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# PLUTONIC ROCKS OF THE EASTERN CENTRAL MINERAL BELT: LITHOGEOCHEMICAL PATTERNS AND IDENTIFICATION OF POTENTIAL SPECIALIZED GRANITOIDS

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## ABSTRACT

*This project was initiated to provide an assessment of the mineral potential of granitoid rocks throughout the eastern Central Mineral Belt of Labrador.*

*Geochemical patterns suggest that both the 1.85-Ga Makkovikian batholith and the 1.65-Ga Trans-Labrador batholith are dominated by silica-rich granitoids, and over 50 percent of the rock samples show $SiO_2$ contents in excess of 72 percent. Most of the less differentiated rock types within the area belong to the Adlavik Intrusive Suite of the Trans-Labrador batholith, a distinctive pyroxene-bearing suite ranging in composition from gabbro to syenite. Granitic* (s.s.) *rocks within the Trans-Labrador batholith can be divided broadly into regional granitoid units, which predominate in the southern part of the area and do not generally display contacts with the country rocks, and small discordant plutons in the north, which show well preserved intrusive contacts. Map patterns suggest that the smaller plutons represent cupolas on the upper surface of a more continous batholith at depth. These small plutons show more differentiated and restricted major-element compositions, when compared to the regional units, and also to the older Makkovikian granitoids. They are also richer in U, Th, Li Rb and F, and locally in Ga, Nb, Zr, Y ,Ce, Pb and Zn, and show a complementary depletion in V, Cr, Ni, Ba and Sr. Levels of Mo and Cu are relatively constant for all units, but are close to detection limits. Variation in incompatible-element abundances within the smaller plutons is much greater than in the regional units, although the latter show much more varied major-element compositions. This is interpreted to indicate a decoupling of major- and trace-element behaviour, which reflects the operation of processes such as hydrothermal alteration and volatile fluxing, and liquid-state processes such as convective fractionation, in addition to the 'normal' process of fractional crystallization.*

*The plutons can be divided into two groups, exhibiting contrasting peraluminous and alkaline tendencies, both of which are spatially related to known mineral occurrences of broadly similar type. In terms of their local geological and geochemical background, these small plutons exhibit some characteristics of specialized granites, and may have potential for granophile mineralization. Some of the more differentiated units within the Makkovikian batholith may also have some potential.*

## INTRODUCTION

### Project Description

The current project was initiated in late 1984 to provide an assessment of the potential of granitoid rocks throughout the eastern Central Mineral Belt, and also to develop an understanding of the evolution and petrogenesis of the ca. 1.65-Ga-old Trans-Labrador batholith, an extensive curvilinear granitoid belt that is one of the most striking geological elements of central Labrador (Figure 1). Field work was undertaken in both the 1985 and 1986 field seasons, and is now essentially complete. Areas surveyed to date are shown in Figure 1.

The most important component of the project is a large-scale geological mapping and lithogeochemistry program utilizing a grid-cell approach similar to that employed in the Ackley granite project in southeast Newfoundland (Dickson, 1983; Tuach *et al.*, 1986). The average site spacing in the sampling program is 2 km. In conjunction with this regional program, several smaller plutons and phases of larger bodies have been examined and sampled in more detail, with an average site spacing of 750 m to 1 km. This project has been closely co-ordinated with a mapping and sampling project directed at clarifying the metallogeny of the Central Mineral Belt. Results of this related work are presented elsewhere by MacDougall and Wilton (1987) and MacKenzie and Wilton (1987).

The regional program is designed to identify plutons or phases of plutons that show geochemical patterns suggesting extreme differentiation and/or specialization. Follow-up mapping and sampling are intended to delineate and assess such units in more detail, and also to define geochemical-zonation patterns in or around units that may pinpoint favourable loci for mineralization. Geochemical data from areas covered in 1986 are as yet unavailable, and this report is thus primarily concerned with lithogeochemical data from

This project is a contribution to the Canada–Newfoundland Mineral Development Agreement, 1984–1989

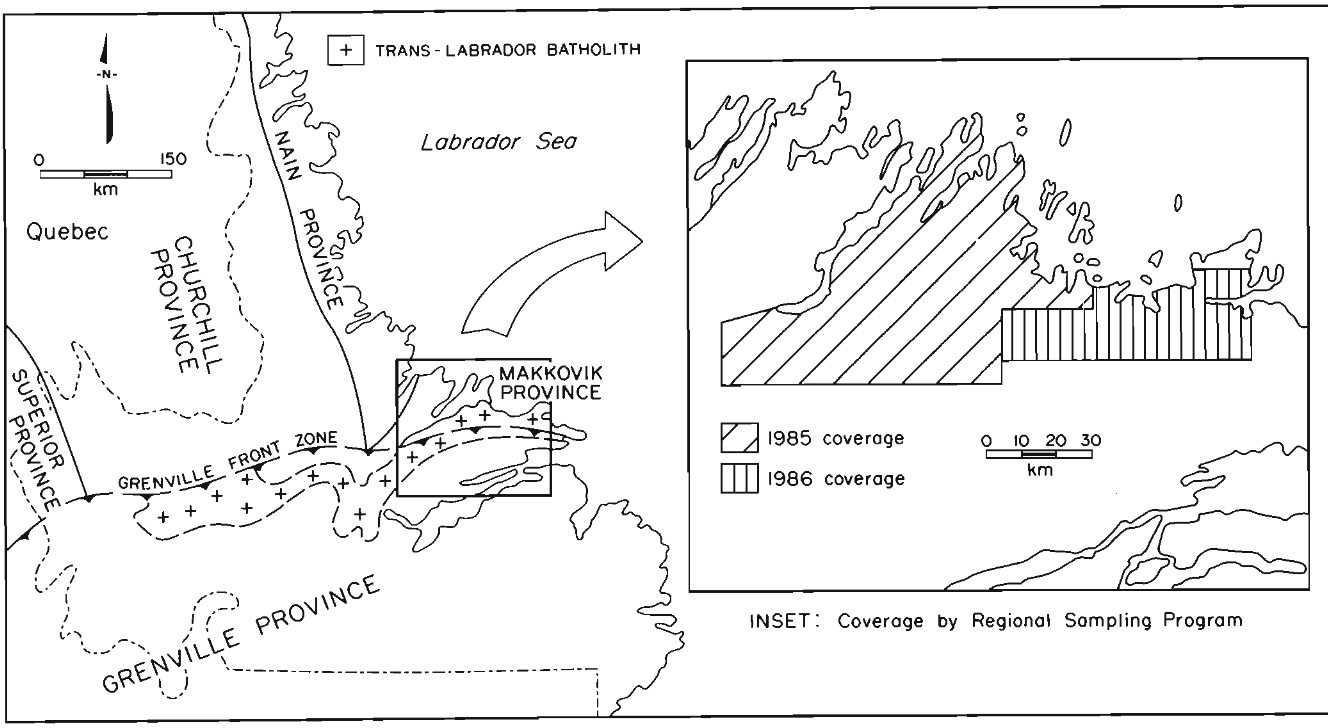


**Figure 1:** *Location map showing areas covered to date by mapping and lithogeochemical sampling.*

areas investigated in 1985. Interpretation of geochemical patterns is based on mean compositions of the various plutons and units. Whilst this approach does not provide details of chemical or spatial variation, it does serve to illustrate the most favourable units for mineralization. Maps showing element distributions will form part of an open file report in 1987.

### Location, Access and Topography

The area includes the northern part of NTS area 13J and adjacent parts of 13K and 13O. It has a maximum length of 140 km and a maximum width of 75 km, and is centred around the small village of Makkovik, which serves as a base during field operations. Physiographically, the area is dominated by a deeply incised and drowned coastline containing numerous fiords and offshore islands. The hinterland is rugged and mountainous for the most part, except in the extreme south and west where an undulating plateau containing numerous boulder fields and bogs predominates. Access to the area is by scheduled air service (LABAIR) or Marine Atlantic coastal boat.

### Previous Work

Previous work in the area is reviewed in detail by Gower *et al.* (1982) and Ryan (1985). 1:250,000 scale mapping was completed by the Geological Survey of Canada (Stevenson, 1970; Taylor, 1975), and concurrent mineral exploration by BRINCO led to the discovery of the presently subeconomic Kitts and Michelin uranium deposits (Gandhi, 1978). Several more general studies were conducted in conjunction with mineral exploration, and include regional geological and structural work (Clark, 1970, 1973; Marten, 1977) and geochemical studies of uranium-bearing volcanic suites (White and Marten, 1980; Evans, 1980).

Geological mapping by the Newfoundland Department of Mines and Energy started in 1976 and was largely complete by 1980. Compilation and synthesis of this data were presented by Gower *et al.* (1982) for the eastern part of the area, and by Bailey (1979) and Ryan (1985) for the west. These mapping programs were directed mostly toward the supracrustal sequences, but the extent and variability of granitoid rocks were recognised. Regional mapping since 1980 in central Labrador has demonstrated that the granitoid rocks of the eastern Central Mineral Belt form the eastern end of a 500-km-long middle Proterozoic granitoid terrane, termed the Trans-Labrador batholith (Wardle *et al.*, 1982). The Trans-Labrador batholith appears to be part of a 1.65-Ga orogenic belt termed the Labrador Orogen (Thomas *et al.*, 1985), which is now largely overprinted by younger Grenvillian events.

Geological mapping during the 1985 field season led to revision of existing unit designations and established a number of new granitoid units.

## GEOLOGY

The geology of the area has been described in detail by Gower *et al.* (1982), and the distribution and characteristics of granitoid units have been described by Kerr (1986). The following section is a general overview intended as a framework for geochemical data presented in later sections. A generalized geological map is shown in Figure 2.

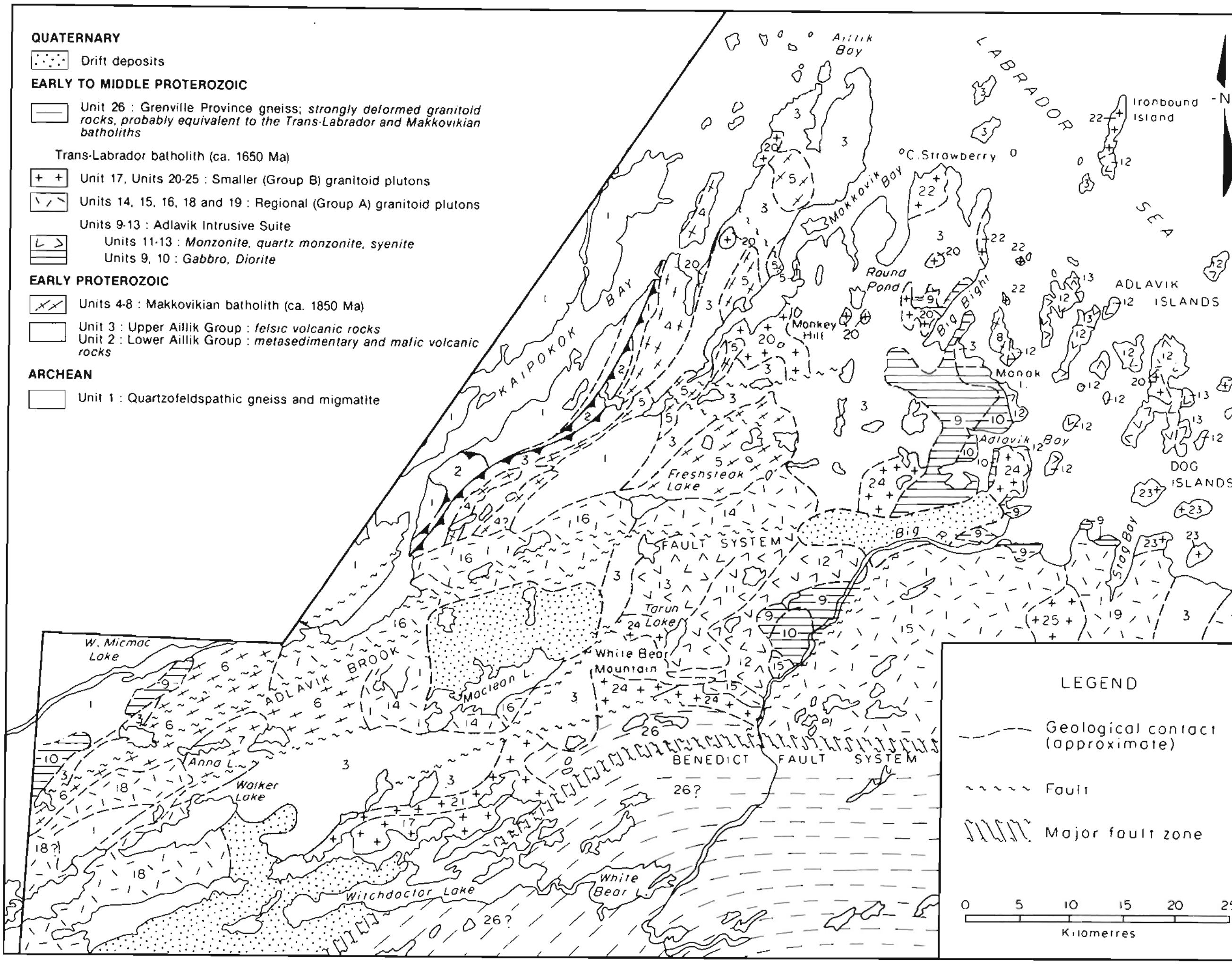


**Figure 2:** *Generalized geological map showing the distribution of units within the Makkovikian and Trans-Labrador batholiths (partly after Gower et al., 1982, and Ryan, 1985). For location within Labrador, see Figure 1. For detailed descriptions of individual units within the four major divisions, see Tables 1 to 4 inclusive.*

## Regional Geology

Five geological assemblages are present within the study area:

1) An assemblage of banded gneisses thought to be of Archean age (Unit 1) that underwent extensive metamorphism during Early Proterozoic orogenic events of ca. 1.85 Ga age.

2) Supracrustal rocks of the Aillik Group (Units 2 and 3), which structurally overlie the gneisses and consist of a lower assemblage of mafic volcanic rocks and basinal sedimentary rocks, and an upper assemblage of felsic volcanic and volcaniclastic rocks. There are some doubts as to the stratigraphic continuity of the group, and the upper and lower portions may be disconformable.

3) Foliated granitoid rocks of the Makkovikian batholith (Units 4 to 8), which intrude the Aillik Group, but were deformed with it during the Makkovikian Orogeny of ca. 1.85 Ga age. They show a syntectonic relationship to deformation and metamorphism of the Aillik Group.

4) Massive, posttectonic intrusive rocks of the Trans-Labrador batholith (Units 9 to 25), which yield radiometric ages of ca. 1.65 Ga. These are more varied in composition than the Makkovikian batholith, but are dominated by siliceous granitoid rocks.

5) Foliated to gneissic granitoids containing east-trending foliations in the south of the area (Unit 26), which form part of the Grenville Province. These are probably strongly deformed equivalents of the Makkovikian and/or Trans-Labrador batholiths.

## Intrusive Rocks

*Makkovikian batholith.* The Makkovikian batholith includes foliated granitoid rocks displaying north- to northeast-trending fabrics that are subconcordant to fabrics developed in the Aillik Group. Limited radiometric age data suggest emplacement between 1.95 and 1.85 Ga, and contact relations around Kaipokak Bay (Marten, 1977) indicate that they are syntectonic with respect to deformation of the Aillik Group and underlying Archean gneisses.

Five units are presently recognized within the Makkovikian batholith. They range in composition from quartz monzonite to granite, and form a discontinuous belt along the northwestern edge of the area, which corresponds broadly with the most intensely deformed portion of the Aillik Group. The characteristics of these units are summarized in Table 1.

*Trans-Labrador batholith.* Posttectonic, generally massive, intrusive rocks of the Trans-Labrador batholith underlie about 75 percent of the study area, and range from pyroxenite to alkali-feldspar granite. These rocks mostly yield radiometric ages of approximately 1.65 Ga. For the purposes of this report, the batholith is divided into three subdivisions. The Adlavik Intrusive Suite (Units 9 to 13) consists of compositionally and texturally distinctive gabbro, diorite, monzonite and syenite. The granitic *(s.s.)* rocks are more difficult to divide on compositional grounds and are thus subdivided into 'regional units' (Group A granitoids) and 'smaller plutons' (Group B granitoids). This division corresponds roughly to two geological groupings separated by the Adlavik Brook fault zone. Group A granitoids form regionally extensive units whose contacts with country rocks are preserved only locally, whereas Group B granitoids form smaller and less continuous units that are commonly separated from one another by extensive areas of Aillik Group country rocks. This arbitrary grouping is preferred in this context as it is thought to reflect different levels of exposure within the batholith (see below for discussion).

### Adlavik Intrusive Suite (Units 9-13)

The Adlavik Intrusive Suite is present in two main areas separated by the Adlavik Brook fault zone, and includes some of the most distinctive rock types within the Trans-Labrador batholith. It was originally defined by Stevenson (1970) to encompass gabbroic and dioritic rocks of the Adlavik Bay area, but is here extended to include mineralogically and texturally similar monzonite, quartz monzonite and syenite spatially associated with the gabbro and diorite. There are five principal units within the Adlavik Intrusive Suite, ranging in composition from olivine gabbro to alkali-feldspar syenite. Their characteristics are summarized in Table 2. The more mafic components of the Adlavik Intrusive Suite display many features indicative of cumulate origin, and map patterns suggest a large-scale compositional layering in which a lower cumulate gabbro—ultramafic sequence is overlain by the more felsic variants. Field relations suggest an overall trend toward more felsic compositions with decreasing age.

### Group A granitoids

Group A granitoids occur mostly south of the Adlavik Brook fault zone and are divided into five major units ranging in composition from quartz monzonite to alkali-feldspar granite. The characteristics of these units are summarized in Table 3.

Some of the Group A granitoids are petrographically similar to the Group B granitoids discussed below. This is particularly evident for the Bayhead granite (Unit 16), which is very similar to the Strawberry and Dog Island granites (Units 22, 23) farther east.

### Group B granitoids

The smaller granitoid plutons of the area are concentrated mostly to the north of the Adlavik Brook fault system, but this category also includes three bodies within the southern part of the area. A total of 15 discrete bodies are present, and these are grouped into seven units. Many are similar, and most can be placed into one of three groupings described below. The characteristics of the seven map units are summarized in Table 4.

The first subgroup comprises the Strawberry (Unit 22) and Dog Island (Unit 23) granites. These are coarse grained, pink to orange, K-feldspar-porphyritic to megacrystic biotite granites that contain widespread accessory flourite. The Strawberry granite is the most variable texturally, and includes fine grained phases around its margins and on Ironbound Island. It displays many features that are indicative of volatile activity and a high level of emplacement, including miarolitic cavities, pegmatite—aplite veins, tuffisite breccias and irregular silicified zones. Both units also display distinctive biotite layering that has a cumulate-like trough-bedded aspect, which imply a low viscosity during crystallization.

The second subgroup comprises the Monkey Hill (Unit 20), Witchdoctor (Unit 17) and Burnt Lake (Unit 21) granites. These are generally finer grained, white to pink, biotite and biotite—muscovite granites that lack widespread flourite. The Witchdoctor and Burnt Lake granites are both characterized by the presence of minor accessory garnet, and are thought to be part of the same pluton.

A third association may be represented by Unit 24, which forms three discrete bodies that appear to be spatially associated with the Adlavik Intrusive Suite. This is dominated by pink to gray biotite—hornblende quartz syenite to granite, which is locally very similar to syenite assigned to the Adlavik suite. Unit 24 contains abundant accessory flourite and very prominent accessory zircon and allanite.

## Structural Setting

The study area straddles the boundary between the ca. 1.85-Ga Makkovik Province and the ca. 1.1-Ga Grenville Province of southern Labrador. The boundary between these two structural provinces runs along the axis of the Trans-Labrador batholith (Figure 1), and is marked by a major zone

**Table 1.** Characteristics of units within the Makkovikian batholith

| Unit # | Description | Mineralogy/Petrology | Mineralization | Comments |
|---|---|---|---|---|
| 4 | Medium grained gray quartz monzonite, minor diorite and granite; plagioclase porphyritic | 15 to 20 percent mafics, biotite ± hornblende in subequal amounts; accessory sphene, apatite, zircon | | Generally strongly foliated, particularily around margins; contains enclaves of diorite/ amphibolite |
| 5 | Medium to coarse grained, variably porphyritic pink granite, monzogranite and quartz monzonite; locally albite rich | Generally 5 percent mafics, biotite + hornblende; prominent sphene, allanite, zircon and fluorite | Disseminated fluorite and pyrite common; some radioactive pegmatites | Variably foliated and recrystallized |
| 6 | Medium to coarse grained pink to red granodiorite, granite and alkali-feldspar granite; locally K-feldspar porphyritic | 5 percent mafics, metamorphosed to fine grained aggregates of biotite and epidote; accessory allanite | Low-grade uranium mineralization in hematized granite; high-grade uranium mineralization found in float | Very strongly deformed; original textures commonly totally obliterated |
| 7 | Granodiorite, diorite, quartz monzonite | Highly variable | | Poorly defined unit |
| 8 | Medium grained, equigranular white to gray leucocratic granodiorite | 5 percent mafics, mostly green biotite and some relict hornblende | | Limited in extent. |

**Table 2.** Characteristics of units within the Adlavik Intrusive Suite

| Unit # | Rock Types | Mineralogy/Petrology | Mineralization | Comments |
|---|---|---|---|---|
| 9 | Medium to coarse grained layered gabbro–ultramafic cumulates, plagioclase cumulates and leucogabbro | Variable–the most mafic and least altered gabbros contain olivine, clinopyroxene and orthopyroxene, with lesser hornblende; red biotite and anatite are prominent accessories | Minor pyrite and chalcopyrite in late (?) pegmatitic rocks (possibly some potential for platinum-group elements) | Originally pyroxene and olivine bearing, but many of the rock types are dominated by secondary (deuteric?) hornblende; cumulate layering is developed in more mafic variants |
| 10 | Coarse grained melanocratic diorite and monzodiorite (similar in appearance to gabbro unit) | Generally hornblende bearing and contains variable amounts of clinopyroxene and orthopyroxene; up to 20 percent interstitial K-feldspar | | No clear contacts with gabbro, and probably gradational with it; local cumulate layering |
| 11 | Coarse grained gray diorite to monzonite containing large plagioclase phenocrysts | Clinopyroxene and hornblende, and lesser orthopyroxene; 15 to 30 percent interstitial K-feldspar | | Similar to Unit 10, but partly transitional to Unit 12 |
| 12 | Coarse grained white to pink monzonite and quartz monzonite containing euhedral mafic minerals; very fresh | Dominant mafic mineral is hornblende, which appears primary; relict clinopyroxene common in more mafic variants; accessory zircon, sphene | | Most extensive unit within the Adlavik suite; in places transitional to syenite and monzogranite |
| 13 | Coarse grained gray to brown syenite and quartz syenite, containing perthitic K-feldspar phenocrysts; locally transitional to granite | Clinopyroxene and hornblende, and lesser fayalite; prominent accessory zircon and allanite | | Dikes of syenite cut Unit 12, but in places the contact between Units 12 and 13 seems gradational |

**Table 3.** Characteristics of regional (Group A) granitoid units within the Trans-Labrador batholith

| Unit # | Rock Types | Mineralogy/Petrology | Mineralization | Comments |
|---|---|---|---|---|
| 14 | Medium grained gray to brown granodiorite, quartz monzonite and monzogranite; commonly plagioclase porphyritic | 10 to 15 percent mafics, biotite + hornblende in subequal amounts; 10 to 30 percent interstitial K-feldspar | | In many respects texturally akin to Unit 12, but more siliceous and finer grained |
| 15 | Medium to coarse grained pink granite and alkali-feldspar granite, commonly K-feldspar porphyritic; distinctive, mantled, ovoidal plagioclase phenocrysts ('pseudorapakivi') | 5 to 10 percent mafics, biotite + hornblende and local relict clinopyroxene; variably recrystallized; accessory sphene, zircon, allanite and fluorite | Local disseminated pyrite | 'Pseudorapakivi' texture distinct from almost all other units; includes some equigranular variants |
| 16 | Coarse grained pink to white granite and leucogranite; K-feldspar porphyritic and locally megacrystic | 5 percent mafics, mostly biotite altered to chlorite, minor relict hornblende; wide-spread accessory fluorite and allanite | Disseminated flourite and pyrite; hematized veinlets | Contains trough-like biotite-rich layers that look like cumulate features; generally similar to Strawberry and Dog Island granites |
| 18 | Medium to coarse grained gray to pink monzonite, quartz monzonite and granite; Seriate to porphyritic texture, containing phenocrysts of both feldspars | 5 to 10 percent mafics, hornblende + green biotite; igneous textures well preserved | | Compositionally more variable than other regional units |
| 19 | Coarse grained porphyritic granodiorite and granite | 5 to 10 percent mafics, mostly hornblende + biotite | | Compositionally and texturally variable; may not be a single unit |

of dislocation termed the Benedict fault system, which is interpreted as a high-angle thrust fault. There is a strong contrast in metamorphic grade and deformation state across this zone, and most of the rocks to the south display strong east–west fabrics and/or gneissic layering, resulting from Grenvillian deformation. North of the Benedict fault system, a series of subparallel fault systems, the most prominent of which is the Adlavik Brook fault system, divide the area into several blocks displaying differing amounts of Grenvillian deformation. These blocks are interpreted to represent progressively higher crustal levels from south to north. North of the Adlavik Brook fault system, Grenvillian effects are minimal, most of the Trans-Labrador granitoid rocks are undeformed, and extensive areas of earlier supracrustal rocks are also preserved. This pattern indicates that progressively higher levels within the Trans-Labrador batholith are represented from south to north. The grouping of these granitoid rocks outlined above may thus largely be an artifact of the different crustal levels exposed on either side of the Adlavik Brook fault zone, and the Group B granitoids may simply be higher level equivalents of the regionally extensive Group A granitoids. The similarity betwen the Bayhead granite (Unit 16) and the Strawberry–Dog Island granites (Units 22 and 23) is evidence of such a link in at least one instance.

## Mineralization

This section is drawn to a large extent from recent work by D.H. Wilton and co-workers at Memorial University (Wilton *et al.*, 1986; MacDougall and Wilton, 1987; MacKenzie and Wilton, 1987), and also from data in the Mineral Occurrence Data System (MODS) files for the area (Kerr, 1982). Figure 3 shows the distribution of mineral occurrences that may be related to granitoid rocks, and also the distribution of Group B granitoids discussed above.

Mineral occurrences are concentrated mostly in the supracrustal rocks of the Aillik Group, and form a wide array of deposit types, which are difficult to explain via any one genetic model. The most abundant commodities are U, F and Mo; these are accompanied by smaller numbers of base-metal and precious-metal showings. Gower *et al.* (1982) subdivided mineral occurrences into four geographic belts, each exhibiting their own characteristics. Belts within the lower Aillik Group near Kaipokok Bay and in the upper Aillik Group between Michelin and White Bear Mountain are dominated by uranium mineralization, but two belts in the Makkovik area are more varied in character and contain substantial Mo, Cu, Pb, Zn, F and U. Mineralization in this area shows no clear correspondance with stratigraphy and/or structure. Ryan (1977) and Gower *et al.* (1982) tentatively suggested a connection between some mineralization in this area and the post-tectonic granitoid rocks, and more recent work by Wilton *et al.* (1986) supports this hypothesis and extends the range of deposit types that may be granite related.

*Endocontact mineralization.* Mineral occurrences actually hosted by granitoids within the area are rare compared to those within the country rocks around their

**Table 4.** Characteristics of small (Group B) granitoid units within the Trans-Labrador batholith

| Unit # | Rock Types | Mineralogy/Petrology | Mineralization | Comments |
|---|---|---|---|---|
| 17 | Coarse grained, white to pink, equigranular leucocratic alkali-feldspar granite | 2 percent mafics, mostly biotite; lesser muscovite; minor accessory garnet | | Similar mineralogically to Unit 21, and possibly a coarse grained phase related to it; moderate to strong foliation, probably of Grenville age |
| 20 | Fine to medium grained, gray to pink, quartz-rich monzogranite and granite; very homogeneous; small plagioclase phenocrysts | 2 percent mafics, mostly biotite strongly altered to chlorite; sparse accessory sphene, zircon, allanite and flourite | Endocontact Mo mineralization; spatial association with numerous hydrothermal veins bearing Cu, Mo, F, Pb, Zn, Ba and U | A composite unit including a number of very similar fine grained granite bodies |
| 21 | Fine grained, gray to white, equigranular leucocratic monzogranite and alaskitic granite | 2 percent mafics, mostly biotite; lesser muscovite and accessory garnet | Endocontact Mo mineraliz- near contact with the Aillik Group | Mineralogically similar to Unit 17; possibly a fine grained roof phase |
| 22 | Medium to coarse grained, pink to orange, leucocratic granite; K-feldspar porphyritic to megacrystic; exhibits cumulate-like biotite layering; restricted finer grained phases around margins | 2 to 5 percent mafics, mostly biotite altered to chlorite; minor hornblende in mafic rich layers; ubiquitous accessory fluorite, abundant allanite and zircon; pegmatites/aplites common | Disseminated fluorite; vein and stockwork-like pyritic zones having anomalous Mo contents; spatial relationship to Pb–Zn–Au–Ag vein-type mineralization | Although generally coarse-grained, variable in texture; tuffisite breccias in xenoliths and near contacts |
| 23 | Medium to coarse grained, pink to red, leucocratic, K-feldspar-porphyritic granite, containing cumulate-like layering; quartz–feldspar porphyry dikes around margins | 2 to 5 percent mafics, mostly biotite altered to chlorite; minor hornblende in mafic-rich layers; ubiquitous accessory fluorite, abundant allanite and zircon | Disseminated fluorite; disseminated galena + chalcopyrite at the margins of aplitic veins | Similar to Strawberry granite, but more homogeneous; locally contains minor riebeckite |
| 24 | Medium to coarse grained gray to buff-pink syenite, quartz-syenite and alkali-feldspar granite containing phenocrysts of coarse perthite, locally transitional to fine grained buff granite | 3 to 10 percent mafics, mostly biotite and lesser hornblende; a few examples have relict fayalite; prominent accessory zircon, allanite and fluorite | Possibly spatially related to a vein style U showing containing Cu, Ag | Locally very similar to Unit 13 syenites, and spatially related to the Adlavik Intrusive Suite |
| 25 | Medium to coarse grained, pink, equigranular granite and alkali-feldspar granite | 3 to 5 percent mafics, biotite + hornblende | | In places resembles Unit 15 |

margins. Heavily disseminated molybdenite rosettes associated with pyrite, chalcopyrite and very minor bornite occur in a fine to medium grained, highly miarolitic to vuggy leucogranite on Duck Island, covering an area of some 100 to 200 m², although disseminated pyrite is present all over the island. Grab samples of representative material contained up to 0.5 percent Mo. The only continuous exposure of the leucogranite is on the island itself, but numerous similar granite dikes, veins and sheets disrupt older granitoids on the mainland up to 2 km from this locality. The Duck Island granitoid resembles the Monkey Hill granite, and is interpreted as the upper surface of a small cupola or satellite intrusion. Molybdenite mineralization of similar aspect is present within the Burnt Lake granite (MacKenzie and Wilton, 1987) adjacent to its contact with the Aillik Group, and covers an area of about 100 m². There is little associated pyrite in this showing. A number of other minor Mo occurrences are shown within granitoid rocks on the mineral occurrence map of the area (Kerr, 1982), but many of these are essentially undocumented. MacDougall and Wilton (1987) report minor molybdenite in satellite bodies at Round Pond, which may also be related to the Monkey Hill granite, but no molybdenite has so far been found in the main body. Irregular pyritic zones near the eastern contact of the Strawberry granite contain elevated levels (25 to 50 ppm versus a background of less than 5 ppm) of Mo, but no visible molybdenite.

Disseminated chalcopyrite and galena are present in the Dog Island granite on Burnt Island and are associated with fine grained aplitic veins (up to 2 m in width) that cut the coarse grained granite. The most abundant mineralization is at the margins of the veins, but grades are low and mineralization is very sporadic. Other Cu–Pb showings are reported from this unit, and also from the eastern lobe of the Strawberry granite.

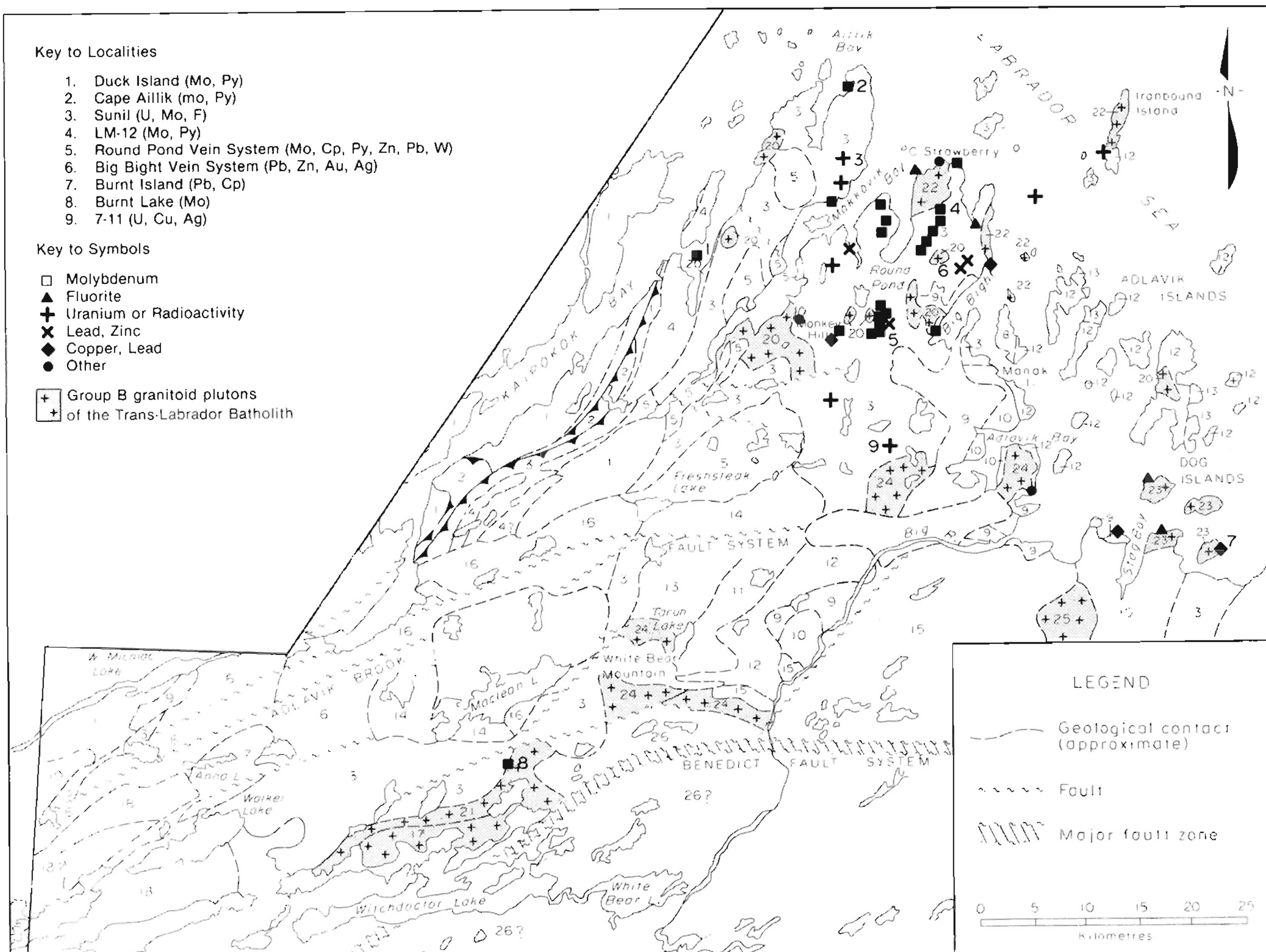


**Figure 3:** *Location map for some of the more important mineral showings and occurrences that may be related to granitoid plutons of the Makkovikian and Trans-Labrador batholiths (after mineral occurrence maps for the area (Kerr, 1982), and Wilton et al., 1986). For location within Labrador, see Figure 1.*

Other mineral occurrences within granitoid rocks include several zones of anomalous radioactivity, most of which are related to pegmatitic segregations, and widespread accessory fluorite in the Strawberry and Dog Island granites. Vein-type fluorite mineralization is less common, but a few centimetre-scale examples are present in both these plutons.

Uranium mineralization within the Makkovikian Melody Hill granite (Unit 6) is suggested by the occurrence of high-grade pitchblende mineralization in granitic boulders near Melody Hill itself. Minor uranium mineralization is present within the granite itself very close to the boulder train, and is associated with intense hematization. A source for the high-grade float has yet to be located.

*Exocontact mineralization.* Mineral occurrences within the Aillik Group around Makkovik show features that strongly suggest they are related to nearby or subjacent plutons. The most obvious and significant examples are in the Round Pond area, where gossans and discordant hydrothermal veins, ranging up to 5 m in width and 100 m in length, are spatially related to two small plugs thought to be satellite intrusions of the Monkey Hill granite (MacDougall and Wilton, 1987). The mineralization is polymetallic, containing Mo, Cu, Zn, Pb, U, F and Ba, and minor W, Ag and Au. MacDougall and Wilton (1987) have recognized several different types of veins, including carbonate-hosted Pb–Zn, massive and stockwork-style pyrite–chalcopyrite, quartz–molybdenite, and fluorite veins containing significant U. Fluorite is a common component of all vein types. A group of carbonate-hosted Pb–Zn veins containing significant Ag and Au occur near Big Bight (Wardle and Wilton, 1985), in close proximity to the eastern lobe of the Strawberry granite. Pb-isotope data from these veins (Wilton *et al.*, 1986) suggest a mineralization age of ca. 1.60 Ga, which is comparable to K–Ar age dates from the granite.

Additional mineralization that may be related to the Strawberry granite is present in the form of numerous, small, low-grade Mo showings around the southern contact and on the peninsula west of Ford's Bight (Figure 3). Many of these are associated with pegmatites and/or aplites containing pyrite, molybdenite and flourite. The largest is the LM-12 showing, where numerous small stockwork-type molybdenite–pyrite veinlets containing minor sphalerite invade the Aillik Group close to, and (presumably) vertically above, the southern contact of the granite, and are also associated with pegmatites containing disseminated Mo. Bleaching and alteration of the Aillik Group is widespread in the area around this southern contact.

Wilton *et al.* (1986) also suggest that some of the apparently stratiform Mo–U mineralization hosted by sheared zones on the Aillik peninsula (Figure 3) may be of stockwork origin, as it consists of numerous locally crosscutting molybdenite–pyrite veinlets. Skarnoid calc-silicate ± fluorite alteration is also associated with these showings and several other small discordant Pb, Zn and Mo showings in the Makkovik area. Skarn development is a very common feature of the Aillik Group in areas proximal to the late granites, where it develops preferentially in reactive compositions such as amphibolite and calcareous metasedimentary rock.

The body of evidence outlined above suggests that the differences between the polymetallic mineralization of the Makkovik area and U-dominated mineralization in the belts to the west may reflect the role of late granitoid plutons in the former area.

## LITHOGEOCHEMISTRY

The area covered in 1985 is represented by a total of 682 bulk samples, of which 599 were collected on a preselected random basis using a grid of 2-by-2-km cells, and are referred to herein as 'regional' samples. The remainder were not collected on a systematic basis, and many of these are unusual rock types. They are, therefore, excluded from average analyses for different units presented in this section.

Geochemical sampling using the grid-cell method is intended to provide a representative and unbiased view of the regional geochemistry, which can be analyzed statistically. The method is described by Dickson (1983) and Kerr (1986), and is very effective in well exposed areas proximal to the coastline, but is less successful in poorly exposed areas where outcrop availabilty becomes the prime control of the sampling pattern. However, the grid-cell pattern was maintained in these areas to control sample spacing.

Samples were crushed and powdered using a ceramic mill to minimize contamination by W, and were analyzed for major elements by atomic absorption spectrophotometry (AA), and for the following trace-element suite:

Ga, Nb, Zr, Th, Y, La, Ce (by ICP spectroscopy).
Ba, Cu, Zn, Pb, Sr, Ni, Li, Rb, Cr, V, Mo, Ag (by AA method).
U (by Neutron Activation, delayed neutron counting).
F (by Ion selective electrode).

A subset of the full database, selected on the basis of the criteria discussed in this section, has been submitted for Sn, W and Ta analysis.

### Overall Geochemical Patterns

A database of almost 600 records is rather indigestible and in most subsequent discussions it is broken into four smaller datasets corresponding to the Makkovikian batholith, the Adlavik Intrusive Suite, and Group A and Group B granitoids discussed above. However, several interesting and potentially important features can be illustrated by a consideration of data for the entire area as a single unit.

Geological observations suggest that both the Makkovikian and Trans-Labrador batholiths contain extensive areas of silica-rich granitoids. The full extent of such rocks is illustrated dramatically by the frequency distribution for $SiO_2$ (Figure 4-A), which is strongly asymmetric and has a peak at about 72 percent $SiO_2$. About 50 percent of the regional samples have $SiO_2$ contents in excess of 72 percent. The rocks were classified on the basis of normative mineralogy using the method of Streckeisen and LeMaitre (1979), which provides an empirical equivalent of the IUGS plutonic-rock-type classification. Almost 60 percent of the regional samples fall into the fields of alkali-feldspar granite, alkali-feldspar quartz syenite, granite *(s.s.)* and quartz syenite.

If separate histograms are constructed for the four geological groupings discussed above (Figure 4-B), it becomes apparent that the frequency distribution for $SiO_2$ is in fact slightly bimodal, and has a subsiduary peak at about 46 to 50 percent $SiO_2$. This bimodality is due largely to rocks assigned to the Adlavik Intrusive Suite, which show a separate distribution reflecting the greater abundance of quartz-poor rock types such as gabbro, diorite and monzonite. The frequency distribution in Figure 4a is thus composite in nature, and suggests that the Adlavik Intrusive Suite should be treated as a discrete subset of the regional data.

The differences between the frequency distributions for $SiO_2$ amongst the other three groups of predominantly granitic rocks are less pronounced, but the $SiO_2$ peak for the Group B granitoids (smaller plutons) is somewhat higher (75 percent $SiO_1$) than the peak for regional units at about 70 percent $SiO_2$. The Group B granitoids also show a much narrower frequency distribution than the Makkovikian and Group A granitoids, suggesting a much more restricted major-element composition.

In terms of overall chemical trends and affinity with other igneous rock series, both the Makkovikian and Trans-Labrador suites show a complex mixture of characteristics that are beyond the scope of this report. On the AFM projection of Irvine and Baragar (1971), they define a broadly calc-alkaline trend, exhibiting a very dense grouping at the alkali corner (Figure 5-A). The Adlavik Intrusive Suite forms a separate grouping due to its higher Fe and Mg content, but little distinction can be made between the three different granitoid groups. In a plot of ($Na_2O$ + $K_2O$) versus $SiO_2$ (Figure 5-B), the high-silica end of the compositional spectrum plots within the subalkaline field, but many of the rocks that show low and intermediate silica contents, and particularily those from the Adlavik Intrusive Suite, are transitional into the alkaline field.

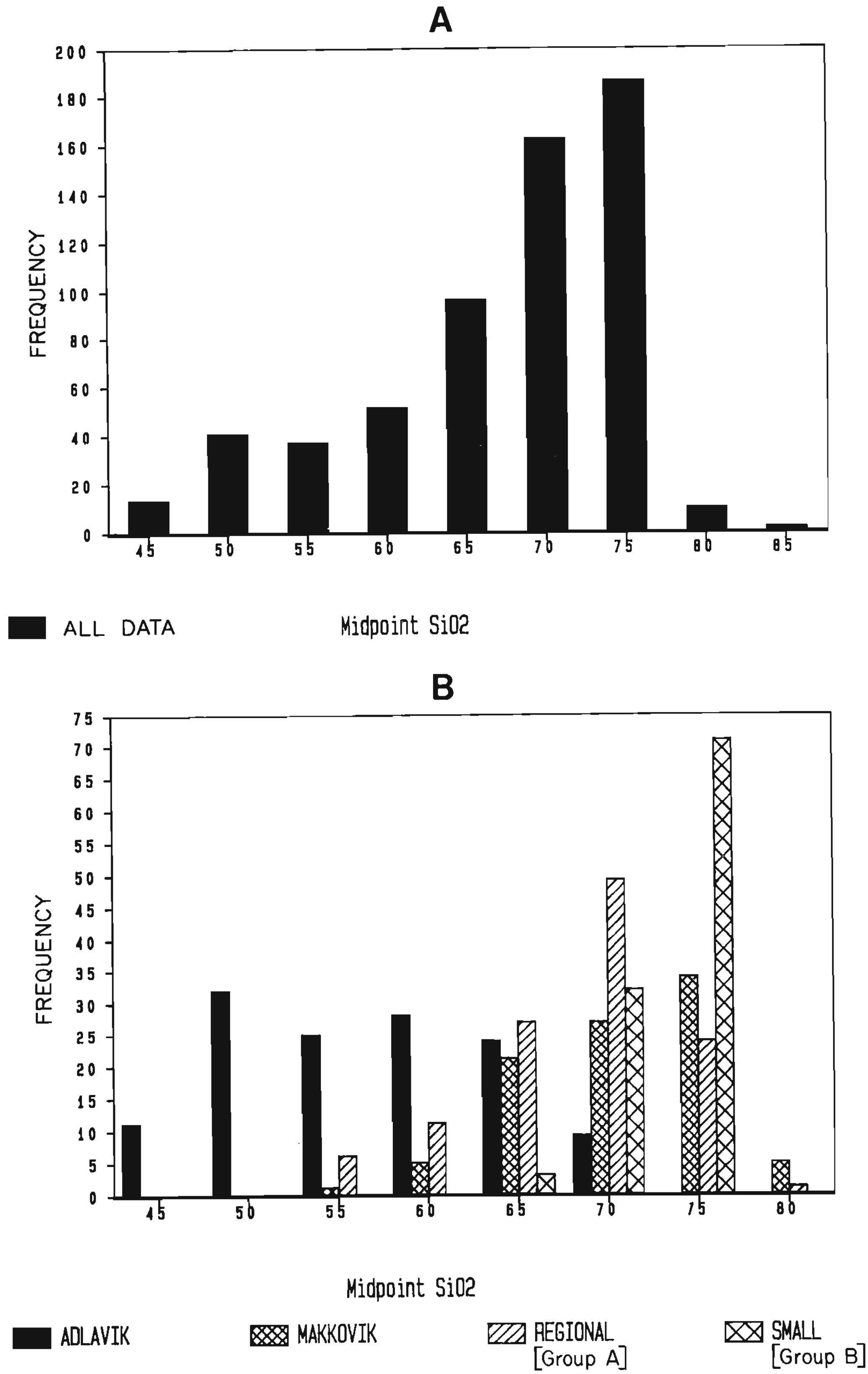


**Figure 4.** *Frequency distributions for silica content of approximately 600 regional samples. A—for all data, regardless of geological affinity; B—subdivided into the four major groupings discussed in the text.*

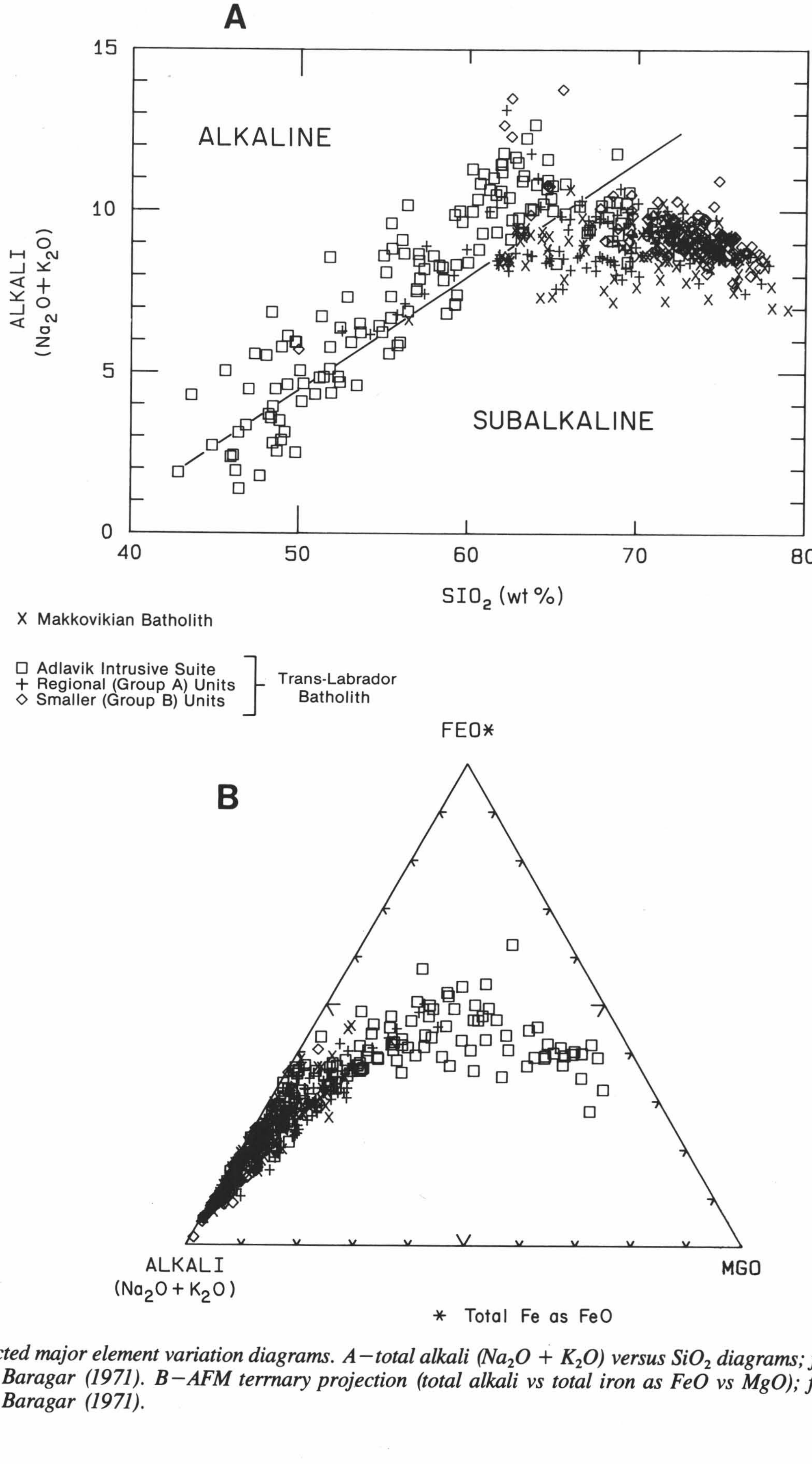


**Figure 5.** *Selected major element variation diagrams. A—total alkali ($Na_2O$ + $K_2O$) versus $SiO_2$ diagrams; field boundary from Irvine and Baragar (1971). B—AFM ternrary projection (total alkali vs total iron as FeO vs MgO); field boundary from Irvine and Baragar (1971).*

**Table 5.** Average compositions of different groups of intrusive rocks in the area

| | ADLAVIK (n=129)† | | MAKKOVIK (n=93) | | REGIONAL (n=118) | | SMALL (n=106) | | UNCERTAIN (n=88) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| $SiO_2$ | 56.93 | 6.99 | 70.59 | 4.93 | 68.27 | 5.13 | 73.16 | 2.46 | 68.47 | 6.88 |
| $TiO_2$ | 0.83 | 0.36 | 0.39 | 0.28 | 0.48 | 0.31 | 0.18 | 0.15 | 0.41 | 0.34 |
| $Al_2O_3$ | 16.29 | 2.15 | 13.98 | 1.53 | 14.74 | 1.55 | 13.55 | 0.89 | 14.70 | 1.81 |
| $Fe_2O_3$ | 2.26 | 0.99 | 1.19 | 0.66 | 1.33 | 0.74 | 0.77 | 0.46 | 1.31 | 0.93 |
| FeO | 4.86 | 1.73 | 1.90 | 1.13 | 2.22 | 1.27 | 1.11 | 0.89 | 1.99 | 1.77 |
| MnO | 0.15 | 0.05 | 0.06 | 0.03 | 0.07 | 0.04 | 0.05 | 0.03 | 0.07 | 0.05 |
| MgO | 3.75 | 3.90 | 0.54 | 0.52 | 0.78 | 0.75 | 0.19 | 0.13 | 1.00 | 1.76 |
| CaO | 5.81 | 3.94 | 1.54 | 1.09 | 2.00 | 1.32 | 0.82 | 0.38 | 2.08 | 2.27 |
| $Na_2O$ | 4.00 | 1.12 | 4.10 | 0.78 | 4.02 | 0.54 | 4.10 | 0.55 | 4.18 | 1.09 |
| $K_2O$ | 3.57 | 1.97 | 4.56 | 1.13 | 4.89 | 0.92 | 5.12 | 0.79 | 4.53 | 1.72 |
| $P_2O_5$ | 0.28 | 0.23 | 0.12 | 0.10 | 0.16 | 0.11 | 0.05 | 0.04 | 0.12 | 0.12 |
| Ga | 20 | 4 | 19 | 4 | 19 | 4 | 18 | 6 | 18 | 5 |
| Nb | 12 | 10 | 19 | 8 | 18 | 8 | 20 | 10 | 18 | 13 |
| Zr | 156 | 111 | 221 | 82 | 207 | 105 | 238 | 127 | 227 | 134 |
| Th | 4 | 7 | 13 | 7 | 14 | 13 | 16 | 8 | 13 | 11 |
| Y | 32 | 19 | 46 | 23 | 44 | 19 | 40 | 29 | 41 | 28 |
| Ce | 94 | 65 | 131 | 57 | 133 | 65 | 133 | 103 | 129 | 84 |
| La | 49 | 33 | 65 | 30 | 68 | 34 | 69 | 56 | 65 | 43 |
| Ba | 917 | 640 | 863 | 520 | 881 | 492 | 453 | 456 | 768 | 625 |
| Cu | 27 | 27 | 7 | 13 | 15 | 75 | 3 | 3 | 9 | 14 |
| Zn | 93 | 28 | 62 | 29 | 65 | 28 | 52 | 43 | 67 | 52 |
| Pb | 10 | 8 | 17 | 7 | 20 | 12 | 23 | 13 | 18 | 10 |
| Sr | 487 | 312 | 169 | 158 | 232 | 181 | 92 | 80 | 217 | 198 |
| Ni | 27 | 60 | 2 | 1 | 2 | 3 | 1 | 0 | 6 | 19 |
| Li | 20 | 9 | 20 | 11 | 22 | 15 | 22 | 19 | 16 | 14 |
| Rb | 82 | 51 | 129 | 45 | 134 | 49 | 175 | 52 | 130 | 70 |
| Cr | 102 | 235 | 4 | 3 | 4 | 5 | 2 | 1 | 15 | 51 |
| V | 113 | 88 | 34 | 27 | 40 | 39 | 15 | 8 | 43 | 54 |
| Mo | 4 | 1 | 4 | 2 | 4 | 1 | 3 | 2 | 4 | 2 |
| Ag | 0.13 | 0.06 | 0.10 | 0.03 | 0.11 | 0.03 | 0.11 | 0.03 | 0.11 | 0.03 |
| U | 2.16 | 1.73 | 4.21 | 2.38 | 4.12 | 2.21 | 5.44 | 4.03 | 4.49 | 5.34 |
| F | 713 | 445 | 683 | 486 | 740 | 444 | 979 | 1054 | 577 | 502 |
| Density | 2.780 | 0.129 | 2.646 | 0.062 | 2.649 | 0.060 | 2.601 | 0.056 | 2.662 | 0.084 |
| Mag. sus.* | 1.67 | 1.77 | 1.06 | 1.07 | 0.89 | 0.95 | 0.59 | 0.59 | 0.92 | 1.06 |

† n = number of samples * magnetic susceptibility

The four groups of intrusive rocks also show significant differences in their mean compositions (Table 5). Data from the Aillik Group and gneissic granitoid rocks south of the Benedict fault zone are excluded from this summary. The most obvious differences are between the Adlavik Intrusive Suite and the other three groups. The former group shows higher CaO, MgO and FeO, lower levels of large-ion lithophile (LIL) elements (e.g., Rb, Pb, Th and U), and higher levels of compatible trace elements (e.g., Cr, V, Ni and Sr). However, for the high-field-strength (HFS) trace elements (e.g., Ga, Zr, Nb, Y), the Adlavik Intrusive Suite shows levels that approach those of the granitoid rocks, even though it shows a significantly lower mean $SiO_2$ content. These features are consistent with the alkaline tendencies displayed by the Adlavik Intrusive Suite (Figure 5-B), and may provide a method for distinguishing the more felsic members from the other three groups.

The regional units (Group A granitoids) of the Trans-Labrador batholith are the least differentiated of the other three groupings, and display the lowest $SiO_2$ contents and the highest levels of compatible trace elements. Slight differences exist between the Group A granitoids of the Trans-Labrador batholith and the Makkovikian granitoids. There are, however, significant differences between these two groups of granitoids and the small plutons (Group B granites) of the Trans-Labrador batholith, which are significantly more differentiated in terms of major-element compositions, and also display higher Rb, U and Th levels, coupled with significantly lower Ba, Sr, V, Ni and Cr. The

**Table 6.** Average compositions of granitoid rocks from the Makkovikian batholith

| | Unit 4 (n=15)† | | Unit 5 (n=36) | | Unit 6 (n=31) | | Unit 7 (n=8) | | Unit 8 (n=6) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| $SiO_2$ | 63.32 | 1.23 | 72.86 | 3.83 | 72.27 | 3.20 | 68.50 | 6.23 | 70.13 | 0.63 |
| $TiO_2$ | 0.83 | 0.07 | 0.29 | 0.20 | 0.30 | 0.22 | 0.46 | 0.33 | 0.25 | 0.05 |
| $Al_2O_3$ | 15.81 | 0.23 | 13.19 | 1.32 | 13.50 | 1.08 | 14.76 | 1.64 | 15.83 | 0.36 |
| $Fe_2O_3$ | 1.79 | 0.36 | 1.12 | 0.55 | 0.97 | 0.67 | 1.28 | 0.85 | 1.06 | 0.23 |
| FeO | 3.06 | 0.71 | 1.52 | 0.73 | 1.74 | 1.10 | 2.45 | 1.68 | 0.90 | 0.17 |
| MnO | 0.10 | 0.01 | 0.06 | 0.03 | 0.04 | 0.02 | 0.07 | 0.04 | 0.04 | 0.01 |
| MgO | 1.25 | 0.41 | 0.29 | 0.31 | 0.41 | 0.36 | 0.85 | 0.73 | 0.54 | 0.03 |
| CaO | 2.95 | 0.46 | 0.99 | 0.69 | 1.18 | 0.71 | 2.52 | 1.67 | 1.78 | 0.19 |
| $Na_2O$ | 4.27 | 0.24 | 4.21 | 0.90 | 3.80 | 0.75 | 3.91 | 0.51 | 4.89 | 0.17 |
| $K_2O$ | 4.75 | 0.47 | 4.65 | 1.43 | 4.59 | 0.97 | 3.95 | 0.84 | 3.93 | 0.13 |
| $P_2O_5$ | 0.26 | 0.03 | 0.07 | 0.06 | 0.09 | 0.07 | 0.19 | 0.16 | 0.12 | 0.01 |
| Ga | 18 | 1 | 22 | 4 | 18 | 2 | 18 | 3 | 13 | 3 |
| Nb | 14 | 1 | 24 | 9 | 21 | 5 | 14 | 6 | 5 | 1 |
| Zr | 224 | 64 | 264 | 84 | 202 | 63 | 155 | 45 | 99 | 19 |
| Th | 9 | 3 | 17 | 8 | 12 | 6 | 12 | 7 | 5 | 3 |
| Y | 37 | 2 | 59 | 26 | 45 | 18 | 29 | 18 | 9 | 1 |
| Ce | 103 | 6 | 126 | 45 | 171 | 66 | 108 | 41 | 46 | 8 |
| La | 53 | 5 | 62 | 25 | 85 | 38 | 55 | 22 | 26 | 5 |
| Ba | 1424 | 112 | 561 | 445 | 828 | 474 | 939 | 335 | 1560 | 159 |
| Cu | 9 | 4 | 4 | 4 | 7 | 15 | 18 | 29 | 5 | 1 |
| Zn | 74 | 8 | 72 | 30 | 45 | 27 | 61 | 29 | 43 | 9 |
| Pb | 16 | 4 | 19 | 7 | 14 | 7 | 19 | 7 | 11 | 3 |
| Sr | 328 | 38 | 82 | 83 | 107 | 88 | 277 | 166 | 596 | 69 |
| Ni | 3 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 1 |
| Li | 23 | 5 | 20 | 11 | 18 | 13 | 20 | 12 | 23 | 6 |
| Rb | 126 | 23 | 147 | 53 | 122 | 35 | 99 | 37 | 79 | 23 |
| Cr | 6 | 3 | 2 | 2 | 4 | 3 | 6 | 5 | 3 | 1 |
| V | 75 | 19 | 21 | 18 | 24 | 17 | 48 | 28 | 29 | 5 |
| Mo | 4 | 0 | 4 | 2 | 3 | 1 | 4 | 1 | 2 | 1 |
| Ag | 0.12 | 0.05 | 0.10 | 0 | 0.10 | 0.02 | 0.10 | 0.00 | 0.10 | 0 |
| U | 4.82 | 0.85 | 4.97 | 2.98 | 3.67 | 1.92 | 2.88 | 0.90 | 1.78 | 0.41 |
| F | 861 | 205 | 714 | 500 | 614 | 473 | 688 | 243 | 411 | 122 |
| Density | 2.689 | 0.068 | 2.624 | 0.045 | 2.635 | 0.054 | 2.709 | 0.080 | 2.636 | 0.008 |
| Mag. sus.* | 1.63 | 1.04 | 1.28 | 1.04 | 0.75 | 1.04 | 0.19 | 0.36 | 1.15 | 0.72 |

† n = number of samples * magnetic susceptibility

levels of the HFS elements differ only slightly from those shown by the Makkovikian and regional granitoids, and Pb, Zn, Cu and Mo contents are also generally similar. Mo and Cu are close to detection limits in most samples, and the slight differences between groups are probably not significant. The high average Cu value for regional granitoids is largely a function of a single sample containing over 800 ppm. As this did not contain any visible sulfide, it is currently being re-analyzed to check for contamination. If this sample is excluded, the regional granitoids show Cu values comparable to those from the other two granitoid groupings.

Granitoid rocks that are not as yet assigned to particular units are mostly from the area south of the Adlavik Brook fault zone. The average for this group is very close to that for the regional granitoids, which includes most of the other units in this area.

Standard deviations for most major elements, compatible trace elements (e.g., V, Cu, Ni and Cr), and Ba and Sr are lower in the Group B granitoids than in the other granitoid groupings, but those for incompatible LIL and HFS trace elements are higher, although Group B shows a much more restricted range of major-element compositions. This suggests that variations in these elements within the Group B granitoids may be 'decoupled' from variations in major-element chemistry and mineralogy resulting from fractional crystallization. The increasing levels and variations in lithophile-element abundances within the Group B granitoids are illustrated by variation diagrams for Rb, (U+Th), F, Li, Zr and Ce (Figure 6).

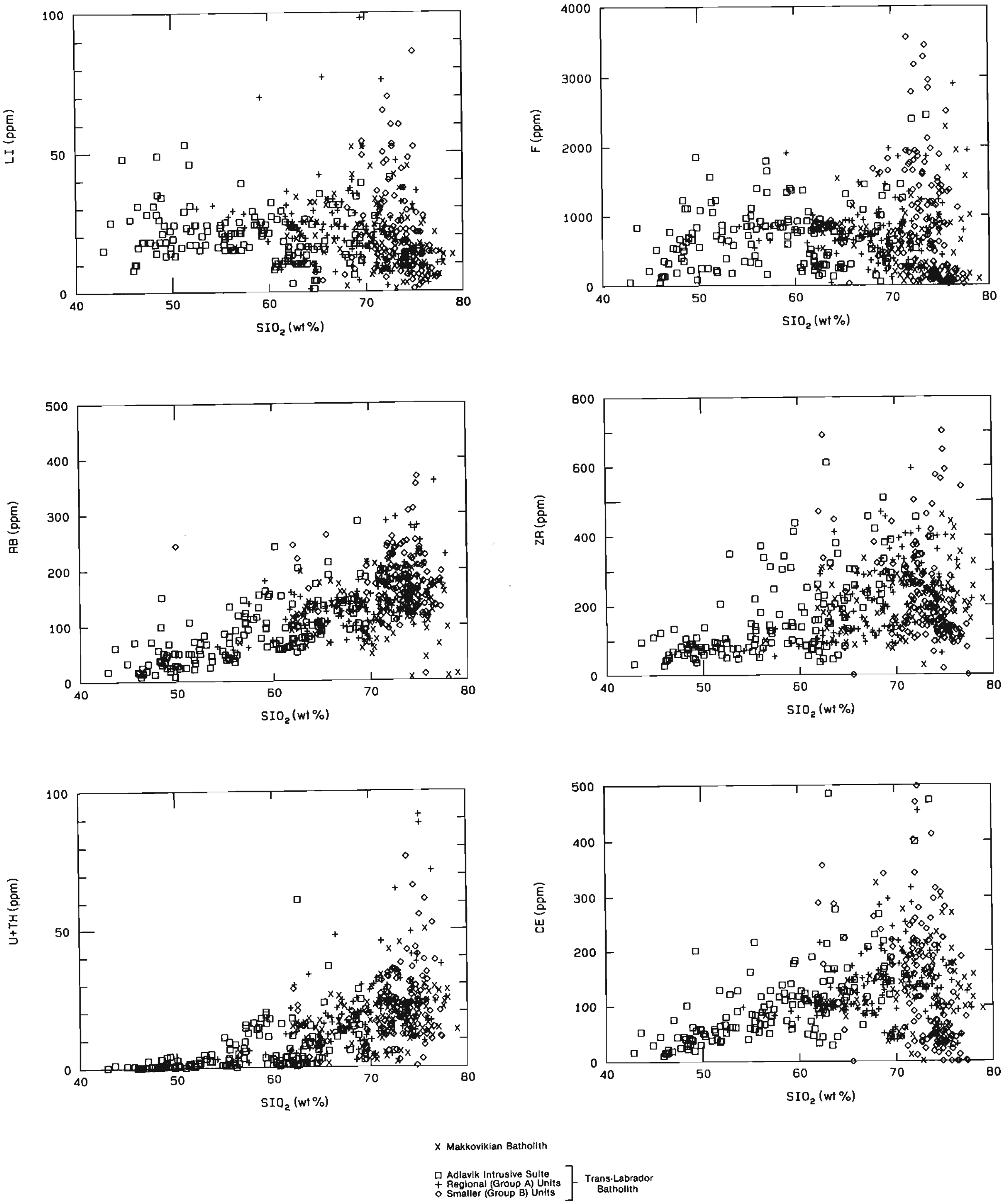


**Figure 6:** *Trace element variation diagrams for Li, F, Rb, Zr, (U+Th) and Ce. Note the generally higher levels among Group B granitoids and the lack of clear correlation with $SiO_2$ at high-silica contents.*

**Table 7.** Average compositions of different units within the Adlavik Intrusive Suite

| | Unit 9 (n=53)† | | Unit 10 (n=15) | | Unit 11 (n=11) | | Unit 12 (n=49) | | Unit 13 (n=20) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| $SiO_2$ | 50.11 | 4.23 | 56.65 | 2.23 | 57.24 | 2.40 | 63.12 | 4.23 | 65.37 | 4.49 |
| $TiO_2$ | 0.89 | 0.39 | 0.87 | 0.27 | 0.93 | 0.28 | 0.75 | 0.31 | 0.57 | 0.35 |
| $Al_2O_3$ | 15.67 | 2.82 | 17.94 | 1.20 | 17.69 | 0.90 | 16.25 | 1.37 | 15.26 | 1.31 |
| $Fe_2O_3$ | 2.88 | 0.94 | 2.15 | 0.59 | 2.25 | 0.59 | 1.64 | 0.80 | 1.39 | 0.61 |
| FeO | 6.36 | 1.23 | 4.71 | 1.10 | 4.60 | 1.04 | 3.46 | 1.08 | 3.56 | 1.84 |
| MnO | 0.17 | 0.03 | 0.13 | 0.03 | 0.12 | 0.04 | 0.13 | 0.05 | 0.15 | 0.08 |
| MgO | 7.55 | 3.85 | 2.79 | 1.14 | 2.41 | 0.59 | 0.95 | 0.69 | 0.38 | 0.36 |
| CaO | 9.70 | 3.04 | 5.56 | 1.34 | 5.14 | 1.06 | 2.55 | 1.25 | 1.71 | 0.81 |
| $Na_2O$ | 2.98 | 1.02 | 4.51 | 0.72 | 4.43 | 0.66 | 4.69 | 0.44 | 4.64 | 0.51 |
| $K_2O$ | 1.54 | 0.87 | 3.12 | 0.70 | 3.82 | 0.79 | 5.28 | 0.90 | 5.82 | 0.61 |
| $P_2O_5$ | 0.31 | 0.30 | 0.36 | 0.13 | 0.37 | 0.17 | 0.24 | 0.16 | 0.15 | 0.16 |
| Ga | 18 | 4 | 20 | 2 | 20 | 3 | 21 | 2 | 24 | 5 |
| Nb | 2 | 3 | 9 | 4 | 15 | 4 | 20 | 7 | 21 | 9 |
| Zr | 84 | 34 | 137 | 77 | 171 | 98 | 229 | 125 | 240 | 131 |
| Th | 1 | 1 | 6 | 6 | 7 | 5 | 7 | 10 | 5 | 7 |
| Y | 19 | 9 | 24 | 6 | 36 | 7 | 41 | 12 | 53 | 31 |
| Ce | 46 | 23 | 73 | 19 | 107 | 18 | 136 | 66 | 182 | 107 |
| La | 25 | 12 | 38 | 9 | 55 | 7 | 69 | 36 | 93 | 55 |
| Ba | 648 | 516 | 1208 | 899 | 938 | 287 | 1157 | 719 | 795 | 594 |
| Cu | 47 | 38 | 28 | 15 | 33 | 10 | 10 | 8 | 7 | 4 |
| Zn | 91 | 24 | 80 | 13 | 87 | 28 | 91 | 24 | 116 | 38 |
| Pb | 5 | 8 | 9 | 5 | 13 | 3 | 16 | 5 | 16 | 6 |
| Sr | 692 | 235 | 696 | 137 | 521 | 98 | 286 | 272 | 109 | 94 |
| Ni | 73 | 97 | 11 | 9 | 11 | 4 | 2 | 2 | 1 | 0 |
| Li | 23 | 10 | 22 | 6 | 19 | 5 | 20 | 8 | 14 | 8 |
| Rb | 44 | 28 | 81 | 25 | 103 | 35 | 111 | 48 | 124 | 61 |
| Cr | 272 | 351 | 26 | 25 | 21 | 9 | 4 | 5 | 2 | 1 |
| V | 193 | 71 | 112 | 55 | 109 | 31 | 44 | 36 | 19 | 10 |
| Mo | 3 | 1 | 3 | 1 | 4 | 1 | 4 | 1 | 4 | 2 |
| Ag | 0.14 | 0.07 | 0.11 | 0.02 | 0.12 | 0.06 | 0.13 | 0.05 | 0.11 | 0.02 |
| U | 0.89 | 0.79 | 2.42 | 1.32 | 3.44 | 1.61 | 3.24 | 1.87 | 2.49 | 1.64 |
| F | 609 | 399 | 840 | 331 | 707 | 337 | 826 | 393 | 618 | 665 |
| Density | 2.907 | 0.105 | 2.776 | 0.074 | 2.758 | 0.049 | 2.683 | 0.038 | 2.673 | 0.049 |
| Mag. sus.* | 2.41 | 2.36 | 1.19 | 0.74 | 1.44 | 1.43 | 1.22 | 1.09 | 1.09 | 0.87 |

† n = number of samples * magnetic susceptibility

### Makkovikian Batholith

A summary of geochemical data for Makkovikian granitoids is shown in Table 6. The most differentiated units are Unit 5 and Unit 6, which display the highest levels of incompatible LIL and HFS trace elements and the lowest levels of compatible trace elements. Units 7 and 8 display the least enrichment in incompatible elements, whereas the Long Island quartz monzonite (Unit 4), despite its generally less differentiated major-element composition, has levels of incompatible and HFS elements that approach those in Units 5 and 6.

The data for Unit 5 includes a subgroup that shows high $Na_2O/K_2O$ ratios that indicate the presence of significant albite. This subgroup is not restricted to any one area, but is present mostly within the three small bodies of Unit 5 northeast of Makkovik Bay. In addition to anomalously low $K_2O$ contents, this subgroup shows extreme depletion in Ba, Sr and Rb. Although it is possible that these represent original magmatic compositional differences, it seems more likely that they result from hydrothermal alteration or albitization. This feature suggests that a closer examination of these units is warranted.

### Trans-Labrador Batholith

*Adlavik Intrusive Suite.* Table 7 shows mean compositions for the five different units within the Adlavik Intrusive Suite. The quartz monzonite and syenite of Units 12 and 13 are the most differentiated members of the suite, and contain the highest levels of incompatible trace elements. There is a smooth increase in the levels of incompatible elements from the gabbro of Unit 9 to the syenitic rocks of

**Table 8.** Average compositions of regional granitoid units within the Trans-Labrador batholith

| | Unit 14 (n=23)† | | Unit 15 (n=39) | | Unit 16 (n=23) | | Unit 18 (n=28) | | Unit 19 (n=11) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| $SiO_2$ | 63.96 | 5.47 | 69.79 | 4.11 | 70.91 | 4.34 | 67.57 | 3.73 | 68.82 | 5.42 |
| $TiO_2$ | 0.78 | 0.37 | 0.39 | 0.21 | 0.36 | 0.30 | 0.45 | 0.18 | 0.38 | 0.27 |
| $Al_2O_3$ | 15.63 | 1.47 | 14.46 | 1.62 | 13.60 | 1.05 | 15.31 | 1.27 | 14.95 | 1.09 |
| $Fe_2O_3$ | 2.03 | 0.68 | 1.18 | 0.53 | 0.90 | 0.62 | 1.33 | 0.62 | 1.22 | 0.86 |
| FeO | 3.31 | 1.47 | 1.61 | 0.76 | 2.33 | 1.20 | 2.04 | 1.05 | 1.79 | 1.22 |
| MnO | 0.11 | 0.04 | 0.06 | 0.03 | 0.06 | 0.04 | 0.07 | 0.03 | 0.06 | 0.03 |
| MgO | 1.42 | 0.94 | 0.44 | 0.27 | 0.41 | 0.47 | 0.95 | 0.48 | 0.92 | 1.11 |
| CaO | 3.20 | 1.53 | 1.35 | 0.70 | 1.34 | 0.86 | 2.29 | 0.91 | 2.18 | 1.77 |
| $Na_2O$ | 4.21 | 0.25 | 4.11 | 0.65 | 3.65 | 0.41 | 3.98 | 0.51 | 4.30 | 0.50 |
| $K_2O$ | 4.21 | 0.92 | 5.48 | 0.60 | 5.22 | 0.76 | 4.68 | 0.71 | 4.25 | 1.03 |
| $P_2O_5$ | 0.26 | 0.14 | 0.11 | 0.07 | 0.11 | 0.11 | 0.18 | 0.08 | 0.11 | 0.04 |
| Ga | 20 | 4 | 18 | 3 | 21 | 3 | 15 | 2 | 18 | 3 |
| Nb | 14 | 7 | 20 | 5 | 26 | 10 | 14 | 5 | 15 | 11 |
| Zr | 149 | 109 | 260 | 76 | 226 | 89 | 144 | 49 | 261 | 159 |
| Th | 4 | 4 | 15 | 7 | 18 | 20 | 17 | 11 | 15 | 21 |
| Y | 41 | 17 | 49 | 13 | 59 | 23 | 31 | 9 | 30 | 23 |
| Ce | 107 | 44 | 143 | 45 | 182 | 92 | 106 | 25 | 116 | 86 |
| La | 57 | 22 | 71 | 24 | 94 | 51 | 54 | 13 | 58 | 41 |
| Ba | 1383 | 489 | 688 | 368 | 645 | 403 | 994 | 430 | 735 | 289 |
| Cu | 16 | 26 | 6 | 6 | 4 | 4 | 7 | 4 | 82 | 230 |
| Zn | 89 | 27 | 55 | 28 | 70 | 27 | 54 | 18 | 60 | 22 |
| Pb | 15 | 4 | 22 | 13 | 26 | 7 | 17 | 8 | 22 | 26 |
| Sr | 364 | 161 | 139 | 94 | 93 | 90 | 316 | 147 | 392 | 255 |
| Ni | 4 | 4 | 1 | 0 | 1 | 1 | 2 | 1 | 4 | 4 |
| Li | 25 | 18 | 16 | 6 | 22 | 20 | 28 | 14 | 18 | 5 |
| Rb | 112 | 32 | 138 | 47 | 174 | 61 | 134 | 49 | 112 | 44 |
| Cr | 7 | 6 | 2 | 1 | 2 | 2 | 4 | 3 | 7 | 12 |
| V | 75 | 50 | 22 | 12 | 25 | 25 | 49 | 24 | 39 | 63 |
| Mo | 4 | 1 | 4 | 1 | 4 | 2 | 3 | 1 | 3 | 2 |
| Ag | 0.11 | 0.03 | 0.10 | 0.02 | 0.12 | 0.05 | 0.10 | 0.00 | 0.14 | 0.05 |
| U | 3.17 | 1.44 | 4.81 | 2.34 | 4.56 | 2.39 | 3.73 | 2.05 | 5.14 | 3.76 |
| F | 674 | 228 | 628 | 395 | 1027 | 672 | 717 | 218 | 724 | 521 |
| Density | 2.69 | 0.06 | 2.61 | 0.07 | 2.63 | 0.03 | 2.68 | 0.04 | 2.64 | 0.02 |
| Mag. sus.* | 1.92 | 1.00 | 0.69 | 0.74 | 0.42 | 0.66 | 0.53 | 0.65 | 1.02 | 0.69 |

† n = number of samples * magnetic susceptibility

Unit 13, and a corresponding decrease in the levels of CaO, MgO, FeO and compatible trace elements. On Harker-type variation diagrams showing the correlation between various elements and $SiO_2$, the various units within the suite show smooth trends.

The levels of HFS and REE elements in the Adlavik Intrusive Suite are comparable to those from more silica-rich (i.e., more differentiated) units in the other three groupings. This reflects the alkaline tendencies of the Adlavik Intrusive Suite compared to the other divisions, and suggests the possibility of a genetic link with some of the smaller granitoid bodies that contain high levels of these elements, in particular Unit 24, which appears to be spatially related to the Adlavik Intrusive Suite.

*Regional units (Group A granitoids).* Table 8 shows average compositions for various regional granitoid units. The regional units are more consistent in composition than either the the Makkovikian suite or the Adlavik Intrusive Suite, but display more variation between units than the Group B granitoids. Unit 14 displays the least amount of differentiation, whereas Unit 15 and Unit 16 display the most differentiated major-element compositions and have the highest levels of incompatible LIL and HFS elements. The former unit is very similar in field characteristics to the Strawberry granite (see Table 9), and also shares most of its chemical characteristics. However, it has slightly lower LIL- and HFS-element levels, and shows a lower mean $SiO_2$ content.

**Table 9.** Average compositions of small granitoid plutons within the Trans-Labrador batholith

| | Unit 17 (N=11)† | | Unit 20 (N=25) | | Unit 21 (N=5) | | Unit 22 (N=14) | | Unit 23 (N=19) | | Unit 24 (N=24) | | Unit 25 (N=7) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| $SiO_2$ | 74.19 | 3.14 | 74.13 | 1.90 | 73.22 | 1.15 | 73.09 | 1.80 | 71.70 | 2.19 | 72.56 | 2.75 | 74.13 | 1.84 |
| $TiO_2$ | 0.09 | 0.14 | 0.08 | 0.09 | 0.16 | 0.05 | 0.22 | 0.11 | 0.23 | 0.12 | 0.27 | 0.17 | 0.16 | 0.07 |
| $Al_2O_3$ | 13.64 | 1.18 | 13.82 | 0.66 | 13.90 | 0.29 | 13.37 | 0.93 | 13.66 | 0.57 | 13.20 | 1.10 | 13.47 | 0.72 |
| $Fe_2O_3$ | 0.51 | 0.27 | 0.59 | 0.50 | 0.57 | 0.16 | 0.83 | 0.32 | 0.82 | 0.46 | 1.03 | 0.49 | 0.79 | 0.19 |
| FeO | 0.58 | 0.19 | 0.51 | 0.31 | 0.86 | 0.27 | 1.40 | 0.73 | 1.64 | 0.95 | 1.60 | 1.10 | 0.55 | 0.32 |
| MnO | 0.04 | 0.01 | 0.05 | 0.03 | 0.04 | 0.01 | 0.05 | 0.02 | 0.06 | 0.04 | 0.07 | 0.04 | 0.04 | 0.02 |
| MgO | 0.14 | 0.13 | 0.18 | 0.11 | 0.27 | 0.14 | 0.26 | 0.14 | 0.20 | 0.12 | 0.18 | 0.14 | 0.18 | 0.14 |
| CaO | 0.73 | 0.44 | 0.73 | 0.30 | 1.00 | 0.27 | 0.87 | 0.26 | 0.95 | 0.43 | 0.85 | 0.42 | 0.67 | 0.37 |
| $Na_2O$ | 4.01 | 0.31 | 4.21 | 0.54 | 3.89 | 0.14 | 3.88 | 0.45 | 4.12 | 0.29 | 3.97 | 0.46 | 4.88 | 1.05 |
| $K_2O$ | 5.15 | 0.61 | 4.90 | 0.86 | 5.00 | 0.26 | 5.20 | 0.85 | 5.34 | 0.35 | 5.44 | 0.34 | 4.06 | 1.52 |
| $P_2O_5$ | 0.03 | 0.03 | 0.03 | 0.02 | 0.05 | 0.02 | 0.06 | 0.04 | 0.06 | 0.03 | 0.05 | 0.05 | 0.04 | 0.03 |
| Ga | 11 | 2 | 15 | 2 | 16 | 1 | 19 | 3 | 22 | 4 | 23 | 7 | 16 | 1 |
| Nb | 10 | 5 | 14 | 6 | 22 | 7 | 21 | 3 | 26 | 10 | 26 | 11 | 22 | 8 |
| Zr | 131 | 33 | 141 | 69 | 166 | 42 | 276 | 119 | 280 | 84 | 346 | 140 | 210 | 47 |
| Th | 17 | 8 | 13 | 9 | 20 | 7 | 19 | 5 | 15 | 9 | 17 | 7 | 18 | 5 |
| Y | 15 | 7 | 21 | 12 | 27 | 8 | 44 | 24 | 51 | 30 | 65 | 33 | 31 | 11 |
| Ce | 56 | 21 | 38 | 34 | 79 | 30 | 147 | 75 | 200 | 57 | 224 | 116 | 93 | 49 |
| La | 26 | 14 | 19 | 18 | 40 | 18 | 78 | 46 | 110 | 31 | 114 | 61 | 46 | 28 |
| Ba | 584 | 1078 | 503 | 398 | 695 | 184 | 447 | 235 | 448 | 200 | 344 | 271 | 326 | 352 |
| Cu | 3 | 2 | 3 | 3 | 3 | 2 | 4 | 3 | 3 | 2 | 4 | 2 | 2 | 1 |
| Zn | 24 | 7 | 32 | 12 | 37 | 7 | 66 | 46 | 65 | 44 | 82 | 54 | 19 | 18 |
| Pb | 20 | 5 | 21 | 8 | 26 | 9 | 25 | 5 | 29 | 19 | 23 | 17 | 10 | 5 |
| Sr | 73 | 96 | 116 | 69 | 105 | 78 | 89 | 59 | 97 | 76 | 59 | 54 | 131 | 140 |
| Ni | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| Li | 8 | 8 | 22 | 14 | 44 | 30 | 29 | 15 | 33 | 25 | 12 | 5 | 11 | 8 |
| Rb | 155 | 34 | 178 | 57 | 223 | 82 | 194 | 41 | 190 | 42 | 161 | 35 | 128 | 53 |
| Cr | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 0 |
| V | 13 | 6 | 17 | 9 | 14 | 11 | 12 | 10 | 19 | 7 | 12 | 4 | 13 | 7 |
| Mo | 4 | 1 | 2 | 1 | 3 | 1 | 3 | 2 | 3 | 1 | 4 | 2 | 4 | 2 |
| Ag | 0.12 | 0.04 | 0.10 | 0.02 | 0.12 | 0.04 | 0.10 | 0.00 | 0.13 | 0.04 | 0.10 | 0.00 | 0.10 | 0.00 |
| U | 4.04 | 1.97 | 6.17 | 7.19 | 6.68 | 3.60 | 6.35 | 2.89 | 4.96 | 1.88 | 4.68 | 1.71 | 6.10 | 1.96 |
| F | 108 | 86 | 323 | 289 | 175 | 119 | 1454 | 858 | 1833 | 1397 | 1009 | 811 | 1105 | 708 |
| Density | 2.598 | 0.015 | 2.596 | 0.037 | 2.632 | 0.010 | 2.552 | 0.111 | 2.629 | 0.029 | 2.607 | 0.042 | 2.607 | 0.019 |
| Mag. sus.* | 0.63 | 0.43 | 0.39 | 0.32 | 0.20 | 0.30 | 0.61 | 0.50 | 0.61 | 0.89 | 0.76 | 0.53 | 0.74 | 0.47 |

† n = number of samples * magnetic susceptibility

*Small plutons (Group B granites).* Average compositions for the seven units in this category are shown in Table 9. In terms of major-element composition, all these units are very similar, but trace-element patterns suggest that at least two and possibly three distinct groups are present. These differences are shown most clearly by the abundance of HFS and REE elements. Units 17, 20 and 21 display significantly lower contents of Ga, Nb, Zr, Y, Ce and La than Units 22, 23 and 24. These differences are complemented by slightly higher levels of Ba and Sr in the first group. Other trace elements, including Rb, Li, U and Th, do not show any systematic variation between the two groups. Mo and Cu levels are low and constant in both groups.

The Monkey Hill granite (Unit 20) shows a major- and trace-element composition broadly similar to that of Units 17 and 21. The average for this unit in Table 9 does not include samples from the plugs of the Round Pond area. Available data from this study and from MacDougall and Wilton (1987) suggest that these plugs are broadly similar in composition, but show slightly higher $SiO_2$ contents and LIL-element abundances.

The Strawberry (Unit 22) and Dog Island (Unit 23) granites form a second subgroup exhibiting different chemical characteristics. They show slightly higher FeO, MgO and CaO contents, and show significantly higher Ga, Zr, Y, Ce, La, Zn and F. The LIL elements Rb, U, Li and Th show levels similar to, or slightly higher than, those for Units 17, 20 and 21, and the Ba and Sr contents are slightly lower. The Strawberry granite also shows an anomalously low density, having a standard deviation that is considerably greater than that for any of the other Group B granitoids. This is interpreted as a reflection of both miarolitic cavities and widespread accessory fluorite. Similarily low (but less variable) densities are shown by Units 17 and 20 .

Unit 24 may constitute a third subgroup, as it displays strong enrichment in Zr, Ce and Y. Th and U contents for Unit 24 are similar to those shown by the Strawberry and Dog Island granites, but the levels of Rb, Sr, Ba and Li are slightly lower. The unit is also characterized by a higher Zn content relative to all other members of this group. There appears to be a strong spatial association between this unit and the Adlavik Intrusive Suite, and the higher Zr and Ce contents of this unit may suggest a genetic link, as the Adlavik Intrusive Suite is similarily enriched in Zr relative to its $SiO_2$ content.

Unit 25, in the southeastern corner of the area, does not show a clear resemblance to any of the other small plutons or to the surrounding porphyritic granites of Unit 15. In many respects, it has a composition that lies between the first two subgroups of Group B granitoids.

**Summary**

Preliminary results from the lithogeochemical portion of this project illustrate several points:

1) Small granitoid plutons (Group B granitoids) assigned to the Trans-Labrador batholith display a much narrower range of major-element compositions than regional granitoid units (Group A granitoids), which are thought to represent deeper levels of the batholith, and also have significantly higher mean $SiO_2$ and lower CaO, MgO and FeO contents.

2) The Group B granitoids show higher contents of incompatible LIL trace elements (e.g., Rb, U) and lower levels of compatible trace elements (e.g., Ba, Sr and V). Higher standard deviations for most incompatible trace elements of all types, coupled with a much smaller variation in major-element composition relative to the other groups, indicate that trace-element behaviour may be decoupled from major-element variations caused primarily by fractional crystallization.

3) Trace-element data for the Group B granitoids indicate the presence of at least two subgroups exhibiting different affinities. One of these (Units 17, 20 and 21) has slightly higher LIL-element levels but markedly lower HFS and REE contents, and is associated with endocontact Mo mineralization in two areas. The other subgroup shows similar LIL-element levels but is richer in HFS and REE elements, and also in F and Zn. These trends indicate that this subgroup has alkaline tendencies, but the rocks are not peralkaline in the strict sense of the term. The second subgroup does not host endocontact Mo mineralization, but does host minor Cu–Pb occurrences and may be spatially related to exocontact Mo and Pb–Zn showings associated with Au and Ag enrichment. Small granite plugs in the Round Pond area, which are spatially related to an extensive system of mineralized polymetallic veins, display compositions comparable to the first subgroup.

4) The gabbro–diorite–monzonite–syenite association of the Adlavik Intrusive Suite shows a lower range of $SiO_2$ content, but is enriched in HFS and REE elements compared to members of the other groups that have similar major-element compositions. One of the Group B granitoid units appears to be associated spatially with the Adlavik Intrusive Suite and shows particularily high levels of these elements, suggesting that there may be a genetic relationship between them.

5) Some units within the Makkovikian batholith and some Group A granitoid units within the Trans-Labrador batholith have major- and trace-element compositions that locally approach those of the smaller plutons. The most notable are the Bayhead granite, which is petrologically and geochemically comparable to the Strawberry and Dog Island granites, and Unit 5 of the Makkovikian batholith, which displays anomalous geochemical patterns that may indicate albitization.

## DISCUSSION AND INTERPRETATION

The characteristics of granitoid rocks associated with a variety of mineral deposits have received much attention and discussion over the last decade or so (e.g., Tischendorf, 1977; Strong, 1981; Ishihara, 1981; Taylor and Strong, 1985). Some of the features that are recognized by most workers as characteristics of 'specialized' granites are as follows:

1) High-silica contents (generally greater than 72 percent) coupled with extreme depletion of CaO, MgO and total iron.

2) Enrichment in LIL trace elements such as Rb, Pb, Li, U and Th, and (in some cases) HFS elements such as Zr, Nb, Ta, Y and Ga.

3) Extreme depletion in compatible trace elements, and also in the LIL elements Ba and Sr, which are partitioned into feldspars and thus behave as compatible elements in rocks of granitic composition.

4) Evidence of volatile activity and hydrothermal alteration, and (in some cases) direct evidence of high-volatile content in the form of enrichment in F, B and Cl.

5) Extreme variation in lithophile-element abundances, contrasting with a very restricted major-element compositional range. This characteristic indicates a decoupling of trace-element behaviour from major-element and mineralogical variations produced by fractional crystallization.

If these criteria are applied to the smaller plutons within the Trans-Labrador batholith, it is clear that they possess most of these characteristics in relation to their own *local* geological and geochemical background. The differences between this group and the other groupings within the Trans-Labrador batholith suggest that the arbitrary division into Group A and Group B granitoid units reflects a real and significant contrast in petrology and geochemistry, and perhaps also a contrast in the processes operating at different levels within the batholith. The decoupling of major- and trace-element variations may indicate the dominance of liquid-state differentiation processes such as volatile fluxing, thermogravitational diffusion and convective fractionation (Hildreth, 1981; Rice, 1981; Walker, 1983). All of these processes have been suggested as contributing factors to geochemical variation in high-silica magma chambers, and also as important controls on the enrichment of ore elements in such environments.

Absolute abundances of lithophile elements within the Group B granitoids are, however, of lesser magnitude if compared to the highly specialized compositions reported from well known metallogenic provinces such as Cornwall and Nigeria. However, the regional Group A granitoids, which provide an estimate of background levels, are depleted in these elements relative to the average low-Ca granite of Turekian and Wedepohl (1961).

This illustrates a major problem in interpreting the geochemistry of granitoid rocks in terms of 'specialized' and 'non-specialized' variants. The levels of incompatible trace elements in any magma depend not only on the degree of fractional crystallization that it experiences, but also on the nature of the source material and the degree of partial melting within it. As a variety of source materials are involved in magma genesis, comparisons of absolute abundances of indicator trace elements between different magmatic provinces may be misleading and should perhaps be approached with caution. For example, Archean crustal material that has undergone high-grade metamorphism during early development may have been a contributor to the Trans-Labrador batholith magmas, and could explain the lower-than-average LIL abundances of the regional granitoid units, and hence the lesser absolute enrichment in the upper levels of the batholith represented by the smaller Group B granitoids.

Although the influence of source material upon overall compositional trends is widely acknowledged, there is no such concensus regarding its importance as a control of mineralization. Some workers (e.g., Strong, 1985; Chappel and White, 1974; Ishihara, 1981) suggest that it is very important, and cite the common association between granophile deposits and muscovite-bearing 'S-type' granites as evidence of a 'sedimentary' source. Others (e.g., Hildreth, 1981; Newberry and Swanson, 1985; Tuach *et al.*, 1986) present an alternate viewpoint, arguing that magmatic processes operating within high-silica magma chambers are sufficient to generate mineralization, irrespective of the ultimate source of the magma. If this is indeed the case, the relative enrichment and depletion of indicator trace elements across the full compositional spectrum of a *single* magmatic province may be far more important than their absolute levels compared to *other* provinces. In terms of their environment, the small plutons of the Trans-Labrador batholith are highly differentiated bodies and the geological and geochemical data discussed in this report suggest that they may have potential for Mo, Pb, Zn and Cu mineralization. Their potential for commodities such as Au, Ag, Sn, W and Ta is as yet largely unknown, and must await completion of the second phase of the geochemical program, which will involve analysis of both the 1985 regional and 1986 follow-up samples for these and other elements.

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