Current Research (1991) Newfoundland Department of Mines and Energy,
Geological Survey Branch, Report 91-1, pages 327-334

PRELIMINARY EVALUATION OF RARE-METAL TARGETS IN INSULAR NEWFOUNDLAND

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ABSTRACT

Exploration for rare-metal mineralization in insular Newfoundland has been very sporadic, and has not yet evaluated all the potential targets. A preliminary field survey of 12 geological units on the Burin Peninsula, the Baie Verte Peninsula and in the Arnold's Cove to Traytown area was carried out to provide samples and field data for detailed laboratory analysis of these rare-metal exploration targets.

Units sampled include: the Kings Point complex, the Cape St. John Group and the spatially associated Seal Island Bight peralkaline granite, the Mic Mac Lake group, the Bull Arm Formation and the spatially associated Louil Hills peralkaline granite, the Mooring Cove Formation felsic volcanic rocks (English Harbour East area), the Cross Hills Plutonic Suite and the St. Lawrence peralkaline granite and its related volcanic—subvolcanic complexes (Grand Beach complex, Rocky Ridge complex, and Winterland porphyry). The Bull Arm Formation is divided into nine different segments due to the large areal extent of the formation; individual segments evaluated are Traytown, Port Blandford, Musgravetown, Plate Cove, Clarenville, Hodges Cove, Sunnyside, Masters Head and Doe Hills.

Radioactivity is the best field method to determine the rare-metal potential of an outcrop, particularly for volcanic and other fine-grained rocks. Most of the areas evaluated had radioactive values in the range 250 to 500 c.p.s. Areas that have outcrops with values above this range, and thus have medium to high rare-metal potential, are the Kings Point complex, the Louil Hills Intrusive Suite peralkaline granite, the Mooring Cove Formation, the Cross Hills Plutonic Suite peralkaline granite, the St. Lawrence peralkaline granite, the Grand Beach complex and the Musgravetown and Doe Hills segments of the Bull Arm Formation. All the samples will be analyzed for rare metals to better evaluate their potential and areas with favourable results will be further evaluated in follow-up work.

INTRODUCTION

Recent research on the rare-metal mineralization in the Strange Lake Zr—Y—Nb—Be—REE deposit (Miller, 1986) and in the Letitia Lake Nb—Be $\pm$ Y showings (Miller, 1987) has led to the development of an exploration model for rare-metal mineralization associated with felsic rocks (Miller, 1988). This model will be applied to felsic-rock settings in Labrador and insular Newfoundland, to evaluate the rare-metal potential and to encourage exploration activity for rare metals in the province; funding for this research will be provided by the Canada—Newfoundland Cooperation Agreement on Mineral Development 1990-1995. This past summer (1990), the first field season of the project, focussed on insular Newfoundland.

Rare-metal mineralization in Labrador occurs in high-level anorogenic intrusions and their near-vent extrusive equivalents (Miller, 1987), which are dominantly peralkaline and felsic in nature. Four geological settings—mineralization modes have been identified in Labrador (Miller, 1989):

1) pegmatite—aplite dykes and late-stage, roof-zone phases in high-level peralkaline granite plutons or associated satellite bodies that did not vent to the surface (e.g., Strange Lake peralkaline granite; Miller, 1989, 1990),

2) pegmatite and pegmatite—aplite dykes in the roof zone of vented peralkaline granites and disseminated mineralization in the near-vent extrusive equivalents or associated subvolcanic satellite bodies (e.g., Flowers River Igneous Suite, Shallow Lake peralkaline granite; Hill, 1981; Miller, 1989),

3) subvolcanic veins associated with peralkaline quartz syenites and disseminated mineralization in the associated peralkaline trachytes within the near-vent environment (e.g., Mann #1 and Two Tom Lake deposits; Miller, 1987), and,

4) disseminated mineralization within high-level, unvented(?), undersaturated peralkaline complexes (e.g., Red Wine Alkaline Intrusive complex; Curtis and Currie, 1981).

Most of these generalized geological settings have been identified in insular Newfoundland (Miller, 1989). Table 1

Table 1. Rare-metal exploration targets in insular Newfoundland

Setting	Area	Plutonic Phase	Volcanic Phase
Setting #2,3	Kings Point	Kings Point Complex (Per±)	Kings Point Complex (Per±)
Setting #1,2	La Scie	Seal Island Bight Peralkaline Granite ?	Cape St. John Group ? (Per?)
Setting #2,3	Mic Mac Lake	None identified	Mic Mac Lake Group (Per?)
Setting #1,2	Clarenville	Louil Hills Peralkaline Granite ?	Bull Arm Formation ? (Per?)
Setting #1,2	English Harbour	Cross Hills Peralkaline Granite ?	Mooring Cove Formation ? (Per?)
Setting #2,3	Burin Peninsula	St. Lawrence Peralkaline Granite	Rocky Ridge Complex (Per)
Setting #2,3	Burin Peninsula	Winterland Porphyry (Per?)	None identified
Setting #2,3	Burin Peninsula	Grand Beach Complex (Per?)	Grand Beach Complex (Per?)

Per? Peralkaline nature not well established; may have peralkaline trace-element characteristics but does not have peralkaline major-element characteristics.

Per± Definitely peralkaline at some outcrops; not peralkaline or questionably peralkaline in others

? Age and petrological relationships between plutonic and volcanic rocks is unknown.

lists the areas and geological units chosen for this study and the rare-metal setting expected in these areas. Each of these areas is being evaluated initially by reconnaissance mapping and sampling programs. All outcrops visited are assessed for rare-metal mineralization; selected outcrops are measured for radioactivity (total counts using an EDA GRS-500 Spectrometer) and sampled for geochemical and/or thin-section analyses. Samples collected will be petrographically studied and geochemically analyzed to help determine the rock type and degree of peralkalinity (a key factor in rare-metal environments), and to determine the representative rare-metal values of the outcrop.

RARE-METAL TARGETS IN NEWFOUNDLAND

The best regional rare-metal targets are felsic volcanic rocks and related intrusive rocks from complexes that are peralkaline, have peralkaline affinities (e.g., high values of Zr, Nb, U, F, REE) or are associated with peralkaline rocks. Units targeted for sampling this summer (Figures 1 and 2) include: the Kings Point complex, the Cape St. John Group and the spatially associated Seal Island Bight peralkaline granite, the Mic Mac Lake group, the Bull Arm Formation (Musgravetown Group) and the spatially associated Louil Hills Intrusive Suite peralkaline granite, the Mooring Cove Formation (Long Harbour Group) felsic volcanic rocks (English Harbour East area), the Cross Hills Plutonic Suite and the St. Lawrence peralkaline granite and its related volcanic–subvolcanic complexes (Figure 3; Grand Beach complex, Rocky Ridge complex, and Winterland porphyry). All target suites were sampled and reconnaissance mapped. Other suites, including the Hare Hill peralkaline granite and Topsails Intrusive Suite (including felsic volcanic rocks of the Sheffield Lake area), will be sampled during 1991.

The sampled areas can be characterized as follows:

1. Kings Point complex (Mercer *et al.*, 1985; Kontak and Strong, 1986)—A felsic subvolcanic–volcanic complex, which consists of peralkaline and non-peralkaline trace-element-enriched granites, porphyries, porphyritic syenite, ash flows, lava flows and breccias (contains the vented granite–syenite and volcanic equivalents of Setting 2 and 3, Table 1; mineralization may occur as veins or pegmatites).

2. Seal Island Bight peralkaline granite (Whalen *et al.*, 1986; DeGrace *et al.*, 1976)—This consists of a riebeckite-bearing peralkaline granite (if the nearby spatially associated Cape St. John Group felsic volcanic rocks are peralkaline or have peralkaline affinity then Setting 2 is applicable, otherwise this is an unvented granite of Setting 1).

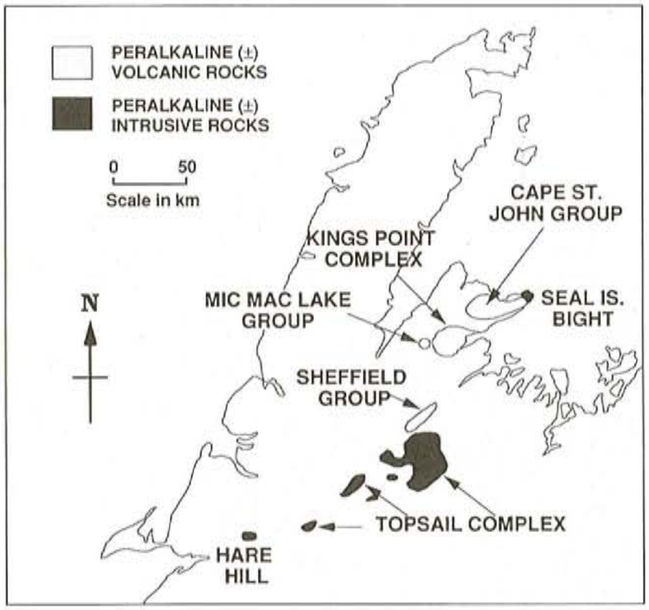


Figure 1. *Rare-metal targets in northwestern Newfoundland; peralkaline and peralkaline-related volcanic and high-level plutonic rocks.*

3. Cape St. John Group (DeGrace *et al.*, 1976)—Dominated by ash-flow tuffs and aphanitic to slightly porphyritic rhyolitic flows and pyroclastics; also includes Cape Brulé Porphyry; (this group could contain mineralized volcanic rocks or veins of Setting 2).

4. Mic Mac Lake group (DeGrace *et al.*, 1976; Hibbard, 1983)—Volcanic—sedimentary sequence consisting of mafic flows, conglomerate, felsic ignimbrite and porphyry, and trachytic flows (may contain mineralized flows or veins of Settings 2 or 3).

5. Bull Arm Formation (King, 1988; Colman-Sadd *et al.*, 1990)—Consists of mafic flows, felsic to intermediate, massive to feldspar porphyritic flows and ash-flow tuffs (mineralization may occur as veins or disseminated in volcanic rocks of Setting 2).

6. Louil Hills peralkaline granite (O'Brien, 1987; O'Brien *et al.*, 1988)—Ranges from riebeckite-bearing fine- to medium-grained peralkaline granite (either Setting 1 or 2 depending on the relationship between the peralkaline granite and the nearby Bull Arm Formation rhyolitic volcanic rocks).

7. Mooring Cove Formation, English Harbour East area (O'Brien *et al.*, 1984)—Consists of rhyolitic massive to banded flows, flow breccia and ash-flow tuffs (occurs in Setting 1 or 2 depending on the age—petrological relationship between these volcanic rocks and the Cross Hills Plutonic Suite peralkaline granite).

8. Cross Hills Plutonic Suite peralkaline granite (Saunders and Tuach, 1989)—Peralkaline phases are aplitic, fine- or medium-grained granite (mineralization occurs in Setting 1 or 2 depending on the petrological relationship with the spatially associated Mooring Cove Formation).

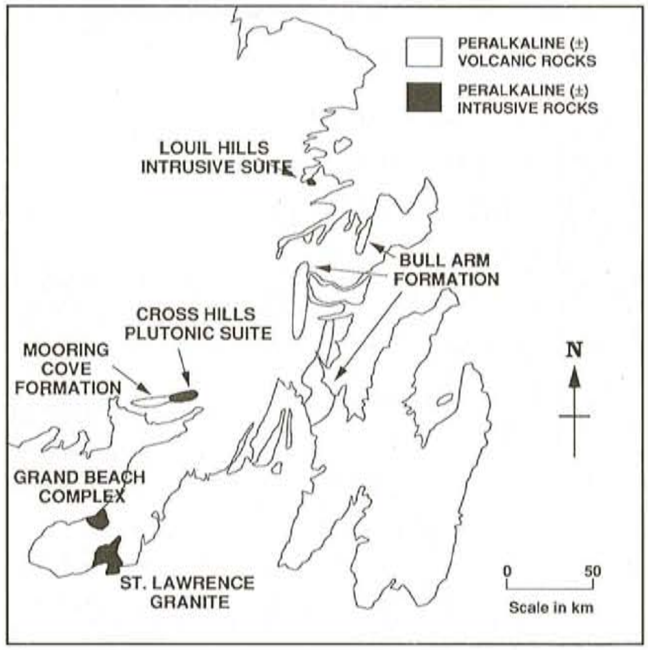


Figure 2. *Rare-metal targets in southeastern Newfoundland; peralkaline and peralkaline-related volcanic and high-level plutonic rocks.*

9. St. Lawrence peralkaline granite (Strong *et al.*, 1978; O'Brien *et al.*, 1977)—Consists of porphyritic and medium-grained granite, quartz—feldspar porphyry, and amphibole syenite (known mineralization in fluorite-rich veins of Setting 2).

10. Grand Beach complex (Strong *et al.*, 1978; O'Brien *et al.*, 1977)—Dominated by quartz—feldspar porphyry and ash-flow tuffs associated with minor rhyolitic flows (may be related to the St. Lawrence peralkaline granite and thus be in Setting 2).

11. Rocky Ridge complex (Strong *et al.*, 1978)—Observed to contain quartz—feldspar porphyry, amphibole—quartz syenite and felsic ash flows (occurs in Setting 2 or 3).

12. Winterland porphyry (Strong *et al.*, 1978)—Characterized by very poor outcrop; observed outcrops are quartz—feldspar porphyry and porphyritic amphibole syenite (probably occurs in Setting 3).

PRELIMINARY EVALUATION OF TARGETS

The modes of occurrence of rare-metal mineralization makes it difficult to visually identify it in the field. Rare-metal-bearing pegmatitic lenses, veins and dykes, as found in Settings 1, 2 and 3, are usually the easiest to identify if the rare-metal minerals are coarse grained. However, aplitic, fine-grained and disseminated mineralization, particularly in the volcanic environments of Settings 2 and 3, is very difficult

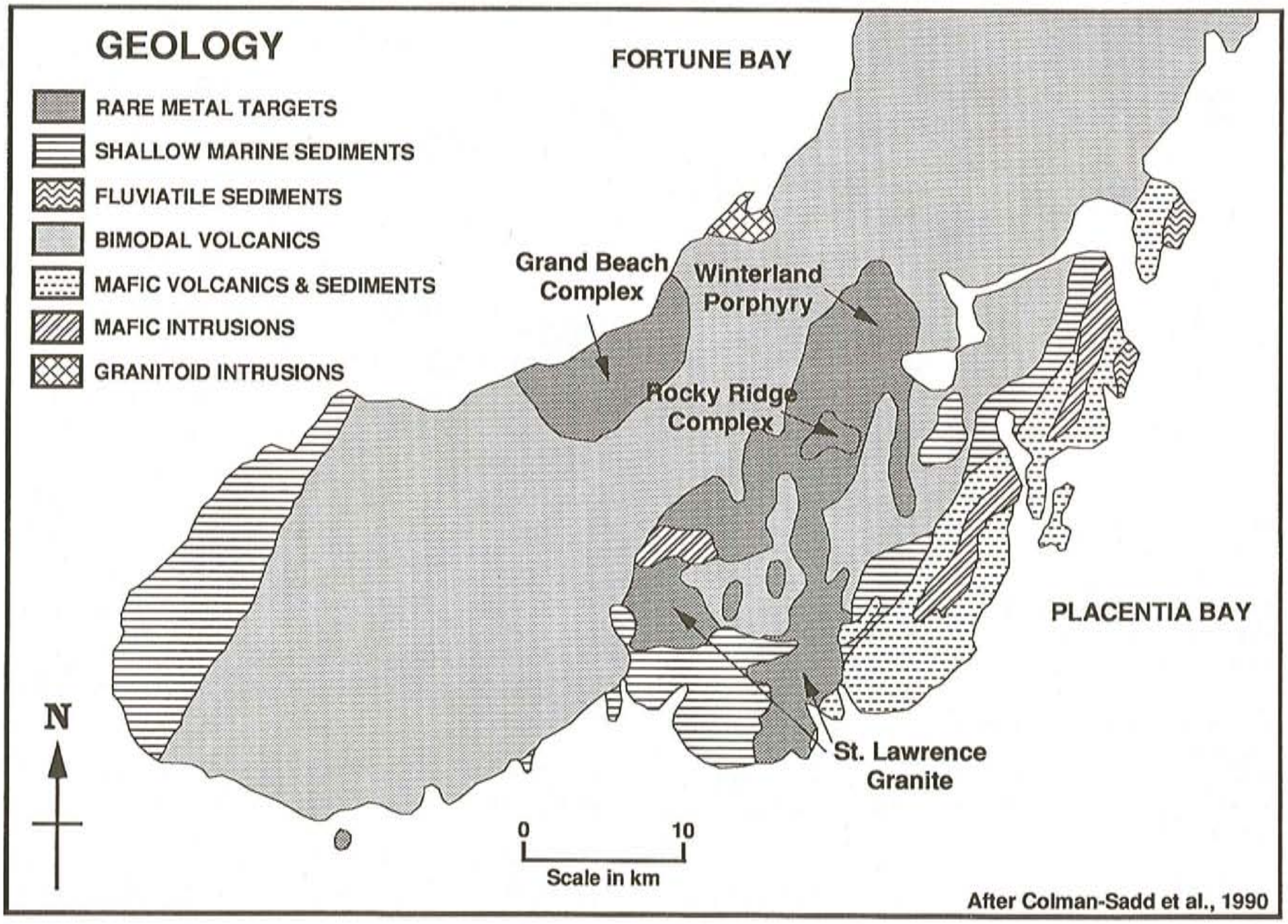


Figure 3. *General geology of the southern portion of the Burin Peninsula; location of the Grand Beach complex, Winterland porphyry, Rocky Ridge complex and St. Lawrence Granite (after Colman-Sadd* et al., *1990).*

to verify due to the fine grainsize. Thus, rare-metal potential cannot be very accurately evaluated in many areas before chemical analyses are available.

A tentative positive correlation between rare-metal content and radioactivity (total counts) in samples studied from both the Letitia Lake showings and the Strange Lake deposit, indicates that radioactivity can be used to determine rare-metal potential. As rare-metal analyses are presently lacking for the samples collected to date, radioactivity, degree of peralkalinity and similarity of environment with known deposits and showings, will be used to make a preliminary evaluation of the rare-metal targets.

These criteria have been applied to the samples collected from the 1990 target areas to give a qualitative idea of the amount of rare metals present; low potential is of no economic interest, medium potential needs further evaluation and high potential suggests rare-metal values of economic interest. The following is a preliminary evaluation of the target areas.

I. Kings Point complex—The quartz—feldspar porphyry, quartz syenite and porphyritic granite of this complex (Figure 4) commonly have total count (TC-1) radiometric values of between 225 and 280 c.p.s., whereas the porphyritic syenite and the ash-flow tuff outcrops usually give values of between 300 and 400 c.p.s. Anomalous values of between 420 and 800 c.p.s. are found in outcrops of phenocryst-poor porphyry, amphibole-bearing porphyry and flow-banded breccias, in certain areas of the complex. The best indication of mineralization was one highly radioactive pegmatite—aplite vein (<10 cm thick), which had values between 2000 and 3500 c.p.s. Pegmatite—aplite veins in the Strange Lake deposit host rare-metal mineralization and commonly have radioactivity measurements above 1000 c.p.s. These observations suggest that parts of the Kings Point complex have high rare-metal potential.

II. Cape St. John Group—The volcanic rocks of this group generally exhibit low radioactivity (200 to 310 c.p.s.) and are probably low in rare metals. Some isolated outcrops of aphanitic volcanic rocks have radioactivity up to 550 c.p.s.; chemical data is needed to better evaluate these outcrops. The Cape Brulé Porphyry is characterized by generally higher radioactivity, 270 to 430 c.p.s., than the surrounding volcanic rocks. Radioactivity and field observations indicate that the

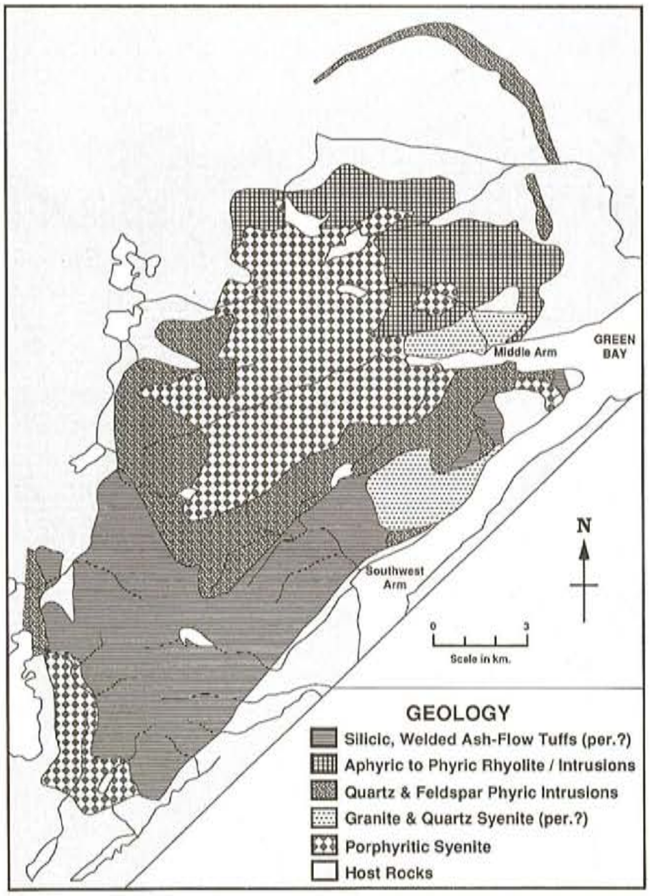
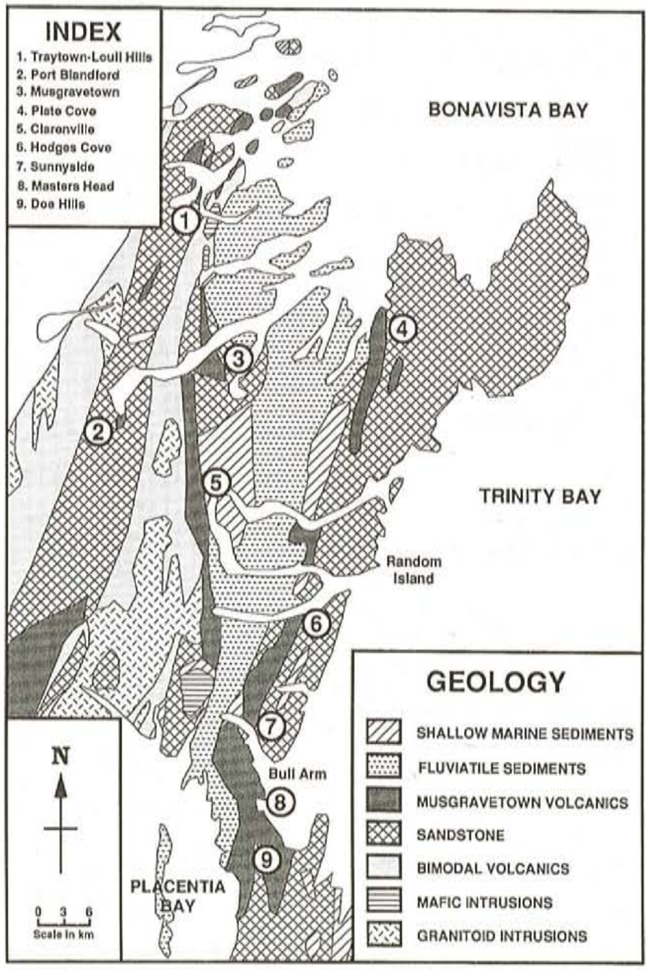


Figure 4. *General geology of the Kings Point complex (after Mercer* et al., *1985; Kontak and Strong, 1986).*



After Colman-Sadd et al., 1990

Figure 5. *General geology of the Traytown to Doe Hills area, eastern Newfoundland; indicates the locations of the sampled areas in the Bull Arm Formation of the Musgravetown Group (after Colman-Sadd* et al., *1990).*

Cape St. John Group is not a good candidate for rare-metal mineralization. Isolated volcanic units and parts of the porphyry may be of interest.

III. Seal Island Bight peralkaline granite—Even though this is a peralkaline granite, the radioactivity is relatively low (200 to 300 c.p.s.), which suggests low rare-metal content; pegmatite—aplite veins were not observed in outcrop.

IV. Mic Mac Lake group—Low to medium radioactivity, from 200 to 400 c.p.s., indicate a low rare-metal potential. This group was not extensively sampled.

V. Bull Arm Formation—The Bull Arm Formation target area was broken down into several segments due to the large areal extent of the formation (Figure 5). These segments are located in the Traytown, Port Blandford, Musgravetown, Plate Cove, Clarenville, Hodges Cove, Sunnyside, Masters Head and the Doe Hills areas. Segments containing outcrops of medium to high relative radioactivity and thus, medium to high rare-metal potential include: Musgravetown and Doe Hills.

1) Traytown—Minor units of felsic to intermediate tuffs and flows in this area have radioactivity values of between 140 and 260 c.p.s. These volcanic rocks appear to have very low rare-metal potential.

2) Port Blandford—Samples, collected from felsic flows and tuffs, in this area give low radioactivity values in the range 220 to 250 c.p.s. Rare-metal potential is very low.

3) Musgravetown—Felsic flows range from 300 to 720 c.p.s. in this area. Several units have values in the upper part of this range and thus have medium to high potential for rare metals.

4) Plate Cove—Felsic flows and porphyries in the Plate Cove area exhibit a range of radioactivity values of between 270 and 410 c.p.s. Samples with values in the upper part of this range may have some rare-metal potential, but this area generally has low potential.

5) Clarenville—Feldspar porphyritic flows in this area range from 210 to 420 c.p.s. Most of these flows have very low rare-metal potential but those with higher radioactivity values may have some potential and must await chemical analysis.

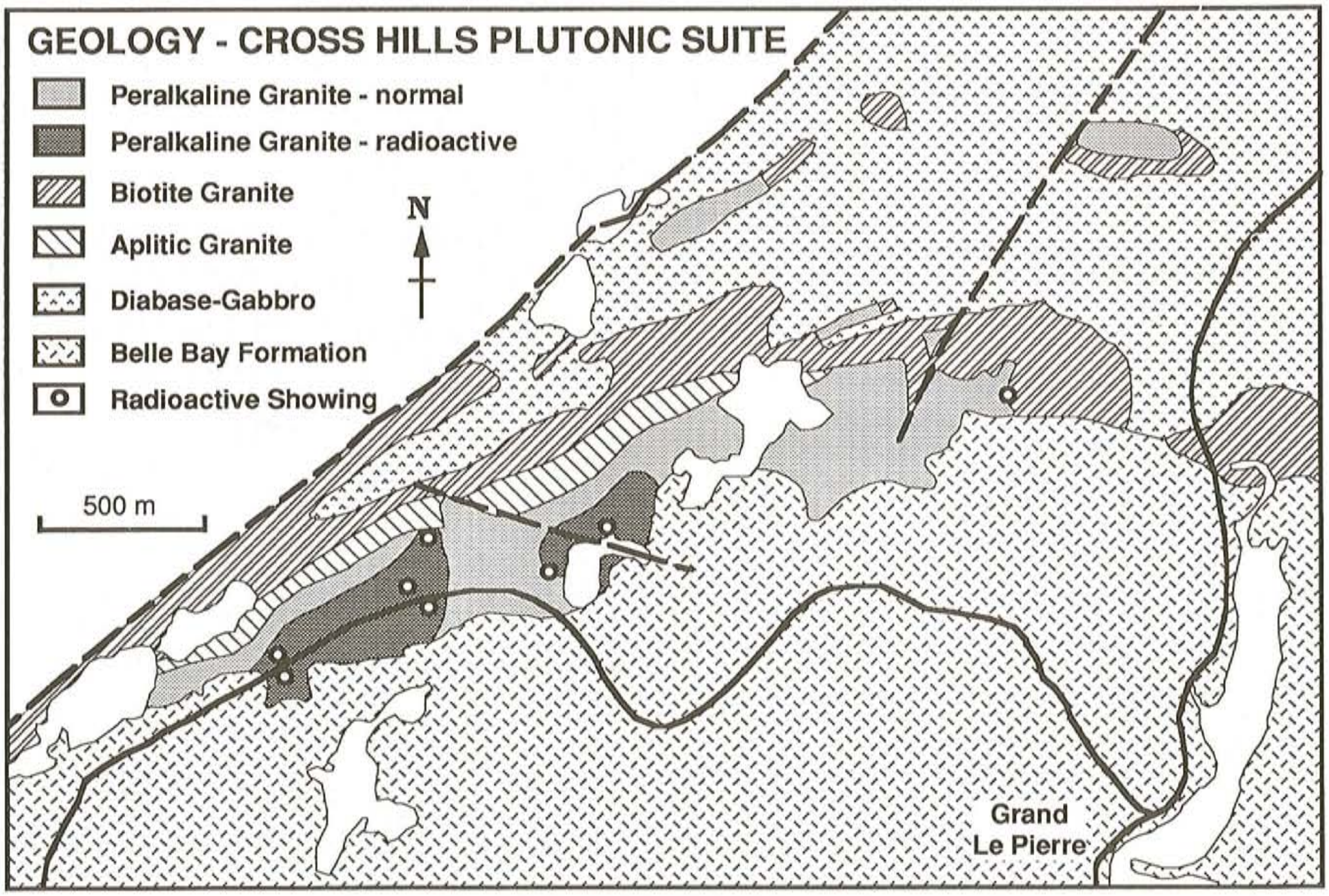


Figure 6. *Geology of the Cross Hills Plutonic Suite; location of radioactive showings and the radioactive peralkaline granite (after Saunders and Tuach, 1989).*

6) Hodges Cove—The few samples of felsic to intermediate tuffs or flows collected from this area have very low radioactivity (250 to 270 c.p.s.) and thus, low rare-metal potential.

7) Sunnyside—Felsic rocks in the Sunnyside area range from 185 to 480 c.p.s. Ash-flow tuffs, porphyries and flows have examples throughout this range. Values in the upper portion of the range suggest local units having medium rare-metal potential although most other units have low potential.

8) Masters Head—The felsic porphyries and ash-flow tuffs in this area range from 200 to 380 c.p.s., and thus have a low potential.

9) Doe Hills—Felsic ash-flow tuffs, porphyries and flows in this area form two groups based on radioactivity. One group has a range of 210 to 360 c.p.s., with most outcrops exhibiting values above 300 c.p.s.; the second group has a range of 480 to 540 c.p.s. The outcrops from the second group have a medium rare-metal potential.

VI. Louil Hills peralkaline granite—This peralkaline granite, as observed in samples from outside of the Terra Nova National Park, appears to have a high potential for rare-metal mineralization as indicated by zones of high spot radioactivity (750 to 900 c.p.s.). It also has a higher general radioactivity than many of the other suites studied (400 to 500 c.p.s.), including the Seal Island Bight peralkaline granite, which is similar in composition.

VII. Mooring Cove Formation—Felsic flows and tuffs exhibit mainly low to medium radioactivity (240 to 360 c.p.s.). Several samples with high radioactivity (600 and 700 c.p.s.) suggest that there are some units of this formation that have medium to high rare-metal potential.

VIII. Cross Hills complex—Two separate bodies of Cross Hills peralkaline granite, the Bark Pond and the northeast occurrences, were sampled and measured for radioactivity. This fine-grained to medium-grained granite can be divided into two groups, a medium radioactivity group (370 to 440 c.p.s.), found at both occurrences, and a high radioactivity group (475 to 1020 c.p.s.), found only at the Bark Pond occurrence (Figure 6). A large number of small radioactive (880 to 1400 c.p.s.) pegmatite—aplite veins (< 15 cm wide) and pods occur within the zone of highly radioactive medium-grained granite. These high values of radioactivity, along with some analyses from these rocks (Saunders and Tuach, 1989), indicate that the Cross Hills peralkaline granite has a high potential for rare-metal mineralization. This setting for rare-metal mineralization is very similar to that at the Strange Lake deposit and thus, should be thoroughly evaluated.

IX. St. Lawrence peralkaline granite–The two major phases of this granitic complex exhibit fairly similar radioactive values. The porphyritic granite phase has values in the range of 370 to 570 c.p.s. and an average of 460 c.p.s. (15 samples) whereas the medium-grained granite phase has a range of 370 to 610 c.p.s., with two observed highs of 720 and 860 c.p.s., and an average value of 510 c.p.s. (23 samples); other minor phases have similar values. These values indicate that there are large segments of this granite, which have medium to high potential for rare-metal mineralization; the two high values may indicate areas for detailed follow-up work. Previous analyses for Y in fluorite from fluorite veins (Strong *et al.*, 1984) indicate that these veins have good potential for Y mineralization, yet radioactivity values in the range 250 to 380 c.p.s. suggest the opposite. A correlation between radioactivity and rare-metal contents in fluorite veins may not exist as it does for granitic bodies and volcanic rocks. The overall radioactivity of this granite is very high and suggests that there is a medium to high potential for rare-metal mineralization.

X. Rocky Ridge complex–The rocks of this complex have low to medium radioactivity (range of 230 to 470 c.p.s.). There appears to be very low potential in this area.

XI. Winterland porphyry–Very rare outcrop has limited the ability to evaluate the rocks of this complex and to establish its bedrock extent. One sample of quartz–feldspar porphyry, several of amphibole-bearing quartz syenite and several of feldspar porphyry were taken from outcrops thought to be in the outcrop area of this complex. Radioactivity measurements range from 230 to 370 c.p.s., with most being below 260 c.p.s. These results indicate that the rare-metal potential is low. The difference in overall radioactivity of the Winterland porphyry rocks verses the St. Lawrence Granite suggests that these rocks are not as closely related as previously thought (Strong *et al.*, 1978).

XII. Grand Beach complex–Much of this complex is characterized by quartz–feldspar porphyry and quartz–feldspar porphyritic ash-flow tuffs with minor felsic flows, debris flows and tuffs. The quartz–feldspar porphyry has a range of radioactivity values of 280 to 400 c.p.s. with an average of 360 c.p.s. (10 samples), whereas the ash-flow tuffs have a range of 330 to 650 c.p.s. with an average of 430 c.p.s. (12 samples). The minor units have values in the range of 260 to 680 c.p.s. The most interesting values, above 500 c.p.s., occur in the ash-flow tuffs (525, 545 and 650 c.p.s.) and in one outcrop area of felsic flows (680 c.p.s.) observed in the complex. The small areas within the complex, which exhibit medium radioactivity, appear to have medium-high rare-metal potential. The Grand Beach complex is generally much lower in radioactivity than the St. Lawrence Granite and thus, may not be as closely related as previously thought (Strong *et al.*, 1978).

CONCLUSIONS

At present, only field observations and radioactivity measurements are available for the samples collected. These data, in particular the radioactivity values, can only be used to make a preliminary evaluation of rare-metal potential.

Most areas sampled have radioactive background values in the 250 to 500 c.p.s. range. Areas that have outcrops with values above this range, and thus have medium to high rare-metal potential, are: Kings Point complex, Louil Hills peralkaline granite, Mooring Cove Formation, Cross Hills peralkaline granite, St. Lawrence peralkaline granite, Grand Beach complex and the Musgravetown and Doe Hills areas of the Bull Arm Formation. One pegmatite–aplite vein in the Kings Point complex and several pegmatite–aplite or pegmatite veins in the Cross Hills peralkaline granite have radioactivity measurements above 1000 c.p.s.; these areas are of particular interest because the mode and radioactive values of the mineralization is similar to that observed in the Strange Lake peralkaline granite.

Geochemical and other data are required to further evaluate these rare-metal targets. Laboratory studies are ongoing. Reconnaissance sampling of other targets in insular Newfoundland, including the Hare Hill peralkaline granite and Topsails Intrusive Suite (including felsic volcanics of the Sheffield Lake area), and some within Labrador will be carried out during the 1991 field season. A detailed sampling and mapping program will also be carried out in the Flowers River Igneous Suite felsic volcanic rocks in 1991. The more encouraging areas, subsequently identified in geochemical and other studies, will be the subject of a follow-up program in the following field season.

ACKNOWLEDGMENTS

Field data for this report was collected in the summer of 1990, during which Ron Ryan capably carried out the duties of field assistant. The hospitality of David Liverman and crew in South Brook for part of the field season is greatly appreciated. The manuscript was improved by the comments of H.S. Swinden and C.F. O'Driscoll.

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