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THE SEARCH FOR KIMBERLITE AND LAMPROITE INTRUSIONS IN NORTHEASTERN LABRADOR: RESULTS OF A SURFICIAL SEDIMENT SURVEY AND BEDROCK ORIENTATION STUDY

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ABSTRACT

The discoveries of gem-quality diamonds in the Northwest Territories of Canada and of microdiamonds in Greenland, both in areas having geological settings similar to portions of Labrador, prompted the Newfoundland Geological Survey to undertake a reconnaissance diamond exploration survey. The survey focused on the Nain and Makkovik structural provinces because they appear to be the best candidates for meeting the requirements of diamondiferous kimberlite and lamproite emplacement. Both are formed of Archean, or re-worked Archean, crust having the potential for thick mantle roots. Field work consisted of the collection of 64 bulk samples of surficial sediment, generally reworked glaciofluvial material. In addition, a bedrock examination was made of alkaline dykes in the Aillik Peninsula area that are superficially similar to kimberlites. Heavy-mineral separations were performed on the bulk sediment samples followed by an optical examination of a portion of the heavy-mineral fraction for kimberlite indicator minerals. Multi-element geochemical analyses were performed on the <180 µm fraction of the bulk samples. The mineralogical examination did not reveal any grains that could be ascribed with confidence to a kimberlite or lamproite origin. In particular, pyrope garnet and chromite were not identified. Green diopside grains were found but the pale-green colours suggest a low chrome content. The chemistry of the sediment samples indicates that the northern part of the Nain Province contrasts with the southern. As an example, the north has higher magnesium values suggesting a more mafic composition. An "envelope" of high arsenic values surrounds the Nain – Makkovik boundary, possible evidence of a major paleohydrothermal system. None of the dykes from the Aillik Peninsula study area contain indications that they have tapped a continental keel carrying rocks or minerals commonly considered to be indicative of the presence of diamonds. Geochemical studies of the Aillik dykes by others indicate they are dissimilar to kimberlites. Although no evidence of kimberlites nor other potentially diamondiferous intrusions was found during the laboratory examination of the Labrador sample suite of rock and sediment samples, only a small part of the area having good potential was sampled, and only a relatively small portion of the total heavy-mineral fraction from each sample was examined.

INTRODUCTION

A two-phase project involving sampling of surficial sediment and bedrock was undertaken in northeastern Labrador during the summer of 1994 to search for indications of kimberlite or lamproite intrusions. The rationale for the study (namely, to determine the possible presence of diamondiferous intrusions) and general descriptions of bedrock, surficial geology and field procedures have already been given in a previous report (Ryan and McConnell, 1995). These are summarized here, the main emphasis of this report being the data derived from the detailed examination of the surficial samples that were collected.

Diamonds have been found during the past 5 years in kimberlite host rocks in the Archean Slave Province in the Northwest Territories. Diamond-bearing kimberlites have also been identified in Greenland in terrane that is thought to have once been contiguous with northeast Labrador. Archean rocks similar in structural setting to both of these areas occur in Labrador in the Nain Province (which includes the Saglek Block in the north and the Hopedale Block in the south) and the Makkovik Province of eastern Labrador. Archean rocks are also found in the Superior Province in western Labrador. Field work in 1994 focused on the Nain and Makkovik provinces (Figure 1), with the bedrock study being undertaken only in the latter.

[1] Labrador Mapping Section

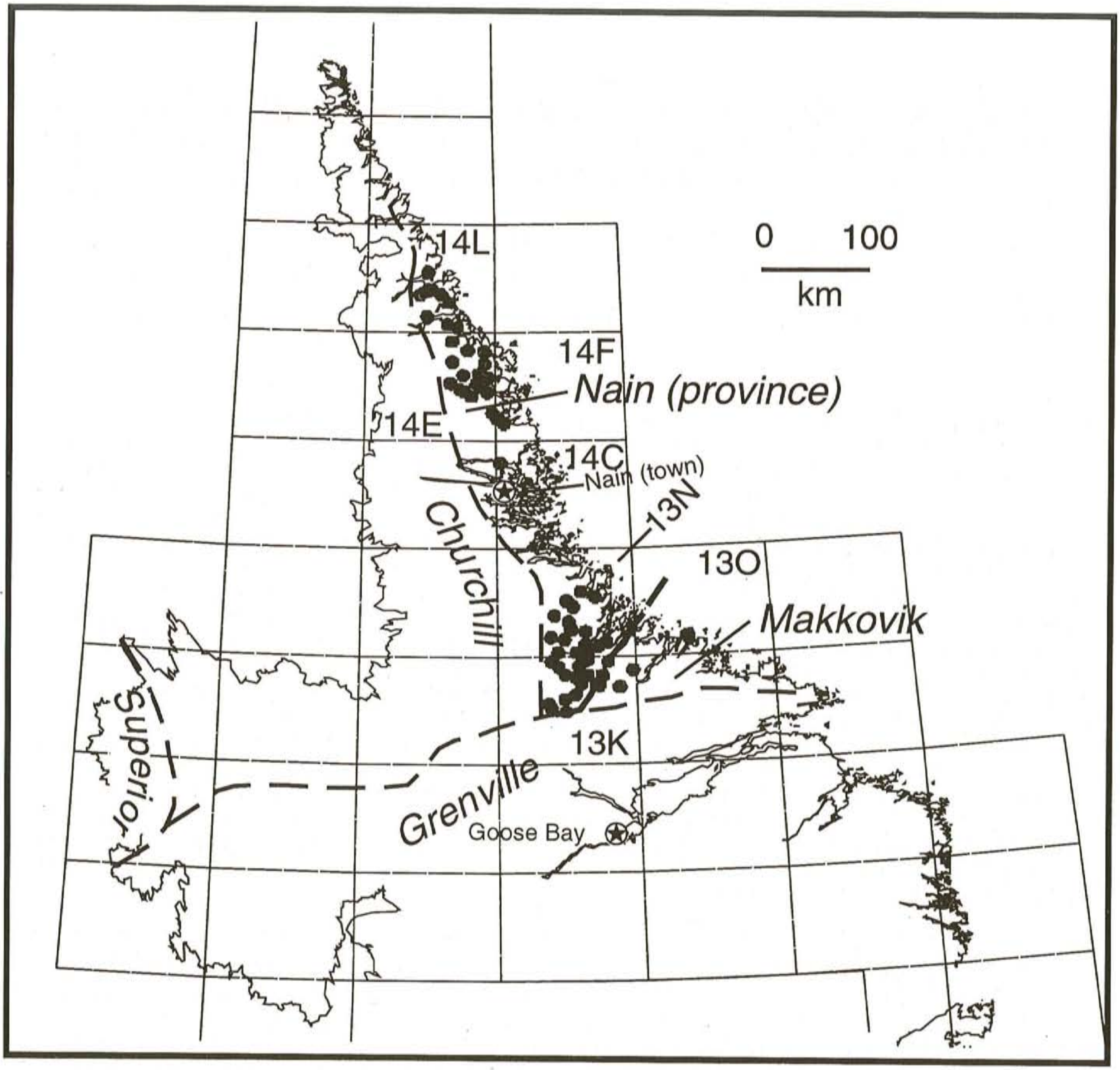

Figure 1. *Location of heavy-mineral sample sites (dots) in relation to structural provinces.*

Kimberlites and lamproites typically form small dykes or pipe-shaped bodies. These rocks weather rapidly under surface conditions and are soft and easily eroded, hence rarely form outcrops. More typically their only surface expressions are small circular ponds or linear depressions resulting from their recessive weathering character. The rocks form from magmas that have ascended rapidly from the mantle to the surface and may be "contaminated" with diamond xenocrysts and eclogite inclusions acquired during the magma's passage through the upper mantle and lower crustal "roots". Their unusual mineralogy, and to a lesser extent geochemistry, provide one method of exploring for these elusive targets. These minerals include chrome diopside and ilmenite, which crystallize directly from the magma, and xenocrystic pyrope garnet and chromite derived from the eclogite inclusions (Kirkley *et al.*, 1991). They have densities greater than 3.1, are resistant to rapid weathering, are durable during post-erosional transport processes and have distinctive optical and chemical characteristics. As such, they are useful as kimberlite indicator minerals and suitable for surficial sediment exploration surveys utilizing heavy-mineral separation techniques followed by optical examination. Stream sediment surveys for heavy minerals in kimberlite terrane in Greenland have identified pyrope garnet, picroilmenite, chrome spinel and chrome diopside (Appel, 1994).

DESCRIPTION OF FIELD AREA

BEDROCK GEOLOGY

The regional geology of Labrador has been summarized at 1:2 000 000 in a recent compilation by Wardle (1996), and the details of the 1994 survey area have been addressed, in part, by Ryan and McConnell (1995). The area is also covered by several 1:100 000-scale geological maps. Suffice it to say here that Labrador geology meets some of the criteria that define prospective areas. For example, as noted above, a significant area of western and coastal Labrador is underlain by Archean crust that has not been severely affected by any tectonism since ca. 2500 Ma. The eastern cratonic remnant is known as the Nain Province, and comprises the Saglek Block to the north and the Hopedale Block to the south. These areas are good candidates to preserve an ancient mantle root. Reworked Archean crust, in areas such as the Makkovik Province, has remained relatively stable since ca. 1800 Ma. Although the existence of a thick lithospheric root beneath either of the Archean cratons and their reworked margins has yet to be proven, the possibility must not be dismissed. Parts of Labrador are also known to be loci of alkaline mafic magmatism, and these areas were the main ones examined from a surficial sampling perspective as candidate regions to host kimberlitic and lamproitic pipes.

The best known occurrence of lamprophyric dykes and rocks that may possibly have a kimberlitic affinity in Labrador is on the Aillik Peninsula, approximately 15 km north of Makkovik (Figure 2; cf. Collerson *et al.*, 1974). The assemblage is also present on the Turnavik Islands, 20 km northwest of the peninsula (Doherty, 1980). These dykes, termed the Aillik Bay alkaline intrusive suite by Malpas *et al.* (1986), have been studied and described in detail by Hawkins (1977), Foley (1982) and Malpas *et al.* (1986). The suite has been emplaced into Paleoproterozoic supracrustal and plutonic rocks of the Makkovik Province, at the reworked southern margin of the Archean Nain Province. The suite comprises sannites, olivine sannites, aillikites, and carbonatites of several generations. (The reader is referred to Hawkins (1977) and Foley (1982) for superb field and petrographic descriptions of these rocks, although it should be borne in mind that the nomemclature of these two investigators differs.) One orange-brown anastomosing aillikite dyke set collected from Cape Aillik during our survey has been dated by the U – Pb method on perovskite; three fractions separated from a sample suite of this dyke set plot near concordia at 585±2 Ma (D. Scott, written communication, 1995) indicating a late Neoproterozoic emplacement age for part of the Aillik assemblage. This dyke predates a brown sannite dyke, of unknown absolute age, in the same outcrop. It is of interest to note that in other parts of the area, the opposite relationship, aillikite dykes trans-gressing sannite dykes, has been observed confirming the multi-generation repetitive aspect of the dykes. If the aillikite dykes that crosscut sannites are the same age as the dated dyke, then the older dykes are obviously Proterozoic, too.

The Saglek - Hebron area (Figure 3) in the northernmost part of the Nain Province is underlain mainly by Archean gneisses that range up to 3.8 Ga in age. Several occurrences of kimberlite dykes and glacially derived kimberlitic boulders have been documented in the Saglek region (Collerson and Malpas, 1977; Bridgwater *et al.*, 1990). Bridgwater *et al.* (1990) reported the existence of a kimberlitic dyke near Hebron village that is biotite-rich and contains olivine-rich nodules and garnetiferous inclusions. Brummer (1978) has noted that an unpublished map of Collerson's shows two kimberlite dykes on Big Island in Saglek Bay (Figure 3), and several "diatremic breccia pipes" in the vicinity of Saglek. A cursory examination of both areas by B. Ryan failed to locate either the dykes or the diatremic breccias. The breccia pipes, if like the one on White Point south of Saglek Bay, are probably not kimberlite pipes. The White Point occurrence appears to be equivalent to breccia dykes in the vicinity of Hebron Fiord (Ryan and Martineau, 1992), and also like those observed by Ermanovics *et al.* (1989) between Hebron and Okak Bay. These dykes are characterized by abundant angular to rounded fragments of fine-grained mafic rock and surrounding gneisses in a chloritized matrix that locally exhibits evidence of original quenching textures. These breccia dykes do not appear to have alkaline affinities; they are probably rapidly injected members of the Early Proterozoic diabase dyke swarm that is prominent in this region.

Recent work in the Nain area has shown the existence of a small number of black-weathering amphibole-rich and carbonate-rich ultramafic lamprophyre dykes in the region (Ryan, 1991, 1992). Most of these are restricted to Satok and Nuasurnak islands, approximately 40 km southeast of Nain, but a few occur on other islands in the area. These dykes seldom exceed 2 m in width, and can be divided into a hornblende-rich group and an olivine- and phlogopite-rich group. All appear to be spatially related to a deformed Early Proterozoic (ca. 2000 Ma) monzonitic and gabbroic intrusion that occurs on Satok Island. They are not known to intrude adjacent Mesoproterozoic (1300 Ma) anorthositic plutons.

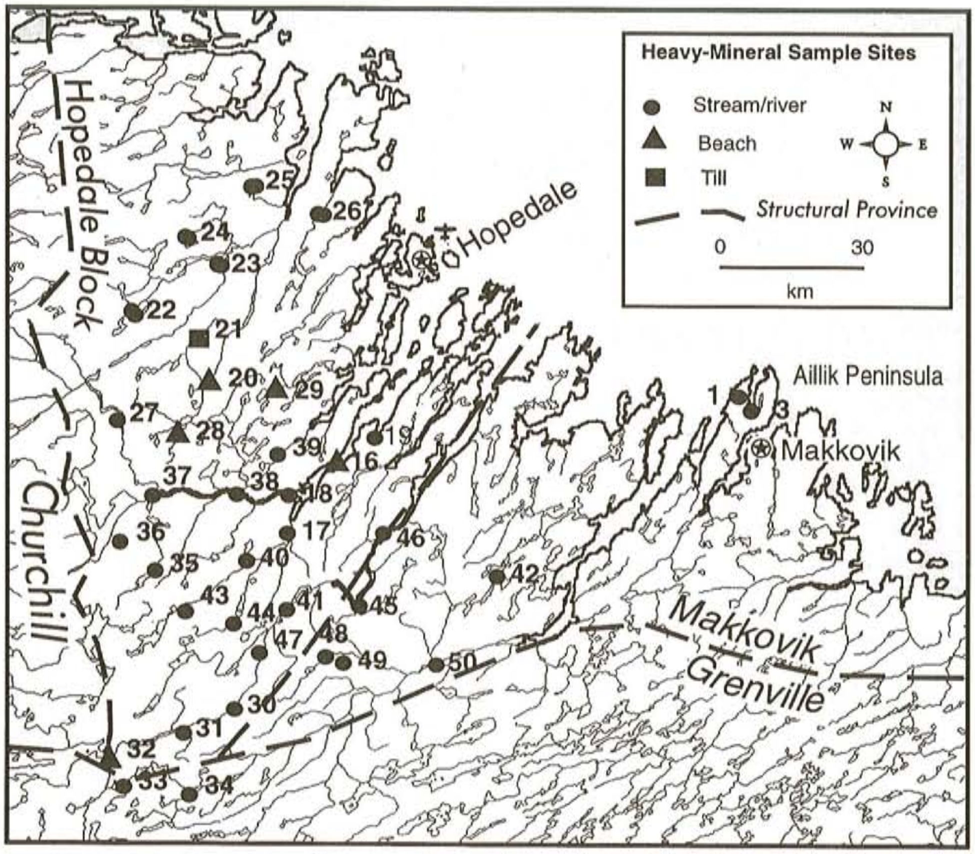

Figure 2. *Location of heavy-mineral sample sites in relation to Hopedale Block, Makkovik, Churchill and Grenville provinces.*

Insufficient work has been done to classify the suite completely, but thin sections indicate some of these rocks fall within the definition of aillikite as used by Malpas *et al.* (1986) for the Cape Aillik dykes. The amphibole in the lamprophyre dykes of the Satok Island area is a deep brown-red barkevikite. A golden yellow pleochroic mineral, tentatively identified as a member of the humite group, occurs in some of these dykes. One aillikite dyke from this suite contains a reddish-brown Ca-, Zr-, Ti-rich mineral that may be calzirtite.

SURFICIAL GEOLOGY

The survey area was glaciated during the Wisconsinan. Easterly to northeasterly flowing ice scoured and eroded bedrock, leaving behind a thin veneer of till over most of the highland areas, and glaciofluvial sediments in most of the major valleys (Klassen *et al.*, 1992). Marine clays are also found in many coastal valleys at current elevations above sea level of 125 m in the south to about 70 m in the north (Batterson, 1995). These glaciofluvial gravels and sands are generally farther travelled than the till deposits, hence samples of such material should reflect a larger source area. The highland areas of the Saglek Block of the Nain Province have considerably more exposed bedrock and less till than the corresponding areas of the Hopedale Block and Makkovik Province. However, glaciofluvial sediments are abundant in all three.

FIELD METHODS

BEDROCK STUDY

The only area subjected to concentrated bedrock examination directly related to the goals of the survey during the 1994 field season was the region around Aillik Bay, where the authors spent two weeks examining the variations in the dyke suite there. The previous studies referenced above were used as guides to locating and naming dykes, and the subsequent petrographic work (see below) has not resulted in any modification to the nomenclature suggested by Malpas *et al.* (1986). A summary of the field characteristics of the Aillik Bay dykes, based on our own work and that of others, has been presented by Ryan and McConnell (1995) and need not be repeated here. Suffice it to say that the dykes around Aillik Bay were classified in the field using the general guidelines given by Foley (1982) and Malpas *et al.* (1986). Dark-brown to dark-grey dykes were classed as sannite, whereas the yellowish-weathering ones were classed as aillikite.

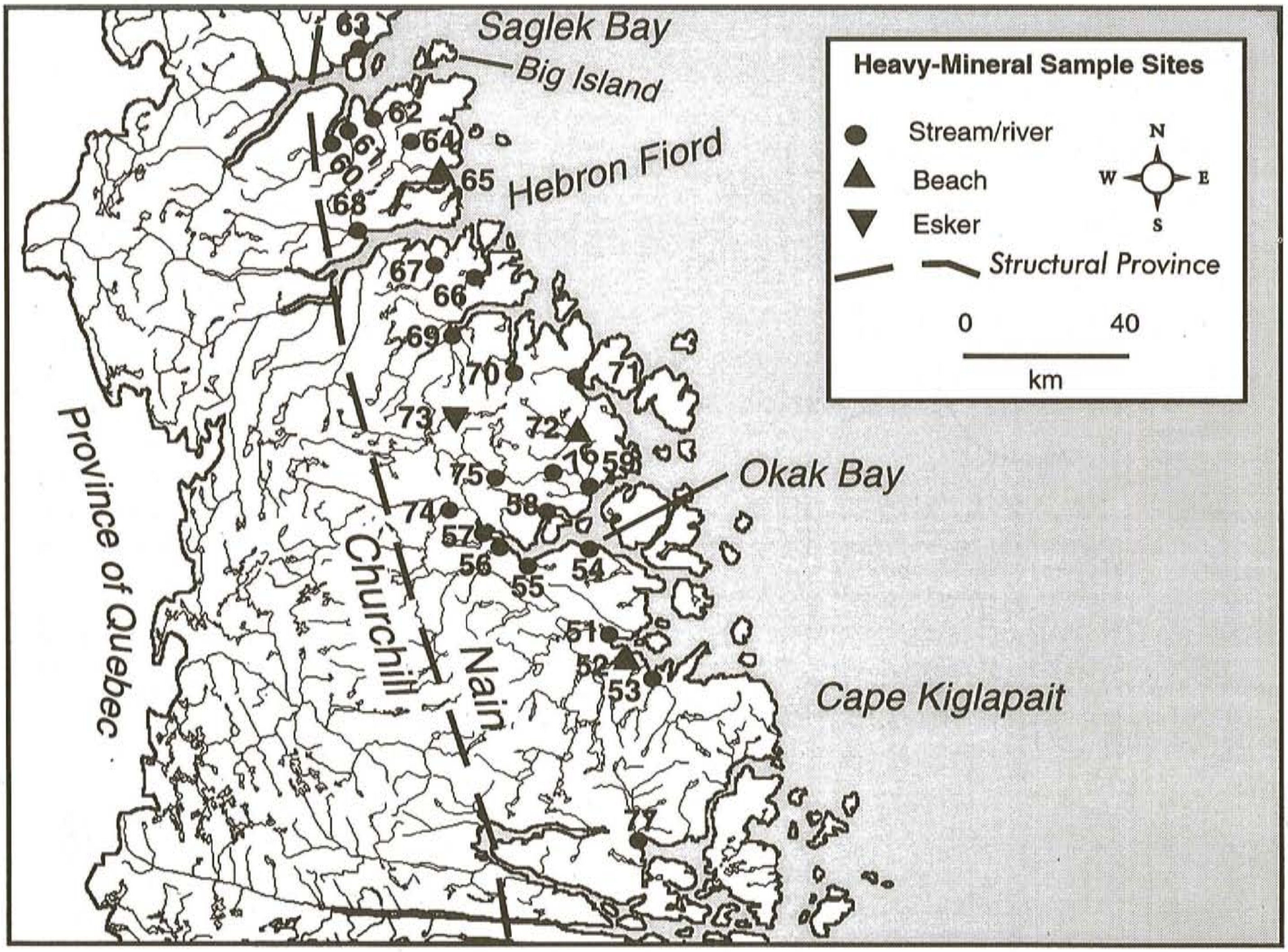

Figure 3. *Location of heavy-mineral sample sites in relation to Nain (Saglek Block) and Churchill structural provinces.*

SURFICIAL SURVEY

Indications of kimberlite and lamproite bodies were sought in the heavy-mineral fraction of surficial sediments. Because deposits of glaciofluvial sands and gravels represent large source areas, sediments derived from these deposits, such as active river sediments and beach sands, were sampled in preference to till. The actual boundaries and sizes of the catchment basins sampled are impossible to define without a greater understanding of the glacial history than is currently available. An order of magnitude estimate of about 100 to 200 km^2 for many basins seems reasonable, however. Fluvial sediments also offer the advantage of providing natural heavy-mineral traps, which provide an additional enrichment factor. The surficial sampling sites were selected based on examination of maps showing the distribution of glacial sediments, especially the Labrador map of Klassen *et al.* (1992) and the regional maps of Fulton *et al.* (1979a and b). Sites were chosen preferentially from areas of reworked glaciofluvial deposits; in addition, one esker and one till were each sampled. Altogether, 64 bulk samples of river, stream, beach, till and esker sediment were collected, wet-sieved on site to <4 mm and shipped to St. John's for further processing. The average volume of the <4 mm samples was 8 litres. At most sites, a small sample for geochemistry and a random collection of 20 pebbles were also obtained. Figures 2 and 3 show the sample sites in relation to drainage and structural provinces.

PETROGRAPHIC SUMMARY OF THE AILLIK BAY INTRUSIVE SUITE

It was noted above that dykes were assigned field names of sannite or aillikite based on criteria given by Malpas *et al.* (1986). This general subdivision has also held up in the petrographic work carried out on a limited selection of rock samples. The following details of the microscopic variations within the suite are based on our own restricted examination of a representative group of the intrusions, augmented by data presented by Hawkins (1977) and Foley (1982).

Nearly colourless or pale yellow-green, locally zoned, salitic clinopyroxene, and (serpentinized and carbonatized) olivine are the chief phenocrystic phases in the sannites. Groundmass phases include acicular clinopyroxene, orange phlogopite or biotite, carbonate, opaque oxides, and an unresolvable assemblage of felsic minerals that probably include nepheline, analcime and potassium feldspar; many rocks have sufficiently fine grain size and secondary alteration such that the groundmass minerals in the rock are not readily identified under the microscope. Some sannite dykes also contain coarse poikilitic reddish-brown phlogopite that overgrows all other phases, and several of the dykes examined exhibit irregular zones or globules comprising carbonate, serpentine (or zeolites), nepheline, and analcime(?). A peculiar comb-like growth of clinopyroxene observed to highlight a layering in some sannite dykes in the field is seen in thin section to include crystals that have a mildly fanning aspect; these extremely elongate pyroxenes seem to represent rapid nucleation from a solidified part of the dyke, a wall for example, through fluid magma within the dyke.

The aillikites are carbonate-rich rocks. Olivine and phlogopite are the main phenocryst minerals, but magnetite is conspicuous as a phenocrystic phase in some dykes. The olivine tends to be heavily serpentinized and replaced by carbonate. Phlogopite phenocrysts are locally zoned from a greenish-brown centre to a red-brown rim. The carbonate-rich matrix is spattered with abundant opaque oxide, and also displays apatite and reddish-brown perovskite or rutile. Glimmerite (mica-rich) nodules, some of which are deformed and recrystallized, are common in some dykes.

ANALYTICAL METHODS

Most geochemical analyses of the surficial sample suite were performed by the Geochemical Laboratory of the Department of Natural Resources. The neutron activation analyses were done by Becquerel Laboratories of Mississauga, Ontario. The heavy-mineral separations, optical examination and indicator mineral picking of the surficial sediments were conducted by Lakefield Research of Lakefield, Ontario, the methods and results of which are presented below.

SAMPLE PREPARATION AND HEAVY-MINERAL SEPARATION PROCEDURES

The microscope examination for kimberlite indicator minerals was performed on the non-magnetic and paramagnetic portions of the >0.25 mm to <1.0 mm fraction of the bulk samples that were obtained from the <4 mm field samples by the process shown on the accompanying flow chart (Figure 4). The average weights of several fractions are shown in parentheses. Step numbers discussed in the text (e.g., S1) are also indicated on the chart.

(S1) – Samples were dried in the Department's geochemical laboratory in St. John's, sieved through a 1 mm mesh and the fine fraction was shipped to Lakefield Research for further treatment.

(S2) – Samples were wet-sieved through <0.25 mm; both fractions were dried and weighed. The coarse fraction proceeded to the next step.

(S3) – Ferromagnetic minerals were removed using hand magnets and stored. The non-ferromagnetic fraction proceeded to Step 4.

(S4) – The samples were processed through a Magstream Model 200 separating the grains into >3.1 and <3.1 specific gravity fractions. The device uses the properties of specific gravity and magnetic susceptibility to achieve separation. The >3.1 SG fraction proceeded to Step 5.

(S5) – Samples were passed through a Frantz Barrier Magnetic separator and divided into three fractions - strongly paramagnetic, weakly paramagnetic and non-magnetic. Two field intensities of 0.1 and 0.5 amperes were used for separation. The non- and paramagnetic fractions proceeded to Step 6.

(S6) – Typically, the two heavy-mineral fractions so recovered were larger than practical to examine in entirety; instead, representative splits of each pair with a combined weight of 50 to 200 g were submitted for microscopy.

(S7) – This fraction was examined microscopically for kimberlite indicator minerals and gold grains as described below.

OPTICAL EXAMINATION

A 50 to 200 g split of the heavy-mineral concentrate was examined using a polarizing binocular microscope for gold grains and the following possible kimberlite/lamproite indicator minerals. Any such grabs were picked and retained in separate vials: pyrope garnet; almandine garnet (orange); chrome diopside (green); ilmenite (black); and chrome spinel (black).

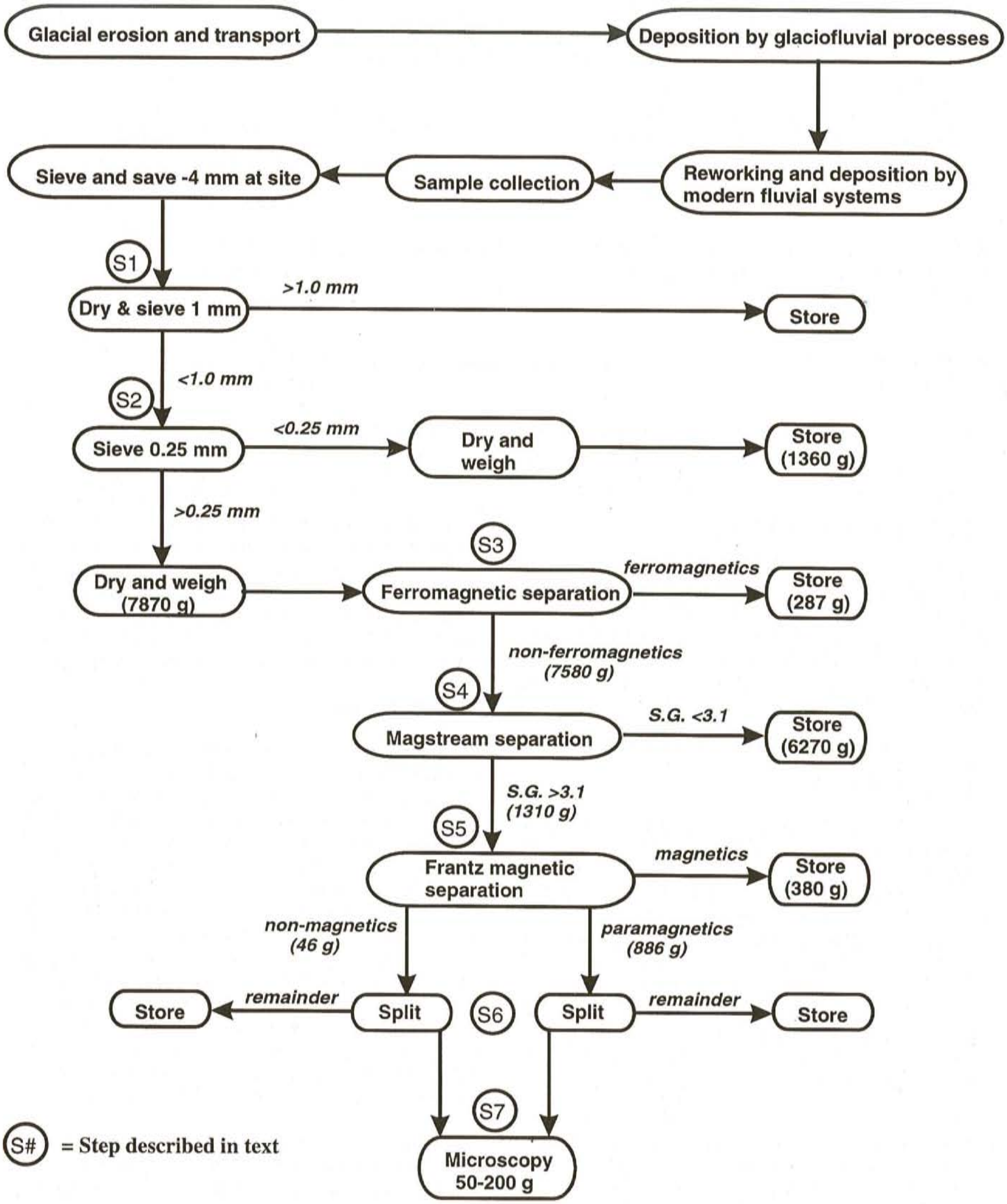

Figure 4. *Indicator-mineral recovery flowsheet. Weights shown are mean weights of the 64 samples.*

Table 1. Analytical methods for surficial sediments

ELEMENTS	METHOD	DIGESTION/ PREPARATION
As, Au, Ba, Br, Ce, Co, Cr, Cs, Eu, Fe, Hf, La, Lu, Mo, Na, Ni, Rb, Sb, Sc, Sm, Ta, Tb, Th, U, W, Zn, Yb	neutron activation analysis (INAA)	5-10 g in shrink-wrapped vial. (total analysis)
Al, Ba, Be, Ce, Co, Cu, Dy, Fe, Ga, K, La, Li, Mg, Mn, Na, Nb, Ni, P, Pb, Sc, Sr, Ti, V, Y, Zn	inductively coupled plasma emission spectroscopy (ICP-ES)	$HF-HClO_4-HCl$ (total digestion)
Cd, Cr, Mo, Rb	atomic absorption spectroscopy (AA)	$HF-HClO_4-HCl$ (total digestion)
Ag	atomic absorption spectroscopy (AA)	HNO_3
F	ion-selective electrode	

GEOCHEMICAL ANALYSES

Samples of surficial sediment were sieved to <170 µm (<80 mesh) and analyzed by several methods for the elements Ag, Al, As, Au, Ba, Be, Br, Cd, Ce, Co, Cr, Cs, Cu, Dy, Eu, F, Fe, Ga, Hf, K, La, Li, Lu, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Rb, Sb, Sc, Sm, Sr, Ta, Tb, Th, Ti, U, V, W, Y, Yb, Zn and Zr. The elements analyzed by each method are summarized in Table 1.

RESULTS AND DISCUSSION

HEAVY MINERALS

The heavy-mineral processing and selection failed to detect any indicator minerals that suggest the presence of kimberlite or lamproite bodies in the area. In particular, no pyrope garnets were recognized (identified on basis of red or purple color) and no chromites were positively identified. Several green diopside grains were found but these are typically pale green and, as such, chrome content may be low to nil. Ilmenite and orange garnet were found in most of the samples, and gold grains were not recovered. The results of the indicator-mineral microscopy performed on the 64 samples of surficial sediment are summarized in Table 2; because no pyropes were identified they are not included.

The apparent absence of both pyrope garnet and high-chrome diopside, although discouraging, does not preclude the possible presence of kimberlites or lamproites in the survey area. The sampled areas reflect only a small part of the region with the potential to contain such intrusions. Moreover, only a small portion (about 10 to 15 percent) of the heavy-mineral concentrate from each sample could be examined and no mineral grain analyses were performed on any of the "possible" high-chrome diopsides, ilmenites or chrome spinels. These concentrates all remain available for further study. Another difficulty encountered was in scanning and picking garnets. The extreme abundance of metamorphic garnets in the area is reflected in the concentrates, thus exacerbating the task of distinguishing among types of garnet.

GEOCHEMISTRY

Kimberlitic rocks have distinctive trace-element signatures. Not only are they enriched in elements typical of ultramafic rocks including nickel (Ni), strontium (Sr) and barium (Br), they also are commonly enriched in elements more frequently found in highly differentiated granitic rocks–zirconium (Zr), niobium (Nb) and rare-earths. Analyses of "kimberlites" (aillikites) from the Aillik Peninsula show a pronounced enrichment in the light rare earths (Foley, 1982). However, because of the large catchment basins associated with the samples collected in this survey, such a signature might be too diluted to recognize. The application of geochemical exploration would be more effectively applied at a larger scale follow-up stage where the presence of kimberlite indicator minerals already provide a focus to the search area. Nonetheless, a selection of kimberlite-associated elements as well as others are listed in the appendix.

Symbol maps of magnesium and arsenic are presented, which illustrate crustal-scale patterns. The distribution of Mg (Figure 5) shows that the Saglek Block of the Nain Province is enriched relative to both the Hopedale Block and Makkovik Province. This suggests that the northern area includes a larger mafic component than the southern area. The distri-

Table 2. Summary of indicator minerals identified in the >0.25 and <1.0 mm range of the paramagnetic and nonmagnetic heavy mineral fractions

Sample #	Alm-Py Garnet Orange	Chrome Diopside Emerald Green	Ilmenite Black	Chrome Spinel Black	Comments
6215001	>50 present	-	10 (>50)	-	
6215003	>25 present	1?	8	-	
6215016	>25 present	-	4	-	
6215017	>100 present	-	6	-	
6215018	>20 present	-	8	-	
6215019	>50 present	-	7	-	
6215020	>20 present	-	4	-	
6215021	>10 present	-	-	-	
6215022	>10 present	1?	3	-	
6215023	>20 present	1	-	-	
6215024	>25 present	1	-	-	diopside from magnetic fraction
6215025	>30 present	-	2	-	
6215026	>10 present	3?	1	-	
6215027	>25 present	-	-	-	
6215028	>10 present	-	-	-	
6215029	>20 present	-	-	-	
6215030	>20 present	-	4	-	
6215031	>20 present	-	-	-	
6215032	>10 present	-	2	-	
6215033	>10 present	-	-	-	
6215034	<10 present	-	1	-	
6215035	>50 present	-	7	-	
6215036	>10 present	1?	2	-	
6215037	>10 present	1?	2	-	
6215038	>25 present	-	10 (>15)	-	
6215039	>25 present	1 pale	8	-	
6215040	>10 present	-	3	-	
6215041	> 50 frosty/pr	-	-	-	
6215042	>5 present	-	-	-	
6215043	> 50 frosty/pr	-	-	-	
6215044	> 50 frosty/pr	-	-	-	
6215045	>10 present	-	9	-	
6215046	>10 present	-	8	-	
6215047	>20 frosty/pre	-	7	-	
6215048	>20 present	-	10 (>15)	-	
6215049	>20 present	-	6	-	
6215050	<5 present	-	-	-	
6215051	>10 present	3 pale	5	-	
6215052	>20 present	3?	10 (>15)	-	
6215053	>20 present	1	5	-	
6215054	>20 present	8 pale	7	-	
6215055	>25 present	6 pale	10 >(15)	-	
6215056	>20 present	-	9	-	
6215057	>20 present	-	10 (>15)	-	
6215058	>20 present	-	10 (>15)	-	
6215059	>20 present	-	5	-	
6215060	>20 present	-	7	-	
6215061	>20 present	-	10 (>10)	-	
6215062	>20 present	-	7	-	
6215063	>20 present	2 pale	6	-	
6215064	>20 present	2?	10	2?	
6215065	>20 present	2?	8	-	
6215066	>20 present	1 *	3	-	* diopside has inclusions
6215067	>20 present	-	6	-	
6215068	>50 present	-	10 (>50)	-	
6215069	>20 present	-	5	-	
6215070	<10 present	-	5	-	
6215071	>20 present	-	5	-	
6215072	>20 present	7	7	-	
6215073	>20 present	1	10 (>20)	-	
6215074	>10 present	-	8	-	
6216075	>10 present	2	7	-	
6215076	>10 present	2?	5?	-	
6215077	>10 present	1	6	-	

Note: 20 (>100) - indicates 20 grains were selected, but >100 were present in sample.
? - indicates uncertainty in identification.

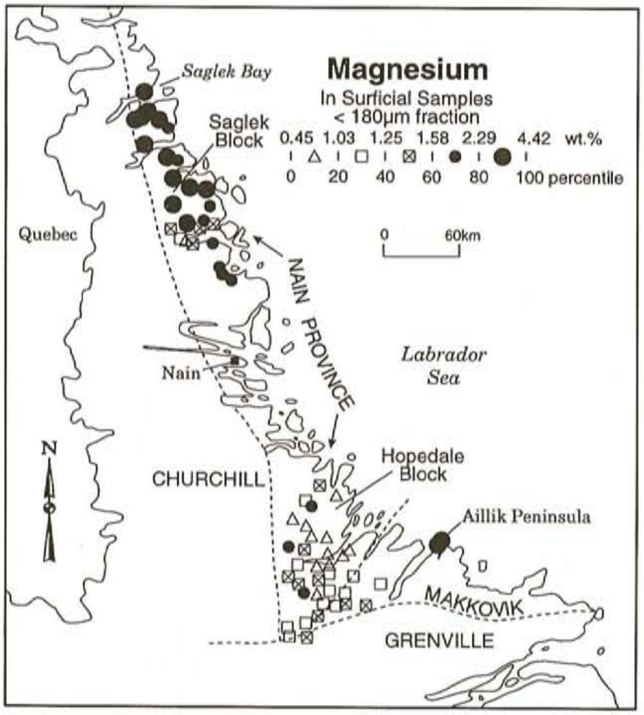

Figure 5. *Magnesium in surficial samples in relation to structural provinces.*

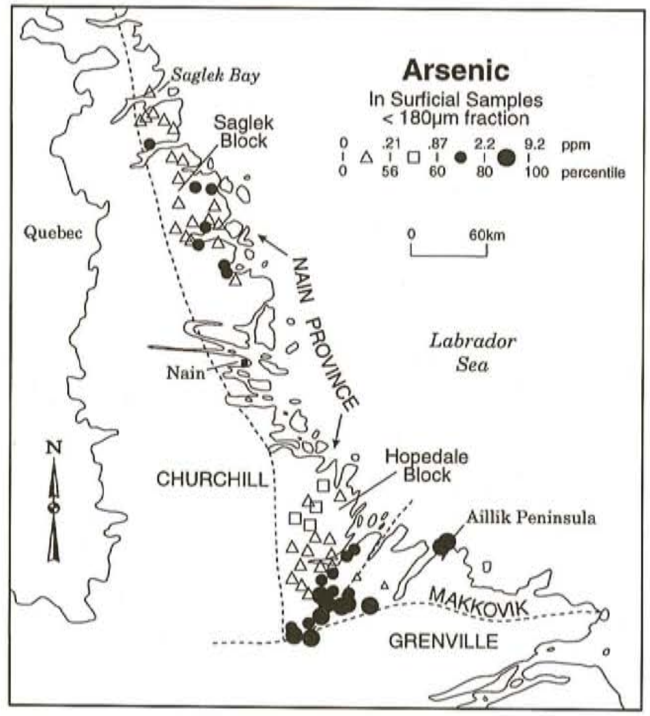

Figure 6. *Arsenic in surficial samples in relation to structural provinces.*

bution of arsenic (Figure 6) shows a different pattern. Most of the samples with high As values occur in an envelope enclosing the Nain Province – Makkovik Province boundary – a major structural break. This enrichment may reflect an ancient hydrothermal system possibly associated with mineralizing events. Such zones have been recognized in lake-sediment patterns on the island portion of the province (Davenport and Nolan, 1991).

BEDROCK

None of the dykes that were examined from the Aillik Peninsula have any petrographic characteristics that indicate they have intersected diamondiferous crust during ascent. For example, even though the glimmerite nodules suggest derivation of the lamprophyres from a mantle staging area (cf. Peterson and LeCheminant, 1993), no xenocrystic minerals typical of fragmented eclogitic rocks have been found in these dykes by us or previous workers. Either the magmas originated at insufficient depth to have sampled any potentially diamond-enriched keel below the crust here, or no such mantle keel exists. Given the tectonic setting of the Aillik Bay area, the latter situation is probably the most realistic explanation and is re-inforced by crust – mantle seismic profiles recently reported by Hall *et al.* (1995). The geochemical signature of the dykes is likewise more akin to alkaline and ultrabasic lamprophyres than to diamondiferous kimberlites.

Malpas *et al.* (1986) presented whole-rock data to illustrate that the geochemical characteristics of the Aillik Bay dykes are significantly different from those of kimberlites, therefore negating any common link to kimberlites. For instance, the olivine-rich rocks from the Aillik region are lower in MgO, and richer in CaO and K_2O than kimberlites. The MgO to CaO ratio is also less than that of typical kimberlites (cf. Hamilton and Rock, 1990). The geochemistry data imply, instead, a relation to an unexposed nephelinite - carbonatite intrusive centre. Malpas *et al.* (*op. cit.*) did, however, entertain the notion that "kimberlite magmatism may be an indirect cause" of the Aillik Bay suite.

CONCLUSIONS

The mineralogical examinations of the heavy-mineral fraction of the bulk sediment samples from regional cachment basins do not provide any evidence of detritus from kimberlites or lamproites. In particular, no pyrope garnets or chromites were identified. Green diopside grains were found but the pale colours suggest low chromium contents rather than the high values commonly associated with chrome diopside from kimberlites. Too few samples representing too small a portion of the potential kimberlite host area were obtained to conclude that such rocks are entirely absent from the Nain and Makkovik provinces. Moreover, only a small portion of each heavy-mineral fraction was rigorously examined for indicator minerals. The chemistry of the bulk sediment samples supports the regional lake-sediment data in suggesting a chemical contrast between the northern and southern portions of the Nain Province - the former appearing to have a larger mafic component. Arsenic data suggest a possible paleohydrothermal system focused on the Nain – Makkovik boundary.

No kimberlitic rocks were identified in any of the areas of bedrock examined on the ground. The most concentrated region of alkaline intrusions, the Aillik Bay area, is a lamprophyre province, with no concrete indications from any of the dykes that they tapped potentially diamondiferous sub-crustal rocks.

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APPENDIX

Selected geochemical analyses of <180 μm fraction of surficial samples from heavy mineral sites.

Sample Number	N.T.S.	UTM Zone	UTM Easting	UTM Northing	As1	Au1	Ba1	Cr1	La1	Nb2	Ni2	Sr2	Zr1
6214001	13O03	21	357700	6117100	8.40	1.0	740	180	54	41	94	385	50
6214003	13O03	21	359300	6114700	5.20	1.0	700	57	42	20	17	285	820
6214016	13N02	20	657450	6108600	1.60	1.0	490	78	21	16	23	317	680
6214017	13K15	20	647600	6093800	1.30	1.0	480	120	31	26	26	305	1200
6214018	13N02	20	648000	6101050	0.20	1.0	750	79	94	68	16	306	4000
6214019	13N01	20	665100	6113400	1.50	1.0	430	25	13	8	13	330	260
6214020	13N07	20	632157	6124720	0.20	1.0	1000	10	16	4	8	420	50
6214021	13N07	20	629616	6132551	0.72	1.0	910	30	41	16	13	374	620
6214022	13N06	20	616499	6138829	0.71	1.0	990	41	36	31	16	392	1700
6214023	13N07	20	633826	6148267	0.60	1.0	430	78	16	9	27	432	360
6214024	13N10	20	627565	6154354	0.20	1.0	560	86	79	294	16	288	7700
6214025	13N10	20	640483	6164309	0.86	1.0	530	140	37	44	32	373	1800
6214026	13N10	20	654069	6159030	0.20	1.0	550	74	23	22	20	394	630
6214027	13N03	20	613422	6116630	0.20	1.0	500	130	87	114	34	286	5500
6214028	13N03	20	625929	6114443	0.20	1.0	270	320	78	66	40	318	2100
6214029	13N02	20	645394	6123297	0.20	3.4	400	69	14	5	18	450	310
6214030	13K10	20	637050	6058000	2.90	1.0	440	270	43	43	42	256	1500
6214031	13K11	20	626930	6053027	2.00	1.0	560	67	21	18	24	333	210
6214032	13K11	20	612227	6047445	2.10	1.0	550	96	25	22	27	314	950
6214033	13K11	20	614933	6041928	4.30	1.0	640	58	28	11	25	175	300
6214034	13K06	20	628253	6040112	4.00	4.1	530	160	32	15	47	194	29
6214035	13K14	20	620919	6086301	0.20	1.0	330	110	19	33	21	349	410
6214036	13K14	20	614016	6091650	0.20	1.0	470	110	32	21	22	404	820
6214037	13N03	20	620249	6101258	0.20	10.0	700	90	73	71	21	296	2800
6214038	13N02	20	637370	6101771	0.20	1.0	130	340	267	316	37	93	10000
6214039	13N02	20	645907	6109912	0.20	1.0	880	40	39	62	17	327	2200
6214040	13K15	20	639587	6087734	2.00	1.0	420	58	19	16	29	312	50
6214041	13K15	20	648097	6078652	1.60	1.0	500	100	27	20	29	297	630
6214042	13K16	20	690037	6084797	0.20	1.0	600	74	58	23	19	453	50
6214043	13K14	20	627149	6078085	0.20	8.7	320	110	18	13	42	299	50
6214044	13K15	20	636804	6075548	2.80	1.0	480	96	26	20	25	279	720
6214045	13K16	20	661783	6078288	1.70	1.0	300	430	55	82	52	179	2600
6214046	13K16	20	666720	6092819	0.20	1.0	410	150	29	37	31	289	1100
6214047	13K15	20	641980	6069453	2.60	1.0	450	150	32	33	32	292	980
6214048	13K10	20	655574	6068453	9.20	1.0	470	120	29	20	31	288	680
6214049	13K10	20	658656	6068171	3.00	1.0	420	230	34	43	40	253	1300
6214050	13K09	20	677884	6066882	4.20	1.0	690	94	54	22	26	342	500
6214051	14E08	20	557800	6347000	1.60	1.0	740	110	28	29	27	441	980
6214052	14F04	20	561500	6341300	2.10	1.0	490	360	49	61	53	344	2700
6214053	14F04	20	568500	6336200	0.20	1.0	410	270	36	64	47	352	2000
6214054	14E08	20	553200	6368100	0.20	1.0	540	280	62	170	41	157	6800
6214055	14E08	20	538350	6363950	1.10	1.0	890	110	51	61	23	215	3300
6214056	14E08	20	531500	6369000	0.20	1.0	1100	45	65	139	6	190	6400
6214057	14E07	20	527500	6371200	0.20	1.0	840	100	53	58	22	201	4100
6214058	14E09	20	542650	6377150	1.40	1.0	730	120	38	25	25	238	1600
6214059	14E09	20	553550	6383300	0.20	1.0	910	120	65	35	20	226	2200
6214060	14L06	20	490206	6467758	0.20	1.0	570	190	41	9	20	158	600
6214061	14L06	20	494512	6470608	0.20	1.0	580	290	40	9	44	205	640
6214062	14L07	20	501023	6473499	0.20	1.0	380	290	72	17	30	176	1100
6214063	14L11	20	497809	6491203	0.20	1.0	380	370	47	9	92	285	750
6214064	14L07	20	509988	6468167	0.20	1.0	240	770	28	6	114	158	460
6214065	14L07	20	516879	6460155	0.20	1.0	460	250	40	5	61	207	440
6214066	14L02	20	525015	6434720	0.20	1.0	500	240	97	20	47	242	520
6214067	14L02	20	515520	6437826	0.20	1.0	480	370	43	6	93	176	400
6214068	14L03	20	496802	6445906	2.80	1.0	610	270	150	47	17	159	1600
6214069	14E15	20	519961	6420329	0.20	1.0	330	970	49	10	117	198	970
6214070	14E16	20	534660	6411355	2.10	1.0	800	330	57	7	96	357	50
6214071	14E16	20	549862	6410346	1.60	1.0	810	280	90	5	61	401	640
6214072	14E09	20	550332	6397269	0.20	1.0	630	220	67	14	52	376	590
6214073	14E10	20	520492	6399531	0.20	1.0	400	220	53	8	13	136	480
6214074	14E10	20	518887	6377498	0.20	1.0	660	65	88	86	13	221	5000
6214075	14E09	20	530242	6385490	0.20	1.0	530	190	120	71	16	148	3800
6214076	14E09	20	544647	6386903	0.20	1.0	680	170	86	46	20	194	3000
6214077	14C13	20	565150	6296000	0.20	1.0	620	100	28	32	19	416	1200