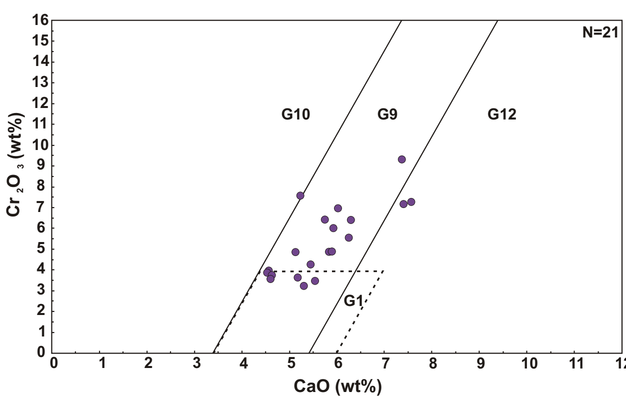

Figure 5. Garnet Cr_2O_3-CaO discrimination plot. One grain plots in the G10 field, and 15 plot within the G9 field. Fields from Gurney and Moore (1994) and Grütter et al. (2004).

TABLE 2. CHEMICAL COMPOSITION OF GARNETS; FOR SAMPLE LOCATIONS SEE TABLE 1 AND FIGURE 2.

Sample ID	UTM Northing	UTM Easting	Na_2O	MgO	Al_2O_3	SiO_2	CaO	TiO_2	Cr_2O_3	MnO	FeO	Total	Garnet Type
NEBC-1	6282870	608712	0.01	19.10	19.59	41.10	6.29	0.02	6.41	0.44	7.58	100.55	G9
NEBC-20	6566238	484386	0.02	19.50	20.49	41.05	5.87	0.00	4.89	0.43	8.29	100.55	G9
NEBC-20	6566238	484386	0.02	20.01	20.83	41.10	5.45	0.05	4.26	0.41	8.51	100.65	G9
NEBC-22	6603120	492464	0.07	20.83	19.38	41.73	5.16	1.00	3.64	0.29	8.04	100.14	G1
NEBC-22	6603120	492464	0.04	19.70	20.65	41.36	5.13	0.11	4.85	0.38	8.66	100.90	G9
NEBC-25	6510030	520870	0.05	20.45	18.23	41.63	5.74	0.63	6.44	0.23	7.03	100.43	G11
NEBC-27	6515567	538244	0.02	19.62	19.81	41.09	6.26	0.05	5.56	0.35	8.00	100.74	G9
NEBC-28	6514501	544774	0.00	18.38	18.32	40.57	7.40	0.00	7.18	0.41	8.27	100.53	G12
NEBC-35	6551005	579502	0.04	20.32	20.72	41.62	5.86	0.01	4.88	0.38	7.09	100.89	G9
NEBC-38	6489088	545698	0.03	20.23	21.42	41.19	5.55	0.01	3.47	0.41	8.07	100.39	G9
NEBC-39	6488921	548332	0.05	20.10	18.42	40.74	5.24	0.30	7.57	0.39	7.58	100.39	G10
NEBC-41	6488850	553059	0.03	19.87	18.77	41.10	6.01	0.09	6.96	0.35	8.37	101.55	G9
NEBC-46	6439810	516735	0.02	19.50	19.05	41.38	5.92	0.16	6.01	0.32	7.79	100.14	G9
NEBC-46	6439810	516735	0.01	19.85	21.82	40.87	5.30	0.03	3.25	0.33	8.03	99.50	G9
NEBC-55	6510906	565930	0.02	17.74	16.62	40.04	7.36	0.06	9.32	0.42	7.47	99.06	G9
NEBC-56	6539487	581232	0.01	16.94	18.62	40.94	7.57	0.01	7.28	0.57	8.50	100.44	G12
NEBC-58	6612910	564017	0.06	20.74	20.98	41.53	4.56	0.28	3.96	0.29	7.84	100.24	G9
NEBC-58	6612910	564017	0.06	20.66	21.15	41.64	4.60	0.29	3.58	0.39	7.93	100.30	G9
NEBC-58	6612910	564017	0.05	20.85	21.10	41.29	4.54	0.26	3.85	0.30	7.58	99.82	G9
NEBC-58	6612910	564017	0.06	20.78	21.01	42.15	4.62	0.31	3.77	0.36	7.54	100.60	G9

TABLE 3. COMPOSITION AND MG# OF CLINOPYROXENES (CR-DIOPSIDES); FOR SAMPLE LOCATIONS SEE TABLE 1 AND FIGURE 2.

Sample ID	UTM Northing	UTM Easting	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	Cr_2O_3	MnO	FeO	Total	Mg #
NEBC-1	6282870	608712	1.21	15.80	6.17	51.31	0.00	20.91	0.30	0.83	0.03	2.79	99.36	0.909978
NEBC-1	6282870	608712	1.85	15.16	7.29	51.70	0.01	19.74	0.43	0.71	0.06	3.01	99.96	0.89966
NEBC-1	6282870	608712	1.41	15.68	6.17	51.34	0.00	20.74	0.26	1.05	0.07	2.74	99.45	0.910806
NEBC-2	6264810	575052	0.16	17.83	1.16	53.32	0.02	23.22	0.10	0.92	0.14	2.90	99.76	0.916483
NEBC-18	6579659	332851	1.44	15.78	6.45	51.27	0.00	19.57	0.42	1.10	0.10	2.71	98.85	0.912209
NEBC-18	6579659	332851	0.16	18.04	0.84	53.55	0.00	22.89	0.13	0.45	0.07	2.89	99.01	0.917638
NEBC-20	6566238	484386	0.70	16.79	1.11	53.13	0.00	22.13	0.03	0.74	0.20	3.55	98.38	0.893889
NEBC-21	6565844	482724	0.70	16.31	1.54	53.56	0.00	22.50	0.06	0.51	0.08	3.91	99.18	0.881399
NEBC-45	6440574	516839	0.45	15.94	2.80	51.96	0.00	22.37	0.16	0.77	0.13	4.85	99.43	0.854281
NEBC-45	6440574	516839	1.44	16.08	6.63	51.17	0.00	19.50	0.38	1.04	0.13	3.19	99.57	0.899722
NEBC-50	6222613	645018	0.16	17.74	1.48	53.24	0.00	23.19	0.12	0.65	0.09	3.03	99.70	0.912654
NEBC-50	6222613	645018	1.64	15.65	6.71	50.99	0.00	19.53	0.46	0.64	0.09	3.10	98.81	0.900126
NEBC-50	6222613	645018	0.47	17.31	3.43	52.52	0.01	21.98	0.01	1.11	0.02	2.21	99.06	0.93332
NEBC-50	6222613	645018	1.50	15.11	7.00	50.95	0.00	20.42	0.35	1.00	0.10	2.61	99.04	0.911777
NEBC-50	6222613	645018	1.24	15.82	5.79	51.91	0.00	21.37	0.36	0.96	0.09	2.79	100.33	0.910081
NEBC-50	6222613	645018	1.18	16.91	4.91	52.43	0.01	20.25	0.13	1.36	0.05	2.74	99.97	0.916749
NEBC-50	6222613	645018	1.55	15.55	6.20	51.41	0.00	20.65	0.30	1.07	0.12	2.48	99.32	0.917881
NEBC-51	6176752	613163	1.47	16.30	7.13	50.98	0.01	18.68	0.37	0.84	0.05	3.36	99.18	0.896459
NEBC-51	6176752	613163	1.38	15.85	5.89	51.72	0.01	20.81	0.26	1.22	0.09	2.56	99.80	0.91698
NEBC-52	6176129	611299	0.11	33.40	4.80	54.15	0.01	0.64	0.09	0.31	0.14	6.50	100.15	0.901617
NEBC-53	6165753	556133	1.29	15.87	6.79	50.79	0.00	19.54	0.42	0.77	0.13	3.19	98.79	0.898615
NEBC-53	6165753	556133	1.65	15.17	6.98	51.02	0.00	19.87	0.62	0.94	0.09	2.73	99.08	0.908319
NEBC-56	6539487	581232	0.31	17.36	2.03	51.55	0.00	21.81	0.30	0.85	0.14	4.47	98.82	0.873772
NEBC-57	6354768	661877	0.69	16.87	1.90	53.36	0.00	22.63	0.15	0.92	0.07	3.10	99.70	0.906524

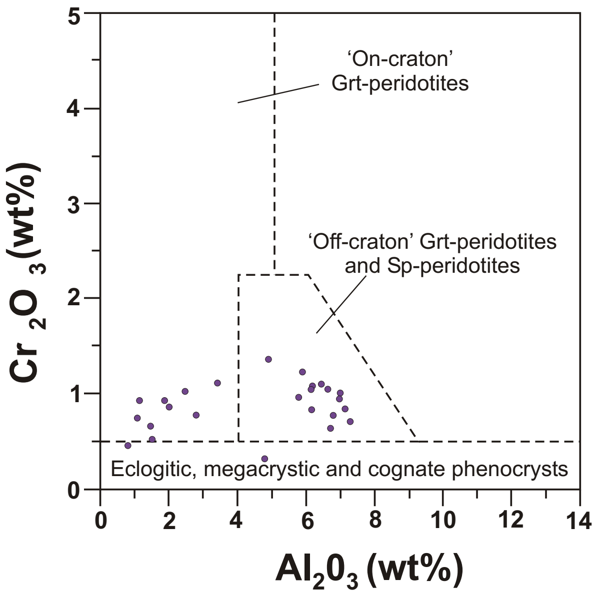

Figure 6. Clinopyroxene Cr_2O_3-Al_2O_3 discrimination plot (*after* Ramsey and Tompkins, 1994). Eight of the grains from this study plot within the on-craton field, further refining interpretations based on the Mg number. Fourteen grains plot within the spinel peridotite and off–craton garnet peridotite fields. Two grains have Cr_2O_3 content below 0.5 wt% and plot within the field of 'eclogitic, megacrystic and cognate phenocrysts.'

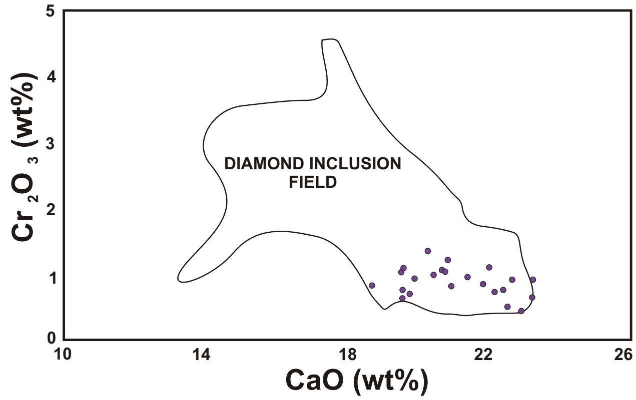

Figure 7. Clinopyroxene Cr_2O_3-CaO plot. The outlined field represents the composition of clinopyroxenes found as inclusions in diamonds (Fipke *et al.*, 1989).

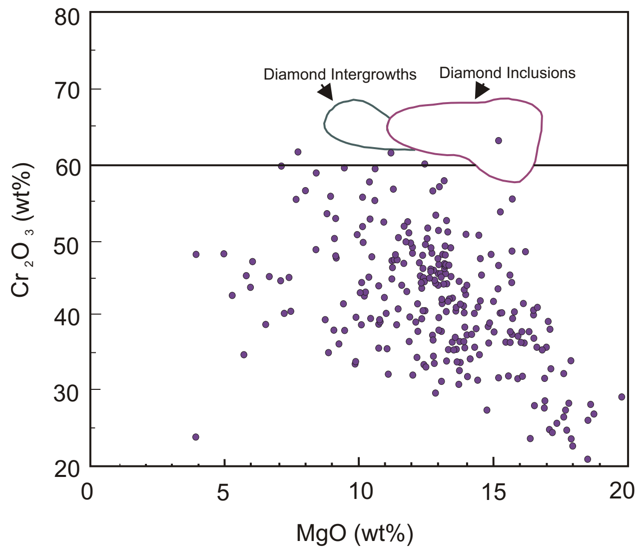

Figure 8. Cr-spinels, Cr_2O_3-MgO diagram. Most of the grains appear to follow the peridotite trend and five of these grains have Cr_2O_3 content of 60 wt% or more. Compositions of spinels found as intergrowths with or inclusions in diamonds from Fipke *et al.* (1989).

ered, only one of the clinopyroxenes plot within the Cr-diopside field for kimberlite xenoliths and xenocrysts; however, when this discrimination plot is applied to parts of the world other than Ontario, it achieves only limited success (Quirt, 2004, Fig. 10B). If the Na-Ca-Cr-Fe diagram of Thorleifson *et al.* (1994) and Quirt (2004) is considered, depending on the plot, about half of the diopsides from northeastern BC would be peridotitic. Normally, Cr-diopsides do not carry as much weight as garnets during the interpretation of heavy mineral data; however, if clinopyroxene of appropriate chemical composition occurs in the same sample with other indicators such as pyrope or ilmenite (or at least in the same geographic area as G9 or G10), it is appropriate to consider it as a full-fledged KIM. A detailed investigation that leads to the Cr-diopside interpretation is underway and it will be published as a separate document. For the purpose of this study, all the clinopyroxenes listed in Table 3 are considered KIMs.

Spinel

As with Cr-diopside, the distinction of kimberlite-related spinels from spinels derived from other sources is not straightforward. Spinels are found in a variety of settings, including layered intrusions, Alaskan-type intrusions, ophiolites, xenoliths within alkali basalts, and boninites. Of the 275 Cr-spinels (chromite) grains picked, 240 grains can be considered as potential KIMs based on their chemical composition. These chromite grains consist mainly of Al_2O_3 (4.70–36.26%), Cr_2O_3 (29.15–62.91%), FeO (13.22–44.45%) and MgO (3.91–19.77%). Smaller constituents are TiO_2 (<4.89%), MnO (<1.74%), NiO (<0.47%) and SiO_2 (<0.30%). The chemical analyses of potential KIM chromite grains can be found in Table 4.

The majority of these grains appear to follow the peridotite trend (Fig. 8). Five of the grains have high chrome content (>60% Cr_2O_3) and an appropriate MgO content to fit the compositional fields of chromite inclusions in diamonds. On the TiO_2 versus 100[Cr/(Cr+Al)] diagram (Fig. 9), the majority of the chromites plot within the garnet peridotite field and at least 16 grains have compositions compatible with chromites found as inclusions in diamonds. To further improve the discrimination between kimberlite-related spinels and spinels from a variety of other sources, additional criteria were selected based on the database of spinels published by Barnes and Roeder (2001, 2004) and other factors, such as the grain-size of spinels from a variety of non-kimberlite/lamproite environments (Grütter and Apter, 1998; McCandless and Dummett, 2003). Details of this enhanced interpretation method will be published as a separate paper, but the results are already incorporated into the current interpretation (Fig. 2). Samples NEBC-1, 7, 23, 43 and 44 contain 18, 71, 25, 37 and 25 chromites, respectively. Sample NEBC-1 also contains Cr-diopside and a G9 garnet, and sample NEBC-44 contains ilmenite that has an appropriate chemical composition to be

TABLE 4. CHEMICAL COMPOSITION OF Cr-SPINELS (CHROMITES); FOR SAMPLE LOCATIONS SEE TABLE 1 AND FIGURE 2 .

Sample ID	UTM Northing	UTM Easting	MgO	Al_2O_3	SiO_2	CaO	TiO_2	V_2O_3	Cr_2O_3	MnO	FeO	NiO	Nb_2O_5	Ta_2O_5	Total
NEBC-1	6282870	608712	12.48	30.72	0.06	0.00	0.56	0.12	33.15	0.09	21.70	0.10	0.05	0.00	99.03
NEBC-1	6282870	608712	9.10	19.06	0.10	0.00	0.25	0.08	47.76	0.00	20.72	0.11	0.00	0.00	97.18
NEBC-1	6282870	608712	14.29	30.05	0.03	0.01	0.12	0.15	35.70	0.03	18.59	0.20	0.02	0.00	99.18
NEBC-1	6282870	608712	19.77	29.97	0.10	0.00	0.27	0.11	29.15	0.15	19.21	0.25	0.00	0.00	98.97
NEBC-1	6282870	608712	12.34	13.07	0.17	0.01	2.65	0.00	46.01	0.03	24.68	0.16	0.00	0.00	99.13
NEBC-1	6282870	608712	7.11	8.24	0.06	0.00	0.04	0.30	59.60	0.16	22.93	0.00	0.00	0.00	98.44
NEBC-1	6282870	608712	8.80	10.11	0.07	0.01	0.10	0.15	53.27	0.04	25.93	0.10	0.00	0.00	98.57
NEBC-1	6282870	608712	9.87	19.45	0.09	0.00	1.02	0.27	39.62	0.19	27.81	0.23	0.04	0.00	98.58
NEBC-1	6282870	608712	9.43	9.35	0.07	0.02	0.04	0.19	59.32	0.01	20.48	0.03	0.05	0.00	98.98
NEBC-1	6282870	608712	15.54	35.36	0.09	0.02	0.16	0.19	31.93	0.04	16.51	0.21	0.03	0.00	100.08
NEBC-1	6282870	608712	5.26	19.11	0.04	0.00	0.32	0.14	42.54	0.04	30.83	0.10	0.08	0.00	98.46
NEBC-1	6282870	608712	11.67	15.16	0.06	0.02	0.07	0.20	51.67	0.00	20.44	0.15	0.00	0.00	99.45
NEBC-1	6282870	608712	3.91	16.75	0.09	0.00	0.09	0.24	47.91	0.00	29.73	0.02	0.00	0.00	98.73
NEBC-1	6282870	608712	15.76	25.98	0.11	0.01	0.60	0.17	40.30	0.00	16.28	0.24	0.03	0.00	99.47
NEBC-1	6282870	608712	10.72	24.24	0.04	0.01	0.70	0.16	35.58	0.09	27.11	0.23	0.00	0.00	98.88
NEBC-1	6282870	608712	12.91	24.67	0.06	0.01	0.13	0.17	43.84	0.00	18.04	0.04	0.09	0.00	99.96
NEBC-1	6282870	608712	10.06	20.08	0.05	0.00	1.22	0.21	38.64	0.00	28.11	0.20	0.00	0.00	98.57
NEBC-1	6282870	608712	13.93	23.93	0.03	0.00	0.04	0.22	43.43	0.03	17.58	0.16	0.00	0.00	99.35
NEBC-5	6265576	573653	13.86	24.51	0.21	0.00	0.75	0.08	41.12	0.11	19.37	0.22	0.06	0.00	100.30
NEBC-5	6265576	573653	13.03	26.59	0.05	0.00	0.31	0.20	37.81	0.04	21.04	0.09	0.00	0.00	99.17
NEBC-5	6265576	573653	13.23	30.65	0.05	0.03	0.65	0.15	33.91	0.11	21.27	0.19	0.00	0.00	100.23
NEBC-5	6265576	573653	13.72	30.39	0.03	0.00	0.29	0.10	32.70	0.07	21.83	0.13	0.07	0.00	99.32
NEBC-6	6297889	522801	13.40	9.88	0.15	0.00	2.67	0.00	48.74	0.00	23.68	0.11	0.02	0.00	98.65
NEBC-6	6297889	522801	13.19	9.68	0.10	0.03	3.29	0.00	47.83	0.03	25.30	0.26	0.00	0.00	99.72
NEBC-7	6304336	520920	16.06	34.79	0.11	0.00	0.43	0.07	31.77	0.05	16.15	0.32	0.08	0.00	99.84
NEBC-7	6304336	520920	7.65	5.67	0.11	0.00	2.75	0.00	55.18	0.00	25.57	0.19	0.00	0.00	97.11
NEBC-7	6304336	520920	15.70	26.96	0.14	0.00	0.59	0.06	39.44	0.00	16.29	0.30	0.03	0.00	99.51
NEBC-7	6304336	520920	12.10	15.29	0.11	0.00	3.67	0.00	39.02	0.05	28.29	0.17	0.02	0.00	98.72
NEBC-7	6304336	520920	16.30	27.74	0.19	0.00	0.78	0.07	37.75	0.00	16.48	0.20	0.00	0.00	99.53
NEBC-7	6304336	520920	12.41	13.45	0.13	0.00	2.84	0.00	44.46	0.00	25.00	0.15	0.00	0.00	98.44
NEBC-7	6304336	520920	15.14	23.33	0.10	0.00	0.07	0.17	43.35	0.00	17.38	0.17	0.06	0.00	99.79
NEBC-7	6304336	520920	17.01	29.47	0.09	0.02	0.19	0.12	39.10	0.04	13.22	0.24	0.05	0.00	99.55
NEBC-7	6304336	520920	12.61	13.85	0.16	0.01	2.61	0.00	44.89	0.06	24.62	0.17	0.00	0.00	98.98
NEBC-7	6304336	520920	7.98	14.56	0.13	0.00	0.25	0.11	56.38	0.03	19.86	0.11	0.00	0.00	99.40
NEBC-7	6304336	520920	12.31	13.08	0.15	0.00	3.04	0.00	43.57	0.00	25.99	0.11	0.04	0.00	98.29
NEBC-7	6304336	520920	11.26	6.06	0.11	0.00	1.98	0.00	56.47	0.00	20.57	0.15	0.00	0.00	96.59
NEBC-7	6304336	520920	12.94	14.17	0.14	0.02	2.58	0.00	45.33	0.00	23.41	0.18	0.00	0.00	98.77
NEBC-7	6304336	520920	11.38	12.58	0.13	0.02	3.22	0.00	38.65	0.17	32.40	0.20	0.02	0.00	98.76
NEBC-7	6304336	520920	12.62	13.29	0.16	0.01	2.57	0.00	45.62	0.05	24.43	0.17	0.00	0.00	98.92
NEBC-7	6304336	520920	12.62	12.39	0.11	0.00	2.90	0.00	45.78	0.03	24.90	0.15	0.00	0.00	98.88
NEBC-7	6304336	520920	16.94	30.17	0.18	0.00	0.75	0.10	35.72	0.00	16.34	0.26	0.00	0.00	100.45
NEBC-7	6304336	520920	17.13	32.37	0.21	0.01	0.62	0.11	32.80	0.00	15.70	0.19	0.00	0.00	99.13
NEBC-7	6304336	520920	11.87	13.90	0.11	0.00	4.04	0.00	39.68	0.12	29.29	0.16	0.07	0.00	99.24
NEBC-7	6304336	520920	10.73	7.49	0.11	0.02	3.40	0.00	43.80	0.10	32.26	0.12	0.00	0.00	98.03
NEBC-7	6304336	520920	10.03	8.88	0.06	0.00	3.87	0.00	42.90	0.21	32.15	0.08	0.00	0.00	98.18
NEBC-7	6304336	520920	12.41	13.24	0.13	0.00	2.66	0.00	44.85	0.03	25.00	0.15	0.03	0.00	98.50
NEBC-7	6304336	520920	16.17	19.81	0.19	0.00	0.71	0.05	48.24	0.00	13.70	0.15	0.00	0.00	99.03
NEBC-7	6304336	520920	13.19	14.36	0.14	0.02	2.44	0.00	45.30	0.14	22.97	0.16	0.01	0.00	98.72
NEBC-7	6304336	520920	13.28	8.22	0.16	0.00	2.90	0.00	50.91	0.02	23.28	0.23	0.01	0.00	99.01
NEBC-7	6304336	520920	13.10	14.97	0.08	0.00	2.83	0.00	43.95	0.05	23.85	0.19	0.06	0.00	99.08
NEBC-7	6304336	520920	12.80	7.84	0.10	0.00	3.58	0.00	44.33	0.09	29.62	0.10	0.00	0.00	98.45
NEBC-7	6304336	520920	15.92	27.67	0.18	0.00	0.87	0.11	37.22	0.00	16.80	0.25	0.04	0.00	99.06
NEBC-7	6304336	520920	17.08	28.27	0.16	0.01	0.71	0.12	38.04	0.00	14.99	0.20	0.03	0.00	99.61
NEBC-7	6304336	520920	12.71	12.17	0.08	0.00	2.33	0.00	48.08	0.01	22.95	0.18	0.11	0.00	98.62
NEBC-7	6304336	520920	13.15	14.07	0.17	0.00	2.44	0.00	46.25	0.00	22.58	0.13	0.00	0.00	98.80
NEBC-7	6304336	520920	13.06	13.99	0.15	0.00	2.60	0.00	45.38	0.00	23.81	0.17	0.02	0.00	99.18
NEBC-7	6304336	520920	12.52	8.26	0.12	0.00	2.70	0.00	51.32	0.06	23.36	0.30	0.00	0.00	98.64
NEBC-7	6304336	520920	16.45	25.58	0.21	0.00	1.00	0.03	40.52	0.00	15.36	0.34	0.01	0.00	99.51
NEBC-7	6304336	520920	9.23	8.51	0.11	0.00	4.57	0.00	36.27	0.29	38.83	0.13	0.06	0.00	98.01
NEBC-7	6304336	520920	13.29	8.10	0.12	0.02	3.92	0.00	41.79	0.05	30.94	0.22	0.00	0.00	98.46

TABLE 4 (CONTINUED)

Sample ID	UTM Northing	UTM Easting	MgO	Al_2O_3	SiO_2	CaO	TiO_2	V_2O_3	Cr_2O_3	MnO	FeO	NiO	Nb_2O_5	Ta_2O_5	Total
NEBC-7	6304336	520920	12.32	13.65	0.17	0.01	2.78	0.00	44.14	0.11	24.94	0.19	0.01	0.00	98.30
NEBC-7	6304336	520920	12.30	13.17	0.15	0.02	2.67	0.00	45.04	0.00	24.98	0.16	0.00	0.00	98.49
NEBC-7	6304336	520920	15.60	22.83	0.07	0.00	0.08	0.14	45.29	0.00	15.42	0.11	0.00	0.00	99.56
NEBC-7	6304336	520920	16.61	30.55	0.14	0.00	0.76	0.08	35.79	0.00	15.14	0.24	0.00	0.00	99.30
NEBC-7	6304336	520920	14.97	24.89	0.09	0.00	0.63	0.13	41.68	0.00	17.09	0.12	0.00	0.00	99.60
NEBC-7	6304336	520920	13.03	14.34	0.16	0.00	2.39	0.00	45.03	0.02	22.98	0.15	0.04	0.00	98.14
NEBC-7	6304336	520920	11.21	7.36	0.09	0.00	4.89	0.00	46.17	0.00	28.85	0.25	0.00	0.00	98.83
NEBC-7	6304336	520920	13.24	14.21	0.16	0.01	2.32	0.00	46.43	0.00	22.92	0.17	0.00	0.00	99.48
NEBC-7	6304336	520920	12.16	12.98	0.13	0.02	3.81	0.00	41.46	0.02	28.41	0.23	0.00	0.00	99.22
NEBC-7	6304336	520920	12.36	15.15	0.12	0.00	3.26	0.00	40.50	0.14	27.27	0.20	0.08	0.00	99.08
NEBC-7	6304336	520920	13.15	14.06	0.17	0.01	2.41	0.00	46.46	0.00	22.75	0.16	0.00	0.00	99.17
NEBC-7	6304336	520920	16.04	28.35	0.09	0.01	0.47	0.08	37.65	0.05	15.87	0.20	0.00	0.00	98.80
NEBC-7	6304336	520920	13.18	14.23	0.15	0.01	2.38	0.00	45.37	0.00	22.89	0.21	0.00	0.00	98.41
NEBC-7	6304336	520920	13.70	16.34	0.12	0.00	1.43	0.01	44.38	0.04	22.63	0.18	0.00	0.00	98.84
NEBC-7	6304336	520920	10.11	15.12	0.18	0.00	0.21	0.10	51.55	0.09	21.79	0.13	0.00	0.00	99.30
NEBC-7	6304336	520920	14.84	23.36	0.20	0.02	1.40	0.03	38.89	0.08	19.60	0.25	0.00	0.00	98.66
NEBC-7	6304336	520920	13.15	7.35	0.12	0.01	2.98	0.00	49.03	0.02	25.93	0.27	0.00	0.00	98.85
NEBC-7	6304336	520920	13.08	11.67	0.13	0.01	1.59	0.00	48.00	0.05	24.01	0.24	0.00	0.00	98.78
NEBC-7	6304336	520920	14.44	16.44	0.08	0.04	1.15	0.04	50.49	0.00	15.92	0.09	0.00	0.00	98.70
NEBC-7	6304336	520920	16.48	28.88	0.23	0.01	0.51	0.07	36.89	0.00	15.39	0.14	0.00	0.00	98.61
NEBC-7	6304336	520920	12.72	5.86	0.15	0.01	2.21	0.00	56.31	0.00	21.55	0.09	0.00	0.00	98.90
NEBC-7	6304336	520920	11.19	9.60	0.07	0.01	3.04	0.00	44.71	0.00	29.62	0.19	0.00	0.00	98.43
NEBC-7	6304336	520920	14.89	17.82	0.09	0.01	1.96	0.00	47.89	0.02	16.68	0.16	0.00	0.00	99.50
NEBC-7	6304336	520920	11.32	7.77	0.11	0.00	3.28	0.00	47.29	0.05	28.13	0.09	0.00	0.00	98.04
NEBC-7	6304336	520920	12.59	14.65	0.19	0.01	2.28	0.00	44.83	0.06	23.63	0.16	0.00	0.00	98.40
NEBC-7	6304336	520920	10.44	8.11	0.09	0.00	3.51	0.00	47.63	0.03	28.55	0.08	0.00	0.00	98.42
NEBC-7	6304336	520920	12.66	11.26	0.13	0.00	2.32	0.00	48.79	0.04	23.58	0.17	0.02	0.00	98.98
NEBC-7	6304336	520920	12.51	8.98	0.13	0.01	2.50	0.00	50.10	0.00	23.61	0.13	0.00	0.00	97.97
NEBC-7	6304336	520920	15.21	25.62	0.22	0.00	0.35	0.16	40.08	0.07	17.07	0.20	0.02	0.00	99.00
NEBC-7	6304336	520920	16.48	28.98	0.11	0.01	0.15	0.12	39.95	0.02	13.77	0.19	0.00	0.00	99.76
NEBC-7	6304336	520920	12.91	9.45	0.12	0.00	1.76	0.00	51.04	0.00	23.02	0.12	0.00	0.00	98.43
NEBC-7	6304336	520920	12.85	7.76	0.14	0.03	2.36	0.00	53.08	0.00	22.91	0.17	0.02	0.00	99.33
NEBC-7	6304336	520920	12.78	13.93	0.13	0.00	2.68	0.00	44.57	0.00	23.77	0.20	0.00	0.00	98.05
NEBC-7	6304336	520920	12.72	12.88	0.14	0.00	2.87	0.00	45.79	0.00	24.95	0.20	0.00	0.00	99.56
NEBC-7 float	6304336	520920	12.46	10.16	0.10	0.00	2.36	0.00	49.32	0.01	23.27	0.09	0.03	0.00	97.80
NEBC-13	6524807	379408	15.65	27.54	0.15	0.02	0.67	0.10	37.43	0.00	17.79	0.25	0.09	0.00	99.67
NEBC-15	6518192	344777	11.64	7.57	0.15	0.07	4.00	0.00	46.76	0.00	27.86	0.13	0.00	0.00	98.19
NEBC-15	6518192	344777	13.91	25.04	0.08	0.00	1.36	0.02	35.57	0.07	22.86	0.21	0.02	0.00	99.13
NEBC-18	6579659	332851	10.91	15.00	0.07	0.01	0.28	0.18	52.17	0.08	20.81	0.03	0.00	0.00	99.55
NEBC-18	6579659	332851	14.00	29.87	0.03	0.00	0.06	0.16	37.35	0.00	18.35	0.07	0.04	0.00	99.92
NEBC-18	6579659	332851	10.35	9.49	0.07	0.00	0.24	0.08	57.45	0.13	21.69	0.06	0.06	0.00	99.64
NEBC-18	6579659	332851	16.62	27.49	0.09	0.00	0.15	0.13	40.89	0.00	14.68	0.26	0.02	0.00	100.32
NEBC-20	6566238	484386	15.24	14.64	0.13	0.00	0.32	0.11	53.56	0.00	15.32	0.32	0.00	0.00	99.64
NEBC-21	6565844	482724	7.07	15.35	0.08	0.00	0.43	0.10	44.46	0.16	30.68	0.05	0.00	0.00	98.39
NEBC-23	6614075	494595	8.86	23.07	0.08	0.01	0.38	0.14	35.00	0.05	31.20	0.28	0.05	0.00	99.12
NEBC-23	6614075	494595	5.70	10.36	0.07	0.00	1.60	0.12	34.73	0.11	44.45	0.13	0.00	0.00	97.27
NEBC-23	6614075	494595	12.30	24.53	0.04	0.00	0.36	0.14	39.47	0.08	22.06	0.15	0.03	0.00	99.17
NEBC-23	6614075	494595	15.19	34.28	0.04	0.00	0.24	0.18	31.71	0.04	17.38	0.12	0.00	0.00	99.19
NEBC-23	6614075	494595	11.98	20.85	0.07	0.00	0.03	0.28	48.09	0.00	18.57	0.03	0.00	0.00	99.90
NEBC-23	6614075	494595	15.88	36.26	0.03	0.03	0.07	0.15	31.54	0.06	15.32	0.21	0.00	0.00	99.56
NEBC-23	6614075	494595	10.14	17.73	0.08	0.02	0.27	0.09	49.54	0.10	21.64	0.09	0.06	0.00	99.75
NEBC-23	6614075	494595	10.19	21.62	0.08	0.03	0.07	0.24	42.51	0.16	23.93	0.15	0.06	0.00	99.03
NEBC-23	6614075	494595	9.91	15.39	0.09	0.00	0.14	0.17	50.51	0.03	22.48	0.10	0.04	0.00	98.86
NEBC-23	6614075	494595	8.73	24.29	0.14	0.00	0.55	0.04	39.31	0.19	26.05	0.11	0.00	0.00	99.40
NEBC-23	6614075	494595	12.93	18.98	0.09	0.00	0.05	0.28	47.42	0.00	19.04	0.16	0.00	0.00	98.94
NEBC-23	6614075	494595	11.87	19.09	0.08	0.00	0.08	0.20	49.38	0.00	19.13	0.09	0.07	0.00	99.98
NEBC-23	6614075	494595	13.30	28.45	0.06	0.00	0.31	0.18	35.42	0.08	20.69	0.10	0.02	0.00	98.61
NEBC-23	6614075	494595	13.24	13.51	0.15	0.02	0.22	0.23	52.38	0.00	18.92	0.12	0.03	0.00	98.80
NEBC-23	6614075	494595	13.91	26.46	0.06	0.00	0.39	0.11	38.33	0.10	19.97	0.27	0.02	0.00	99.62
NEBC-23	6614075	494595	12.78	28.47	0.08	0.01	0.47	0.14	33.61	0.12	23.09	0.21	0.00	0.00	98.98

TABLE 4 (CONTINUED)

Sample ID	UTM Northing	UTM Easting	MgO	Al_2O_3	SiO_2	CaO	TiO_2	V_2O_3	Cr_2O_3	MnO	FeO	NiO	Nb_2O_5	Ta_2O_5	Total
NEBC-23	6614075	494595	10.76	21.98	0.04	0.02	1.01	0.21	39.29	0.18	25.93	0.22	0.00	0.00	99.65
NEBC-23	6614075	494595	14.48	30.03	0.06	0.00	0.46	0.16	34.77	0.08	19.62	0.18	0.00	0.00	99.85
NEBC-23	6614075	494595	15.61	26.89	0.09	0.00	0.79	0.10	37.66	0.02	17.83	0.20	0.00	0.00	99.20
NEBC-23	6614075	494595	13.96	24.38	0.09	0.00	0.25	0.21	42.68	0.01	17.85	0.14	0.02	0.00	99.60
NEBC-23	6614075	494595	15.17	20.23	0.10	0.00	0.18	0.11	46.43	0.03	16.95	0.20	0.00	0.00	99.40
NEBC-23	6614075	494595	7.72	5.62	0.11	0.00	0.13	0.14	61.40	0.20	23.51	0.04	0.01	0.00	98.88
NEBC-23	6614075	494595	13.88	23.90	0.05	0.00	0.03	0.25	43.24	0.04	18.42	0.20	0.00	0.00	100.01
NEBC-23	6614075	494595	13.33	14.87	0.11	0.00	1.42	0.00	46.57	0.00	22.08	0.19	0.00	0.00	98.57
NEBC-23	6614075	494595	12.82	34.61	0.04	0.00	0.10	0.15	29.66	0.10	21.65	0.08	0.01	0.00	99.24
NEBC-25	6510030	520870	5.94	14.31	0.03	0.00	0.09	0.09	43.53	0.17	35.02	0.13	0.00	0.00	99.31
NEBC-25	6510030	520870	10.12	8.13	0.07	0.02	0.61	0.17	55.48	0.01	23.23	0.04	0.00	0.00	97.88
NEBC-27	6515567	538244	11.32	10.35	0.09	0.00	2.29	0.00	47.82	0.07	27.23	0.21	0.05	0.00	99.43
NEBC-27	6515567	538244	16.11	31.88	0.08	0.03	0.06	0.10	36.27	0.00	16.10	0.32	0.00	0.00	100.95
NEBC-38	6489088	545698	9.82	26.04	0.01	0.00	0.24	0.18	33.48	0.16	29.45	0.18	0.04	0.00	99.62
NEBC-39	6488921	548332	6.52	23.31	0.10	0.00	0.82	0.05	38.63	0.16	29.55	0.10	0.00	0.00	99.25
NEBC-39	6488921	548332	9.44	9.68	0.12	0.00	4.12	0.00	37.89	0.23	36.32	0.04	0.00	0.00	97.83
NEBC-39	6488921	548332	11.07	30.71	0.07	0.00	0.11	0.11	32.16	0.12	25.08	0.17	0.00	0.00	99.60
NEBC-39	6488921	548332	6.02	11.52	0.06	0.00	0.18	0.13	46.99	0.13	32.82	0.08	0.00	0.00	97.93
NEBC-40	6486881	557911	11.95	14.60	0.08	0.00	0.38	0.11	48.91	0.04	22.01	0.10	0.05	0.00	98.24
NEBC-42	6512245	517785	7.19	15.17	0.07	0.00	0.45	0.08	40.21	0.23	34.98	0.17	0.02	0.00	98.58
NEBC-43	6549892	460825	13.73	31.05	0.06	0.00	0.26	0.18	33.72	0.10	20.72	0.16	0.02	0.00	99.98
NEBC-43	6549892	460825	13.25	16.77	0.11	0.01	1.48	0.02	44.14	0.00	23.41	0.20	0.00	0.00	99.37
NEBC-43	6549892	460825	14.40	33.32	0.04	0.00	0.08	0.22	31.32	0.06	20.58	0.17	0.04	0.00	100.24
NEBC-43	6549892	460825	12.34	21.18	0.07	0.01	0.42	0.09	47.79	0.00	18.15	0.02	0.00	0.00	100.08
NEBC-43	6549892	460825	17.60	34.79	0.15	0.00	0.45	0.11	32.21	0.00	14.63	0.13	0.00	0.00	100.08
NEBC-43	6549892	460825	15.00	28.82	0.10	0.01	0.03	0.17	37.68	0.03	17.59	0.22	0.00	0.00	99.65
NEBC-43	6549892	460825	13.61	30.49	0.05	0.01	0.67	0.20	33.76	0.07	21.37	0.14	0.03	0.00	100.40
NEBC-43	6549892	460825	12.71	27.47	0.10	0.00	0.23	0.12	37.23	0.07	22.18	0.19	0.00	0.00	100.30
NEBC-43	6549892	460825	13.72	29.13	0.07	0.00	0.32	0.18	36.49	0.04	20.02	0.06	0.03	0.00	100.06
NEBC-43	6549892	460825	15.66	12.20	0.15	0.02	0.61	0.04	55.15	0.00	15.55	0.26	0.08	0.00	99.71
NEBC-43	6549892	460825	15.15	5.14	0.17	0.00	0.19	0.00	62.91	0.00	15.05	0.25	0.01	0.00	98.86
NEBC-43	6549892	460825	13.75	23.13	0.05	0.00	0.62	0.19	41.44	0.00	20.43	0.15	0.01	0.00	99.76
NEBC-43	6549892	460825	13.41	16.86	0.10	0.00	1.78	0.03	45.02	0.07	23.08	0.21	0.00	0.00	100.57
NEBC-43	6549892	460825	10.09	13.72	0.12	0.03	1.72	0.00	44.25	0.09	28.71	0.12	0.12	0.00	98.97
NEBC-43	6549892	460825	10.25	18.20	0.08	0.00	1.18	0.02	42.92	0.09	26.68	0.07	0.00	0.00	99.49
NEBC-43	6549892	460825	9.40	16.99	0.12	0.00	1.61	0.05	41.43	0.02	30.21	0.21	0.00	0.00	100.04
NEBC-43	6549892	460825	12.16	25.35	0.03	0.00	0.10	0.14	37.75	0.07	23.37	0.14	0.05	0.00	99.18
NEBC-43	6549892	460825	12.74	29.54	0.06	0.03	0.04	0.25	36.69	0.07	19.70	0.10	0.00	0.00	99.21
NEBC-43	6549892	460825	10.99	23.46	0.07	0.01	0.13	0.18	40.22	0.13	24.50	0.13	0.01	0.00	99.83
NEBC-43	6549892	460825	12.24	12.86	0.14	0.01	2.21	0.00	46.85	0.00	24.83	0.22	0.01	0.00	99.36
NEBC-43	6549892	460825	15.61	30.27	0.09	0.01	0.19	0.16	36.32	0.07	16.13	0.27	0.00	0.00	99.12
NEBC-43	6549892	460825	13.44	28.49	0.06	0.00	0.27	0.19	36.36	0.07	21.12	0.18	0.03	0.00	100.21
NEBC-43	6549892	460825	7.45	16.44	0.07	0.00	1.59	0.01	40.46	0.13	32.79	0.12	0.00	0.00	99.07
NEBC-43	6549892	460825	13.57	27.14	0.08	0.00	0.11	0.19	40.56	0.04	18.75	0.17	0.05	0.00	100.66
NEBC-43	6549892	460825	12.92	22.50	0.05	0.01	0.14	0.10	46.61	0.03	17.95	0.12	0.00	0.00	100.42
NEBC-43	6549892	460825	13.49	31.93	0.04	0.00	0.01	0.15	35.33	0.00	18.57	0.09	0.03	0.00	99.63
NEBC-43	6549892	460825	13.68	33.26	0.05	0.00	0.24	0.15	30.84	0.00	20.78	0.17	0.03	0.00	99.22
NEBC-43	6549892	460825	14.12	30.68	0.08	0.00	0.34	0.16	34.23	0.09	20.49	0.13	0.03	0.00	100.36
NEBC-43	6549892	460825	9.13	14.26	0.08	0.02	0.43	0.14	47.50	0.08	27.20	0.09	0.00	0.00	98.93
NEBC-43	6549892	460825	10.39	14.36	0.30	0.00	0.02	0.21	52.59	0.10	21.81	0.07	0.09	0.00	99.94
NEBC-43	6549892	460825	14.26	28.30	0.15	0.00	0.10	0.17	40.21	0.06	16.26	0.09	0.02	0.00	99.62
NEBC-43	6549892	460825	13.55	27.96	0.03	0.01	0.08	0.19	37.02	0.10	21.41	0.14	0.00	0.00	100.50
NEBC-43	6549892	460825	13.05	24.51	0.04	0.00	0.04	0.21	42.04	0.03	19.52	0.10	0.00	0.00	99.55
NEBC-43	6549892	460825	15.67	16.11	0.12	0.00	1.35	0.00	48.29	0.00	17.33	0.33	0.08	0.00	99.27
NEBC-43	6549892	460825	11.78	13.23	0.13	0.03	0.22	0.08	52.25	0.06	22.16	0.21	0.02	0.00	100.16
NEBC-43	6549892	460825	11.16	5.98	0.11	0.02	0.20	0.01	61.26	0.11	19.96	0.10	0.10	0.00	99.02
NEBC-43	6549892	460825	13.45	25.24	0.08	0.02	0.04	0.22	42.15	0.00	19.08	0.23	0.00	0.00	100.50
NEBC-44	6549887	461981	10.79	26.39	0.07	0.01	0.34	0.15	39.02	0.06	22.33	0.07	0.00	0.00	99.24
NEBC-44	6549887	461981	12.42	16.79	0.13	0.01	2.03	0.00	40.52	0.09	26.23	0.19	0.03	0.00	98.43
NEBC-44	6549887	461981	12.96	11.66	0.09	0.00	0.23	0.04	56.90	0.00	16.87	0.09	0.00	0.00	98.83

TABLE 4 (CONTINUED)

Sample ID	UTM Northing	UTM Easting	MgO	Al_2O_3	SiO_2	CaO	TiO_2	V_2O_3	Cr_2O_3	MnO	FeO	NiO	Nb_2O_5	Ta_2O_5	Total
NEBC-44	6549887	461981	11.03	25.59	0.07	0.00	0.32	0.15	35.51	0.05	26.09	0.19	0.00	0.00	98.99
NEBC-44	6549887	461981	12.41	10.27	0.07	0.00	0.27	0.03	59.80	0.00	16.76	0.11	0.00	0.00	99.72
NEBC-44	6549887	461981	14.19	29.75	0.07	0.00	0.34	0.13	37.45	0.01	17.36	0.13	0.10	0.00	99.52
NEBC-44	6549887	461981	10.70	27.66	0.14	0.00	0.07	0.20	38.72	0.50	21.51	0.08	0.07	0.00	99.64
NEBC-44	6549887	461981	15.25	28.68	0.05	0.01	0.05	0.22	40.15	0.00	15.39	0.16	0.04	0.00	100.01
NEBC-44	6549887	461981	9.87	28.02	0.03	0.00	0.43	0.20	33.78	0.13	26.52	0.20	0.02	0.00	99.19
NEBC-44	6549887	461981	10.58	10.04	0.07	0.00	0.19	0.05	59.24	0.00	19.14	0.02	0.00	0.00	99.32
NEBC-44	6549887	461981	9.05	18.28	0.05	0.00	1.94	0.05	37.96	0.10	31.60	0.19	0.00	0.00	99.21
NEBC-44	6549887	461981	4.95	8.21	0.06	0.00	0.24	0.12	47.99	0.22	36.59	0.04	0.00	0.00	98.42
NEBC-44	6549887	461981	9.04	14.60	0.05	0.00	0.23	0.08	50.01	0.75	23.70	0.05	0.00	0.00	98.51
NEBC-44	6549887	461981	14.79	30.22	0.04	0.00	0.09	0.20	38.46	0.04	15.58	0.11	0.00	0.00	99.51
NEBC-44	6549887	461981	11.77	16.37	0.13	0.01	1.67	0.02	43.09	0.00	25.74	0.19	0.00	0.00	99.00
NEBC-44	6549887	461981	8.37	4.70	0.11	0.02	1.63	0.00	48.51	0.15	34.13	0.29	0.00	0.00	97.91
NEBC-44	6549887	461981	11.83	27.40	0.07	0.01	0.34	0.22	36.43	0.30	22.57	0.12	0.03	0.00	99.33
NEBC-44	6549887	461981	16.00	30.06	0.09	0.02	0.23	0.08	36.41	0.00	15.48	0.17	0.05	0.00	98.57
NEBC-44	6549887	461981	15.67	23.12	0.16	0.01	0.28	0.09	44.26	0.00	15.27	0.29	0.04	0.00	99.19
NEBC-44	6549887	461981	14.34	30.33	0.09	0.00	0.00	0.16	38.18	0.01	16.54	0.11	0.03	0.00	99.81
NEBC-44	6549887	461981	13.12	9.02	0.13	0.00	0.32	0.04	57.62	0.00	19.14	0.19	0.00	0.00	99.59
NEBC-44	6549887	461981	13.98	17.34	0.13	0.00	1.59	0.00	43.87	0.00	21.69	0.28	0.04	0.00	98.91
NEBC-44	6549887	461981	13.15	12.82	0.12	0.00	0.53	0.06	46.63	0.09	25.19	0.12	0.00	0.00	98.70
NEBC-44	6549887	461981	14.52	24.10	0.10	0.00	0.43	0.17	41.94	0.00	17.79	0.16	0.00	0.00	99.20
NEBC-44	6549887	461981	11.71	18.24	0.05	0.01	0.06	0.24	49.57	0.04	20.98	0.08	0.00	0.00	100.97
NEBC-45	6440574	516839	16.81	32.17	0.12	0.00	0.05	0.18	35.20	0.00	14.98	0.27	0.00	0.00	99.78
NEBC-45	6440574	516839	15.44	29.91	0.11	0.01	0.61	0.19	36.31	0.02	17.15	0.20	0.00	0.00	99.95
NEBC-45	6440574	516839	12.39	29.42	0.07	0.00	0.25	0.22	33.46	0.06	22.84	0.18	0.00	0.00	98.88
NEBC-45	6440574	516839	12.13	27.69	0.03	0.01	0.16	0.18	34.33	0.10	24.88	0.13	0.00	0.00	99.64
NEBC-45	6440574	516839	14.50	16.39	0.14	0.00	1.34	0.00	47.33	0.00	19.21	0.17	0.00	0.00	99.08
NEBC-45	6440574	516839	12.95	28.00	0.06	0.01	0.01	0.19	37.90	0.07	20.67	0.16	0.00	0.00	100.02
NEBC-45	6440574	516839	14.82	32.88	0.04	0.03	0.01	0.21	36.26	0.01	15.77	0.19	0.00	0.00	100.20
NEBC-45	6440574	516839	13.90	27.78	0.05	0.00	0.08	0.16	40.25	0.00	18.08	0.08	0.00	0.00	100.38
NEBC-45	6440574	516839	13.33	27.09	0.08	0.00	0.00	0.26	41.94	0.05	17.31	0.12	0.06	0.00	100.23
NEBC-46	6439810	516735	13.05	33.85	0.02	0.03	0.18	0.25	31.22	0.09	20.48	0.15	0.07	0.00	99.40
NEBC-47	6360037	509264	17.87	33.35	0.18	0.00	0.09	0.13	33.96	0.07	13.23	0.23	0.00	0.00	99.10
NEBC-47	6360037	509264	11.58	16.85	0.10	0.00	1.26	0.00	43.86	0.05	25.25	0.12	0.00	0.00	99.06
NEBC-47	6360037	509264	12.74	28.42	0.08	0.00	0.35	0.17	34.53	0.08	22.06	0.12	0.00	0.00	98.55
NEBC-50	6222613	645018	13.98	19.51	0.13	0.02	0.00	0.14	50.52	0.00	15.26	0.07	0.00	0.00	99.63
NEBC-50	6222613	645018	10.58	6.81	0.12	0.02	0.33	0.06	55.04	0.12	25.13	0.14	0.10	0.00	98.44
NEBC-50	6222613	645018	9.12	8.52	0.06	0.00	0.25	0.00	52.63	0.12	26.50	0.05	0.00	0.00	97.24
NEBC-50	6222613	645018	11.44	20.42	0.06	0.00	1.26	0.24	40.77	0.08	23.75	0.21	0.00	0.00	98.23
NEBC-50	6222613	645018	8.93	11.73	0.08	0.00	0.04	0.21	55.50	0.03	22.52	0.05	0.00	0.00	99.09
NEBC-50	6222613	645018	10.41	9.66	0.12	0.00	0.84	0.11	39.47	0.04	36.83	0.11	0.00	0.00	97.58
NEBC-50	6222613	645018	10.93	24.43	0.07	0.00	0.03	0.21	42.20	0.05	21.05	0.06	0.00	0.00	99.02
NEBC-50	6222613	645018	11.81	8.10	0.10	0.00	0.28	0.00	50.75	0.12	27.17	0.18	0.00	0.00	98.49
NEBC-52	6176129	611299	8.40	7.47	0.12	0.00	0.06	0.23	58.66	0.05	23.42	0.13	0.05	0.00	98.58
NEBC-52	6176129	611299	11.40	20.28	0.08	0.01	0.03	0.21	47.25	0.02	20.64	0.05	0.07	0.00	100.04
NEBC-52	6176129	611299	14.54	18.37	0.13	0.02	0.83	0.10	45.25	0.01	19.88	0.18	0.00	0.00	99.30
NEBC-52	6176129	611299	11.44	16.53	0.09	0.01	0.16	0.16	50.09	0.02	20.95	0.03	0.00	0.00	99.48
NEBC-52	6176129	611299	13.58	26.74	0.06	0.00	0.11	0.19	40.90	0.05	18.51	0.10	0.00	0.00	100.23
NEBC-52	6176129	611299	12.95	18.62	0.12	0.00	1.65	0.02	39.56	0.00	26.03	0.14	0.00	0.00	99.09
NEBC-52	6176129	611299	7.37	13.23	0.08	0.02	0.31	0.26	44.89	0.20	31.74	0.13	0.05	0.00	98.29
NEBC-52	6176129	611299	10.36	21.98	0.08	0.00	0.04	0.19	44.91	0.05	22.04	0.03	0.00	0.00	99.67
NEBC-54	6152653	530479	11.20	14.64	0.08	0.00	0.58	0.09	47.08	0.00	25.65	0.06	0.04	0.00	99.43
NEBC-57	6354768	661877	16.88	32.72	0.13	0.03	0.53	0.08	31.56	0.07	17.14	0.29	0.00	0.00	99.43
NEBC-57	6354768	661877	13.22	26.29	0.09	0.01	0.23	0.29	40.37	0.04	18.68	0.22	0.00	0.00	99.43
NEBC-57	6354768	661877	16.08	26.44	0.15	0.01	0.39	0.15	41.45	0.05	16.23	0.19	0.03	0.00	101.18
NEBC-58	6612910	564017	13.89	29.38	0.07	0.02	0.20	0.18	36.46	0.15	19.78	0.14	0.04	0.00	100.30
NEBC-58	6612910	564017	5.80	11.10	0.07	0.01	0.34	0.12	45.14	0.23	35.90	0.13	0.00	0.00	98.84
NEBC-58	6612910	564017	6.64	15.57	0.07	0.01	0.36	0.13	45.04	0.17	30.52	0.17	0.00	0.00	98.67
NEBC-58	6612910	564017	13.09	24.42	0.14	0.01	0.59	0.13	41.49	0.08	19.08	0.17	0.00	0.00	99.20
NEBC-58	6612910	564017	14.40	20.02	0.16	0.00	1.60	0.05	40.96	0.02	22.17	0.18	0.00	0.00	99.57

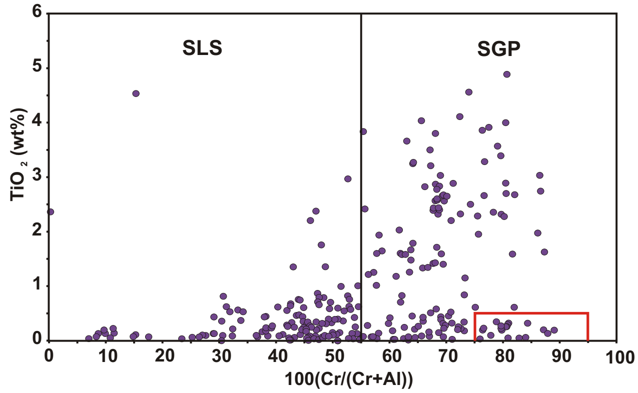

Figure 9. Cr-spinel TiO_2-100[Cr/(Cr+Al)] diagram. The majority of the chromites plot within the garnet peridotite field. At least 16 grains have compositions compatible with chromites found as inclusions in diamonds, indicated by the rectangle. SLS – spinels from spinel peridotites, SGP – spinels from garnet peridotites; fields from Ramsey and Tompkins (1994).

interpreted as kimberlite related. A substantial portion of spinels from these samples have the characteristics of lamproite-derived spinel; however, it is possible that some of the spinel from NEBC-7 originated from lamprophyre dikes or diatremes related to the Aley carbonatite complex (also referred to as the Ospika pipe), which is located less than 100 km from the sample site. At this stage, microprobe analyses of spinels from this complex have not been undertaken.

Ilmenite

Ilmenite is one of the most widely used KIMs. It is a common member of the megacryst suite, and the major compounds TiO_2, MgO, CrO_2, MnO_2 and Fe_2O_3 are used to distinguish kimberlitic ilmenites from those that are non-kimberlitic (Wyatt *et al.*, 2004). Seven grains of ilmenite were picked and analyzed (Table 5). Based on the TiO_2-MgO plot (Fig. 10), all the analyzed ilmenite indicator grains plot within the kimberlite field (*i.e.,* to the right of the curve marked 'A').

As shown in Figure 11, the Cr_2O_3-MgO plot also suggests that the same seven grains identified in Figure 10 are associated with kimberlite. The fields of typical North

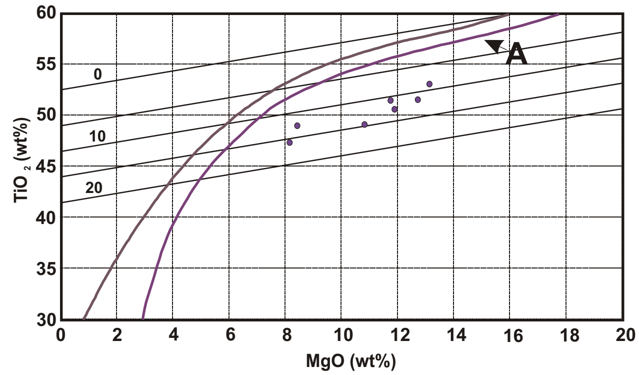

Figure 10. Ilmenite TiO_2-MgO discrimination plot (*after* Wyatt *et al.*, 2004). Seven grains plot within the kimberlite field, which is located to the right of the curve marked 'A'.

American, South African (on- and off-craton) and Australian kimberlitic ilmenites are provided in Figure 11 for reference, and are based on data from Wyatt *et al.* (2004). Six of these ilmenites come from samples collected in the Etsho Plateau region east of Fort Nelson and one originates from a sample collected approximately 110 km north of Fort St. John near the BC-Alberta border (Fig. 2).

Olivine

Olivine is considered a useful KIM in cold climates. Olivine is the most common rock-forming mineral in kimberlites; however, it is also present in a variety of other ultramafic rocks, basalts and mantle xenoliths in BC (Voormeij and Simandl, 2004a, b). Due to its occurrence in diverse rock types, olivine is less diagnostic and it does not provide as much information regarding the diamond potential of northeastern BC as do garnets, ilmenites, spinels or Cr-diopsides. Nevertheless, in association with other indicator minerals, olivine may play an important role in the evaluation of indicator mineral anomalies. Olivine from kimberlites and peridotites is MgO-rich (close to the forsterite end-member of the olivine solid solution series) and is colourless to pale yellow or pale green. Its chemistry is characterized by Mg numbers $[100*Mg^{+2}/(Mg^{+2}+Fe^{+2})]$ between 84 and 95 and notable traces of NiO. Most of the olivines from the study area fall within that range (Table 6; Fig. 12). Olivines that are found as inclusions in diamonds

TABLE 5. CHEMICAL COMPOSITION OF ILMENITES; FOR SAMPLE LOCATIONS SEE TABLE 1 AND FIGURE 2.

Sample ID	UTM Northing	UTM Easting	MgO	Al_2O_3	SiO_2	CaO	TiO_2	V_2O_3	Cr_2O_3	MnO	FeO	NiO	Nb_2O_5	Ta_2O_5	Total
NEBC-27	6515567	538244	8.16	0.10	0.00	0.02	47.39	0.00	1.68	0.26	41.06	0.06	0.16	0.00	98.89
NEBC-38	6489088	545698	11.87	0.55	0.05	0.03	50.60	0.00	1.81	0.26	33.07	0.11	0.22	0.02	98.59
NEBC-39	6488921	548332	12.70	0.58	0.05	0.01	51.54	0.00	0.95	0.19	32.01	0.07	0.15	0.00	98.25
NEBC-44	6549887	461981	8.42	0.16	0.04	0.00	48.97	0.00	0.97	0.27	40.09	0.10	0.31	0.01	99.35
NEBC-44	6549887	461981	13.11	0.37	0.05	0.04	53.05	0.00	1.07	0.24	30.73	0.12	0.16	0.03	98.97
NEBC-55	6510906	565930	10.82	0.48	0.00	0.05	49.09	0.00	0.10	0.28	36.87	0.03	0.15	0.02	97.89
NEBC-57	6354768	661877	11.75	0.61	0.06	0.01	51.48	0.00	0.42	0.26	33.93	0.00	0.13	0.00	98.64

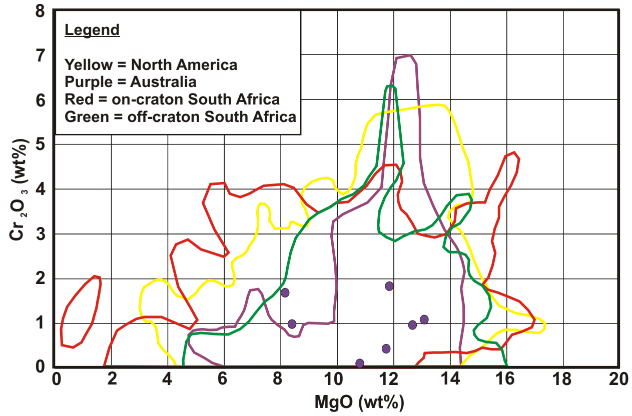

Figure 11. Ilmenite Cr_2O_3-MgO discrimination plot (*after* Haggerty, 1991). Simplified fields representing North American, Australian and South African (on- and off-craton) kimberlitic ilmenites derived from plots by Wyatt *et al*. (2004). All seven ilmenite grains from northeastern BC plot within the fields representing South African and North American kimberlitic ilmenites. Five of the seven grains also fall within the field of Australian kimberlitic ilmenites.

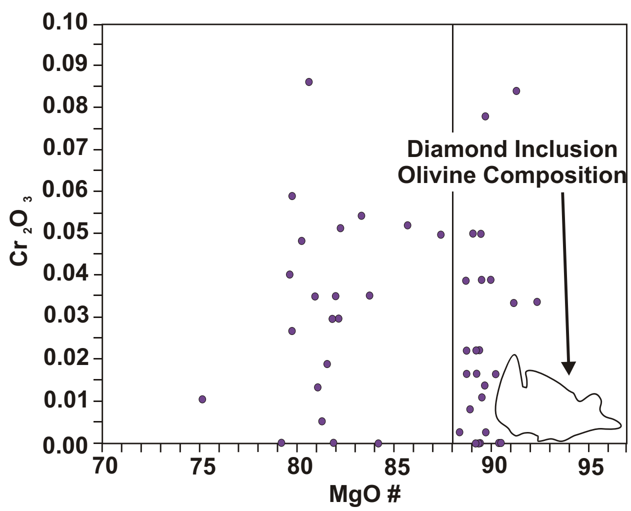

Figure 12. Olivine Cr_2O_3-Mg# discrimination plot. Olivines with an Mg# >88 are commonly, but not uniquely, associated with kimberlites. Twenty-six grains from this study have an Mg# >88. The outline of olivine compositions found as solid inclusions in diamonds is from Fipke *et al.* (1995). None of the grains recovered during this study fit that profile.

commonly plot in an irregularly shaped field on Fipke *et. al.*'s (1995) Cr_2O_3-Mg# discrimination plot (Fig. 12).

The Mg-rich variety of olivine, identified in samples from northeastern BC, is commonly pale yellow-green in colour, equidimensional, subrounded to rounded, and has a fresh appearance. Microprobe data on 47 olivine grains recovered from collected samples are presented in Table 6 and plotted on the Cr_2O_3-Fo diagram (Fig. 12). None of the olivine grains collected during this study fall within the compositional field of olivines found as inclusions in diamonds.

The concentrations of olivine in samples NEBC-16 and 18 suggest that these olivines may be derived from known ultramafic rocks west of the study area, rocks that are part of the Cache Creek and Slide Mountain terranes, or from alkaline pipes or dikes in the Kechika River area. This interpretation is consistent with Mathew's (1980) inference of the glacial history of the area and thus expected sediment transportation patterns.

DIAMOND AND FLUORITE

One of the most intriguing aspects of this study is a recovery of a clear diamond that cannot be attributed to a specific sample. It was recovered from the -1.18+0.85 mm fraction of heavy mineral concentrate derived from sample NEBC-11. The stone is a transparent diamond (Fig. 3) with crystal faces measuring 1.05×1.03×0.73 mm and weighing 1.34 mg (0.0067 carat). Apparently, because of its size and colourless nature, this diamond may have been sitting on the screen (or lodged within the screen) for an unspecified length of time without being detected and before making its way through the screen. If this explanation is correct, the diamond may have come from any of the ten samples numbered from NEBC-1 to 10, which were processed before sample NEBC-11 entered the system. This diamond may have also come from samples belonging to a previous client (contamination). Therefore, the sample from which this diamond was recovered cannot be established.

Besides the above described diamond, the heavy mineral fraction of sample NEBC-11 also contained abundant fluorite. Fluorite (CaF_2) is a relatively soft (4 on Moh's hardness scale), brittle mineral with well-developed cleavage. Fluorite is commonly found as an ore or gangue mineral in Mississippi Valley-type Pb-Zn deposits (Leach and Sangster, 1993), vein-type fluorite, fluorite-barite veins (Hora, 1996a, b) and carbonatite deposits (Birkett and Simandl, 1999). It is relatively common in samples from northeastern BC, and it is particularly abundant in concentrates from samples NEBC-11 and 12, where it is the most abundant nonmagnetic heavy mineral. The fluorite is most likely derived from local sources, such as the known fluorite occurrences of Mile 397, Stone, Rep 6, Ctv T-7 and Hope H-3 (Fig. 13).

There is no established association between diamonds and fluorite in classical kimberlite or lamproite-hosted diamond deposits; however, both of these minerals have a similar density (3.52 and 3.13 g/cm^3, respectively) and are nonmagnetic. The lack of obvious genetic association between diamond and fluorite in primary diamond deposits is probably the main reason why the SGS Lakefield Research laboratory interpreted this diamond as probable contamination. The diamond does not show visible signs that are characteristic of alluvial diamonds, such as scuffing and scratching concentrated at the edges of the crystals, percussion marks and green or brown spots, which are related to radiation damage. The lack of these signs prevent speculation whether this diamond was derived directly from a primary diamond deposit (with little glacial or glaciofluvial or fluvial transport) or if it was transported for long distances from its primary source.

DISCUSSION AND RECOMMENDATIONS

The geology of the Precambrian basement in northeastern BC is poorly understood, but there are indications that it could be more favourable for diamond exploration than previously reported (Simandl, 2004; Simandl and Davis, 2005). Therefore, the results of this study are important, particularly if the modified diamondiferous mantle

TABLE 6. CHEMICAL COMPOSITION AND MG# OF OLIVINES; FOR SAMPLE LOCATIONS SEE TABLE 1 AND FIGURE 2.

Sample ID	UTM Northing	UTM Easting	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	Cr_2O_3	MnO	FeO	Total	Mg #
NEBC-16	6548532	340361	0.02	49.91	0.00	40.08	0.01	0.06	0.02	0.00	0.14	10.19	100.44	0.897276791
NEBC-16	6548532	340361	0.02	41.66	0.03	38.44	0.00	0.28	0.01	0.00	0.19	19.48	100.11	0.792166542
NEBC-16	6548532	340361	0.03	50.06	0.03	40.05	0.00	0.05	0.02	0.00	0.12	9.44	99.79	0.904375441
NEBC-16	6548532	340361	0.00	50.00	0.00	40.72	0.00	0.05	0.00	0.02	0.14	9.66	100.59	0.902232176
NEBC-16	6548532	340361	0.01	50.56	0.16	40.52	0.00	0.13	0.00	0.08	0.09	8.60	100.16	0.912901199
NEBC-16	6548532	340361	0.00	48.76	0.02	39.92	0.01	0.11	0.00	0.00	0.14	11.42	100.39	0.883907029
NEBC-17	6568296	330650	0.03	39.01	0.04	37.16	0.00	0.24	0.03	0.01	0.22	23.02	99.76	0.751307804
NEBC-18	6579659	332851	0.00	49.16	0.04	40.27	0.02	0.07	0.01	0.01	0.15	10.90	100.62	0.889381538
NEBC-18	6579659	332851	0.02	48.79	0.04	39.74	0.01	0.11	0.02	0.04	0.10	11.07	99.95	0.887062621
NEBC-18	6579659	332851	0.00	49.71	0.01	40.53	0.00	0.04	0.03	0.04	0.13	10.37	100.86	0.895221689
NEBC-18	6579659	332851	0.00	48.84	0.03	40.02	0.00	0.06	0.00	0.02	0.18	11.04	100.20	0.887437969
NEBC-18	6579659	332851	0.00	48.98	0.03	40.15	0.00	0.05	0.00	0.00	0.18	10.50	99.88	0.892654771
NEBC-18	6579659	332851	0.00	44.09	0.02	38.25	0.01	0.22	0.04	0.03	0.19	17.05	99.89	0.821757035
NEBC-18	6579659	332851	0.03	43.75	0.04	38.96	0.00	0.24	0.00	0.00	0.17	17.21	100.40	0.819268606
NEBC-18	6579659	332851	0.01	49.19	0.02	39.89	0.00	0.07	0.01	0.00	0.16	10.50	99.85	0.893045135
NEBC-18	6579659	332851	0.02	49.11	0.04	40.21	0.00	0.07	0.00	0.02	0.11	10.54	100.12	0.892556252
NEBC-18	6579659	332851	0.01	49.09	0.01	39.82	0.00	0.06	0.02	0.00	0.21	10.55	99.78	0.892381564
NEBC-18	6579659	332851	0.01	43.59	0.05	38.51	0.02	0.21	0.02	0.01	0.19	18.13	100.76	0.810864545
NEBC-18	6579659	332851	0.00	48.90	0.05	39.72	0.01	0.11	0.01	0.05	0.18	10.69	99.71	0.890753872
NEBC-18	6579659	332851	0.04	49.03	0.05	40.23	0.01	0.09	0.03	0.00	0.19	10.33	99.99	0.894318803
NEBC-18	6579659	332851	0.02	42.46	0.04	38.19	0.00	0.21	0.00	0.05	0.24	18.59	99.80	0.802767803
NEBC-18	6579659	332851	0.05	43.16	0.03	38.80	0.01	0.24	0.02	0.04	0.27	18.08	100.70	0.809688989
NEBC-18	6579659	332851	0.01	45.25	0.06	38.96	0.00	0.22	0.00	0.04	0.21	15.63	100.37	0.837703925
NEBC-18	6579659	332851	0.02	43.51	0.04	38.91	0.01	0.20	0.02	0.02	0.20	17.51	100.43	0.815819074
NEBC-18	6579659	332851	0.03	41.85	0.05	38.24	0.00	0.22	0.05	0.06	0.27	18.94	99.72	0.79751405
NEBC-18	6579659	332851	0.02	46.55	0.04	39.47	0.00	0.09	0.01	0.05	0.21	13.86	100.30	0.856846945
NEBC-18	6579659	332851	0.02	45.39	0.03	38.78	0.00	0.08	0.02	0.00	0.17	15.18	99.66	0.8420612
NEBC-18	6579659	332851	0.03	49.35	0.06	40.58	0.00	0.09	0.03	0.02	0.14	10.60	100.90	0.892413402
NEBC-18	6579659	332851	0.01	43.65	0.05	38.79	0.00	0.24	0.01	0.03	0.18	17.26	100.21	0.818503832
NEBC-18	6579659	332851	0.00	45.09	0.03	39.13	0.02	0.22	0.02	0.05	0.21	16.06	100.83	0.833500275
NEBC-18	6579659	332851	0.02	49.48	0.03	40.00	0.02	0.08	0.00	0.08	0.12	10.12	99.94	0.897045379
NEBC-18	6579659	332851	0.01	49.73	0.03	40.28	0.00	0.11	0.00	0.05	0.13	10.44	100.78	0.894647235
NEBC-18	6579659	332851	0.00	43.65	0.04	38.59	0.00	0.21	0.00	0.01	0.25	17.89	100.63	0.81304251
NEBC-18	6579659	332851	0.00	43.70	0.05	38.79	0.00	0.24	0.00	0.04	0.20	17.10	100.11	0.819991566
NEBC-18	6579659	332851	0.01	42.87	0.07	38.11	0.00	0.26	0.05	0.09	0.22	18.31	99.99	0.806682982
NEBC-18	6579659	332851	0.00	47.65	0.05	39.73	0.01	0.07	0.04	0.05	0.13	12.23	99.96	0.874143503
NEBC-18	6579659	332851	0.00	49.38	0.02	40.00	0.00	0.07	0.00	0.02	0.15	10.44	100.09	0.893974877
NEBC-18	6579659	332851	0.00	42.61	0.08	38.64	0.00	0.24	0.00	0.03	0.19	19.26	101.06	0.797693604
NEBC-18	6579659	332851	0.00	50.25	0.02	40.55	0.01	0.05	0.00	0.00	0.14	9.41	100.42	0.904945707
NEBC-18	6579659	332851	0.00	49.28	0.02	40.28	0.01	0.08	0.04	0.01	0.15	10.28	100.13	0.895254953
NEBC-18	6579659	332851	0.02	49.09	0.02	39.94	0.01	0.08	0.00	0.02	0.15	11.10	100.43	0.887455775
NEBC-34	6539551	581206	0.02	49.82	0.04	40.58	0.02	0.06	0.01	0.04	0.21	9.88	100.68	0.899918975
NEBC-37	6570249	567872	0.02	51.57	0.00	41.06	0.00	0.04	0.00	0.03	0.13	7.61	100.46	0.923568485
NEBC-46	6439810	516735	0.01	50.61	0.00	40.63	0.00	0.00	0.00	0.03	0.08	8.76	100.14	0.911496993
NEBC-50	6222613	645018	0.00	49.18	0.02	39.99	0.00	0.06	0.01	0.01	0.15	10.12	99.54	0.896521253
NEBC-50	6222613	645018	0.00	44.25	0.04	38.82	0.00	0.22	0.00	0.05	0.25	17.01	100.64	0.822622844
NEBC-52	6176129	611299	0.01	42.31	0.02	38.37	0.01	0.21	0.02	0.04	0.23	19.24	100.47	0.796719761

root exploration model is applied to northeastern BC (Simandl, 2004).

There are several areas with anomalous counts of kimberlite indicator minerals (Fig. 2). As indicated in the text, these minerals may not have the same source, a concept supported by the glacial history of the area. Samples collected from areas close to the Etsho Plateau are of particular interest because they contain a variety of indicator minerals, including pyrope garnets, Cr-spinel, olivine, ilmenite and Cr-diopside.

Sample NEBC-50, from south of Taylor (Fig. 2), contains 16 indicator grains consisting of Cr-spinel, Cr-diopside and olivine. Sample NEBC-7, from about 100 km northwest of Hudson Hope, is unique because it contains 71 Cr-spinel grains. A direct correlation between the number of indicator mineral grains and proximity to their source is unlikely, as different sampling media were used. As expected, some of the highest indicator mineral counts come from active river sediments, where natural concentration was anticipated.

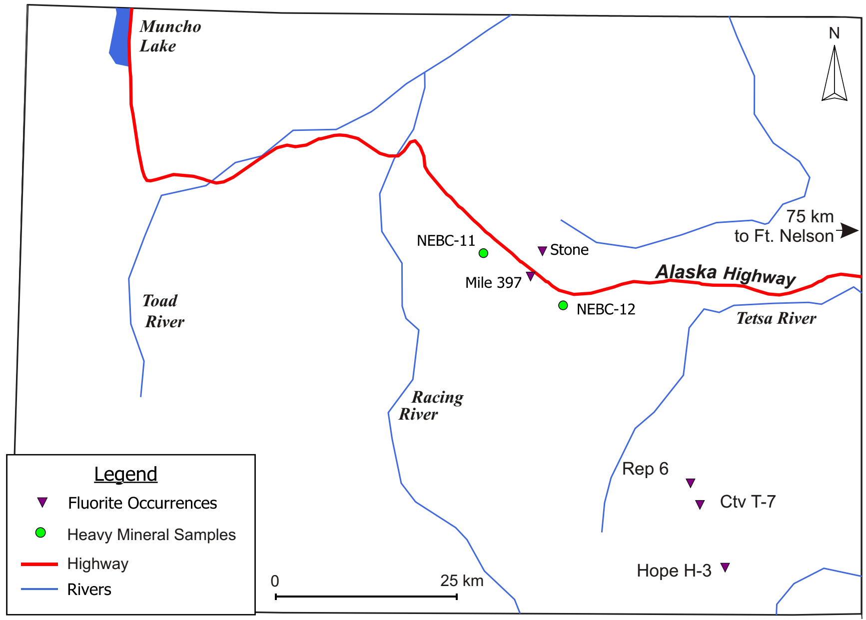

Figure 13. Detailed map showing the location of samples NEBC-11 and 12, which contain the highest concentrations of fluorite grains. Sample NEBC-11 was originally reported to contain a diamond. The known fluorite occurrences are shown as triangles. Their descriptions are available through the BC Ministry of Energy, Mines and Petroleum Resources website at http://www.em.gov.bc.ca/mining/geolsurv/minfile/search/.

In the following discussion, the distribution of anomalous glaciofluvial samples in relation to the maximum extent of the Laurentide, Cordilleran and Rocky Mountain glacial systems, which is approximated by Mathews' line on Figure 2 (Mathews, 1980), is considered.

The first important observation is that all the samples that contain pyrope garnets are located east of Mathews' line, mostly between Fort Nelson and the Etsho Plateau. The samples from this region are characterized by a variety of indicator minerals. They contain G9, G10, G12 and G1 garnets, ilmenite, Cr-spinel and Cr-diopside, as well as G3 garnets recovered during the previous field season (Levson *et al.*, 2004; Simandl *et al.*, 2005). Possible sources for these garnets are known diatremes located northeast of the study area within the Slave Craton, known diatremes of the Buffalo Head Terrane, or undiscovered pipes cutting the Mesozoic to Paleozoic sedimentary rocks in the Etsho Plateau region. Some of these grains may have been previously reworked and incorporated into the sedimentary sequence itself. There is a rapid decline in KIM concentrations in stream sediments with increasing distance from pipes in the Buffalo Head Hills area (Friske *et al*., 2003). This suggests that these kimberlites are unlikely sources for high concentrations of indicator minerals reported in this study and in Simandl *et al.* (2005). Currently, there are no high concentrations of KIMs reported along the BC-Northwest Territories border. This makes the local origin of the garnets a viable hypothesis. The northern portion of BC's Alkaline Province is not known to contain primary lithologies such as those described by Canil *et al.* (2005); therefore it is an unlikely source of these garnets.

If the samples west of Mathews' line with the highest KIM contents are examined, Cr-spinel and olivine with some Cr-diopside are the potential indicator minerals. The source of these minerals is more difficult to interpret than pyrope garnets or ilmenites because the distinction between Cr-spinels associated with kimberlites and lamproites from those associated with other ultramafic rocks, such as layered intrusions, ophiolites, Alaskan complexes, boninites and minerals from xenoliths in basalt, is a complex procedure. Ultramafic rocks are common in the Cache Creek and the Slide Mountain terranes (Voormeij and Simandl, 2004a, b), but these terranes occur well to the west of the study area.

The details of the interpretation will be the subject of a related paper; however, results of the discrimination procedure are incorporated into Figure 2. The results of this study indicate that a number of Cr-diopsides and Cr-spinels may be related to alkaline intrusions located within the northern portion of the Alkaline Province, as described in Pell (1994) and Simandl (2004).

Based on a combination of discrimination methods (Simandl and Robinson, work in progress), it is possible that some of the Cr-spinels from samples NEBC-1, 7, 23, 44, 50, 52 and 58 are lamproite-related. A more detailed study of chromite morphology, as described by Lee *et al.* (2004), and some trace element analyses are required to corroborate this.

Samples from the Fort St. John area are characterized by dominant Cr-spinels and Cr-diopside kimberlite indicators. Sample NEBC-1, from northeast of Fort St. John, is an exception. It contains 22 indicator grains consisting of Cr-spinel, Cr-diopside and one G9 garnet. Sample NEBC-23 is regolith and sample NEBC-43 is bedrock, both corresponding to the Dunvegan conglomerate and containing numerous Cr-spinel grains. This finding is extremely significant because it demonstrates that at least some of the Cr-spinels were incorporated into the Upper Cretaceous Dunvegan Formation before being incorporated into surficial deposits. If these Cr-spinel grains are indeed related to kimberlites or lamproites, then the age of primary alkaline rocks from which they were derived is upper Cretaceous or older. Under those circumstances, detailed studies of the Dunvegan Formation may reveal potential heavy mineral traps favourable for formation of paleoplacer diamond deposits. Deep incisions into the Dunvegan Formation, described by Plint and Wadsworth (2003), may represent invaluable information that can help to zero in exploration on potential diamond paleoplacer targets.

The following is a series of other important points and recommendations:

- The Etsho Plateau region contains several samples that warrant further investigation. This region is particularly interesting because of the wide range of KIMs retrieved. Before designing a follow-up exploration program, samples from Simandl *et al.* (2005) should be incorporated into the database generated by this study. There are also high concentrations of non-garnet indicators in the southern part of the study area worth following up.
- Because of the uncertainty regarding the provenance of the diamond recovered, it is recommended that sites NEBC-1 to 11 be resampled and the new samples analyzed. The diamond recovered from sample NEBC-11 may have originated at any of these sites. The samples from these sites that contain high concentrations of potential KIMs are particularly worthy of follow-up. However, the possibility remains that the diamond was derived from one of the samples submitted by the previous client.
- Further studies should pay close attention to the indicator mineral content of sedimentary bedrock. Such information is invaluable in establishing the provenance of Cr-spinel and potentially other indicators in surficial materials commonly sampled by exploration companies and to assigning an age to the potential primary sources of diamonds (including possibly yet undiscovered kimberlite or lamproite pipes). It is therefore recommended to sample material from the strategically located, large-diameter boreholes that are drilled for oil and gas in the Fort Nelson and Fort St. John areas and study recovered heavy minerals.
- Heavy mineral samples should also be examined for the presence of fluorite, barite, sulphides (base metals), gold and platinum. Mississippi Valley-type (MVT) deposits and sedimentary exhalative (SEDEX) type mineralization have been reported in a number of boreholes drilled in this area for oil and gas and a number of known fluorite and barite deposits were reported in this area.
- Many samples are worthy of follow-up. Of particular interest are the samples in the Fort Nelson area that contain several indicator minerals (pyrope garnets, including G10, ± Cr-spinels, ± Cr-diopside ± olivine ± ilmenite). Samples NEBC-38 and 39 are good examples in spite of their low total indicator grain content. The final interpretation of kimberlite potential should also incorporate the data of Simandl *et al*. (2005).
- A number of samples, such as NEBC-1 and 7, contain high concentrations of Cr-spinel. Preliminary interpretation indicates that these Cr-spinels may be lamproite-derived, but this interpretation should be tested using international databases. When a potential source is identified, the composition of Cr-spinels from this source should be compared with that of spinels from anomalous samples. For example, it would be worth comparing the compositions of spinels from the Ospika pipe with those of spinels recovered from sample NEBC-7.
- Available geophysical data obtained during oil and gas exploration, particularly in the Etsho Plateau region, should be re-examined to locate anomalies that may correspond to diatremes and/or dikes.
- There is a major gap in sample coverage in the central portion of the study area, on both sides of the Mathews' line, and in the Trutch and Pink Mountain areas. At least 15 helicopter-supported samples would be required to complete reconnaissance-scale coverage in this region, east of the Mathews' line. There may not be a need for helicopter support west of this line. Samples from this area may contain indicator minerals as well.
- If the Dunvegan Formation is confirmed to contain indicator minerals, as indicated by samples NEBC-23 and 43, then paleogeomorphology could be used to focus exploration on paleoplacer deposits.

SUMMARY

Kimberlite indicator minerals, including peridotitic garnets, ilmenite, Cr-diopside, spinel (chromite) and olivine, were recovered from the -0.5+0.25 mm size fraction of heavy mineral concentrates from northeastern BC. The same indicator minerals, plus corundum and eclogitic garnets, were previously recovered from the Fort Nelson area (Simandl *et al.*, 2005). The concentrates in this study were produced from glaciofluvial sand and gravel and stream sediments. Thirty-eight of the fifty-eight samples collected in this study contain potential KIMs, some with more than one mineral type. Most of the indicator grains appear fresh and subrounded or subangular, but several have sharp edges. Garnets do not appear to have kelyphitic rims, but a few may have an orange-peel texture, suggesting that they were subject to some degree of transportation or at least local reworking.

Indicator minerals present in some samples proximal to, or on, the Etsho Plateau, occur in small-scale, low-energy glaciofluvial systems, and may have a local source perhaps somewhere on the plateau itself, as described by Simandl *et al.* (2005). A number of these samples have several types of kimberlite and diamond indicators. Other samples, particularly those occurring in large-scale, high-energy glaciofluvial systems, may not contain locally derived KIMs. Ongoing studies east of the BC-Alberta border by the Alberta Geological Survey and the Geological Survey of Canada will aid in determining if an eastern provenance for the KIMs in the Etsho Plateau area is a viable hypothesis. The Northwest Territories are another potential source of these indicator minerals. It remains to be established to what degree the till and regional stream sediment sampling will constrain these reconnaissance-scale anomalies.

For anomalies located west of Mathews' line, the indicator minerals could be locally derived or derived from diatremes located within the Alkaline Province, as reviewed by Simandl (2004). If there are no anomalies upstream or within tributaries of the rivers that were sampled, then the indicator minerals are most likely local. More work is required to determine the source of these anomalies and to confirm if these Cr-spinels are lamproite/kimberlite derived.

The Dunvegan Formation in the Fort Nelson area contains Cr-spinels (*e.g.*, samples NEBC-23 and 43). Systematic sampling and analyses of cuttings from oil and gas wells for heavy minerals is recommended to gain better background information about potential sources of these KIMs.

If the glaciofluvial and fluvial sampling in the neighbouring regions of Alberta and the Northwest Territories do not reveal high concentrations of indicator minerals, then the significance of the indicator anomalies presented on Figure 2 will be further enhanced, pointing to a local provenance.

CONCLUSION

The results of this reconnaissance kimberlite/diamond indicator mineral study, in combination with the tectonic setting of northeastern BC and most recent basement age dates, suggests that northeastern BC has potential to contain kimberlite/lamproite-hosted diamonds.

The presence of potential indicator minerals (Cr-spinels) within the Dunvegan Formation supports the hypothesis that paleoplacer diamond deposits may be present. However, this also opens the possibility that some of the KIMs in glaciofluvial or fluvial sediments may have been derived from sedimentary bedrock, rather than directly from kimberlite or lamproite pipes. Cr-spinel is particularly resistant to weathering and to transport-induced abrasion; it is a mineral that is relatively prone to recycling. Most pyrope garnets (mainly G9 and one G10), encountered in this study, come from glaciofluvial samples that are located in the Etsho Plateau region. These pyropes are associated with a variety of other KIMs, including Cr-diopside, suggesting a more proximal source. As expected, active river sediments have a high, largely Cr-spinel indicator mineral content.

The diamond reported from sample NEBC-11 may have been derived from any of the samples in the NEBC-1 to 11 series. Another possibility is that it came from samples submitted by a previous client (*i.e.*, contamination). Follow-up geological, geochemical and geophysical studies related to KIMs and diamond targets are justified in northeastern BC.

ACKNOWLEDGMENTS

The document benefited from the constructive comments of Suzanne Paradis of the Geological Survey of Canada at the Pacific Geoscience Centre, Sidney, BC, and Brian Grant of the BC Ministry of Energy, Mines and Petroleum Resources, Victoria, BC. Enriching discussions with Herman Grütter, Mineral Services Canada and John Gurney from Mineral Services Laboratories, South Africa, are gratefully acknowledged. Jan Bednarski, Geological Survey of Canada, Sidney, BC, is thanked for his insights into the Quaternary history of the region. Laura Simandl from St. Margaret's School, Victoria, BC, is thanked for photographic documentation of the fieldwork and meticulous sampling.

This study was possible due to financial support from the Rock to Riches program of the BC and Yukon Chamber of Mines and support from the BC Geological Survey and Resource Development and Geoscience Branch of the BC Ministry of Energy, Mines and Petroleum Resources.

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