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# GEOCHEMICAL CHARACTERISTICS OF THE GULL LAKE INTRUSIVE SUITE AND DEVILS ROOM GRANITE, WESTERN WHITE BAY, NEWFOUNDLAND

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## ABSTRACT

*This paper documents the geochemical and metallogenic characteristics of the Devonian Gull Lake intrusive suite and the related Devils Room granite, of the western White Bay area. The Gull Lake intrusive suite is divided into a number of distinct rock types. In probable chronological order, these are the Black Duck Ponds trondhjemite, an un-named diabase and gabbro unit, the Moose Lake granite, the Gull Pond granite and the Big Davis Pond granite. The Black Duck Ponds trondhjemite ranges from foliated to massive, and is considered to be a pre- to syn-Acadian intrusion that may have been derived from partial melting of a mafic source. The diabase and gabbro unit, the Moose Lake granite and the Gull Pond granite are considered to have evolved from the same parent magma, which also produced the Devils Room granite. The Moose Lake, Devils Room and Gull Pond granites are mineralogically and chemically similar post-collisional, I-type granites. They are subsolvus (contain both K-feldspar and plagioclase), subalkaline and metaluminous. The Big Davis Pond granite, which is probably the youngest phase, is mineralogically and geochemically distinct and shows characteristics of A-type granites. It is a high-level, hypersolvus, leucocratic alkali-feldspar granite and may have been produced by partial melting of a depleted source. Although minor molybdenite and fluorite mineralization occurs in both the Gull Lake intrusive suite and the Devils Room granite, the potential for significant granophile element mineralization is low. However, anomalous gold mineralization occurs in the Big Davis Pond granite, and the Gull Lake intrusive suite should be explored for gold, especially since it may be a feeder for the Sops Arm Group, which hosts several gold occurrences.*

## INTRODUCTION

This report describes the geochemical characteristics of the Devonian Gull Lake intrusive suite and the related Devils Room granite of the western White Bay area of Newfoundland (Figure 1). The area is located at the eastern end of the Appalachian Orogen and is bisected by the Doucers Valley fault complex, a major structural lineament that separates Mid to Late Proterozoic granitic and gneissic basement of the Long Range Inlier (overlain by Eocambrian to Cambrian platformal sediments) from Cambro–Ordovician oceanic and later continental rocks to the east.

The Gull Lake intrusive suite outcrops to the east of the Doucers Valley fault complex, and is one of several plutons of similar age that occur in west-central Newfoundland. The Devils Room granite outcrops west of the Doucers Valley fault complex and is the western-most Devonian intrusion in Newfoundland. The objectives of this study are to document the geochemical and metallogenic characteristics of the Gull Lake intrusive suite and the Devils Room granite, and test the hypothesis that the two units are related as suggested by Heyl (1937) and Lock (1969).

The geochemical data has been obtained from samples of the northern part of the Gull Lake intrusive suite, collected in 1981 by W.R. Smyth and H.S. Schillereff. Samples of the Devils Room granite were collected by W.D. Dunford (as part of a B.Sc. thesis); several samples were also collected by J. Tuach in 1985 and 1986, as part of a wider ranging study of granite metallogeny in insular Newfoundland.

### Regional Geology

The regional geology of western White Bay (Figure 2) has been described by Smyth and Schillereff (1982) and Tuach (1987). The oldest rocks in the area are Precambrian quartzofeldspathic gneisses of the basement Long Range Inlier, which outcrops west of the Doucers Valley fault complex. These are intruded by Late Proterozoic megacrystic to equigranular, granodioritic to granitic plutons. The gneisses and intrusive rocks are unconformably overlain by platformal clastic rocks and carbonates of the Eocambrian to Cambrian Coney Arm Group.

The Paleozoic rocks to the east of the Doucers Valley fault complex include Cambro–Ordovician ophiolitic,

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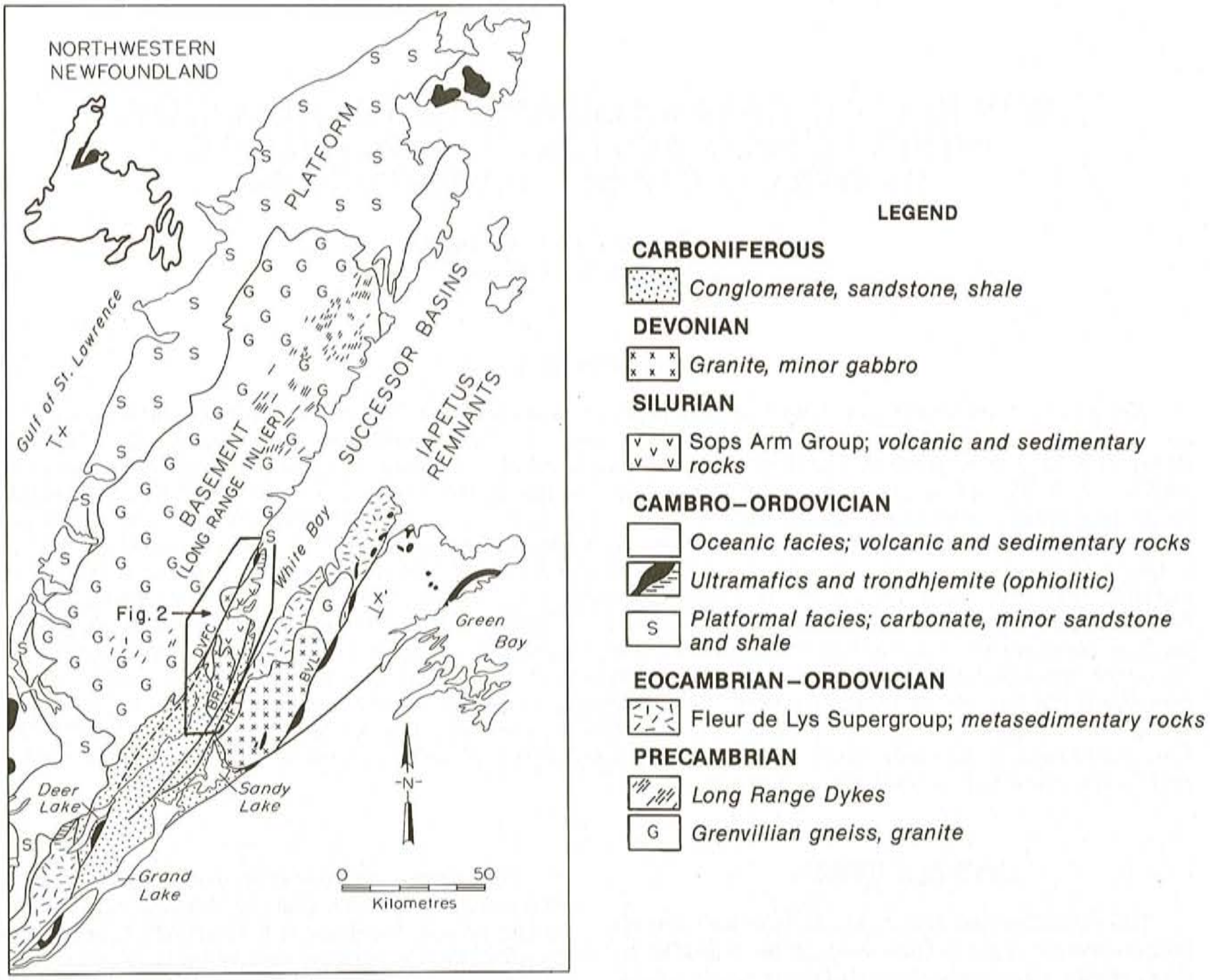


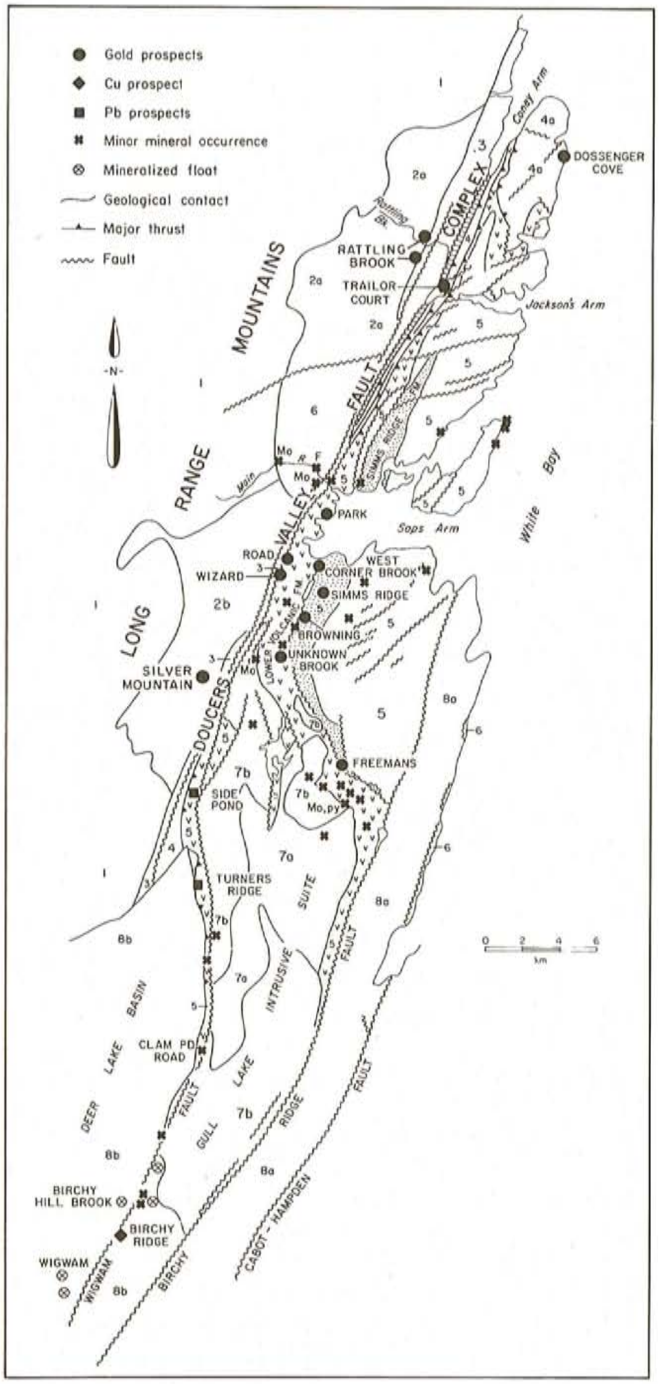
**Figure 1.** *General geology and tectonic elements of northwestern Newfoundland (from Tuach, 1987).*

volcanic and volcaniclastic sequences of the southern White Bay Allochthon (Smyth and Schillereff, 1982). These represent vestiges of the Iapetus Ocean (Williams, 1979) that were obducted westward during the Ordovician Taconian Orogeny (Williams and Stevens, 1974). The allochthonous rocks include slate, mélange (containing minor ultramafic blocks) and polydeformed mafic schist, which form a laterally continuous, thin belt along the Doucers Valley fault complex. The ophiolitic Coney Head Complex (Williams, 1977), which is composed of tonalite–trondhjemite and minor gabbro and granite, is also included in the southern White Bay Allochthon (Smyth and Schillereff, 1982).

Silurian volcanic and sedimentary rocks of the Sops Arm Group unconformably or structurally overly rocks of the Coney Arm Group and the southern White Bay Allochthon. Within the Sops Arm Group, the Lower Volcanic formation and the Simms Ridge Formation host several gold occurrences (Figure 2). The Sops Arm Group dips moderately to the east and has been affected by west-directed thrusting that produced recumbent fold structures and a well-developed cleavage in the sedimentary units. It has been interpreted as one of several terrestrial caldera complexes formed during and after the final closure of Iapetus (Coyle and Strong, 1987).

The Gull Lake intrusive suite (Figure 2) consists of gabbroic to granitic rocks that intrude the Sops Arm Group. A preliminary age of about 398 Ma (P. Erdmer, 1986, *in* Tuach, 1987) has been obtained from zircon separates, from a massive to porphyritic granite phase (the Moose Lake granite). Coyle and Strong (1987) interpreted the suite to be a feeder for the overlying Silurian volcanic rocks of the Sops Arm Group.

The Devils Room granite intrudes the Long Range Inlier on the western side of the Doucers Valley fault complex (Figure 2). Smyth and Schillereff (1982) believed it to be of Precambrian age, because Paleozoic intrusions into the Long Range Inlier or carbonate platform were unknown at the time, and because intrusive contacts with the Eocambrian to



**LEGEND**

**UPPER PALEOZOIC (Basin-fill sequences and intrusions)**

CARBONIFEROUS

8 **8a,** Anguille Group (Tournaisian): *greywacke, shale, minor sandstone and conglomerate;* **8b,** Deer Lake Group (Visean): *conglomerate, sandstone, siltstone*

DEVONIAN (ca. 398 Ma)

7 Gull Lake intrusive suite: **7a,** *intermediate and mafic intrusive rocks;* **7b,** *granite and trondhjemite*

6 Devils Room granite

SILURIAN

5 Sops Arm Group

**LOWER PALEOZOIC ALLOCHTHON**

CAMBRIAN – MIDDLE ORDOVICIAN

4 Southern White Bay Allochthon: *partially ophiolitic (mélange containing ultramafic blocks is cross-hatched);* **4a,** Coney Head Complex

**LOWER PALEOZOIC AUTOCHTHON (Platform)**

3 Coney Arm Group: *carbonate, shale, quartzite*

**PRECAMBRIAN (Grenvillian basement)**

MIDDLE PROTEROZOIC AND EARLIER

2 *Massive to foliated, feldspar-megacrystic, granitoid plutons;* **2a,** *Apsy pluton;* **2b,** *Main River pluton*

1 *Leucocratic gneiss, amphibolite, and gabbro*

**Figure 2.** *General geology and mineral occurrences in western White Bay. Compiled by Tuach (1987) from mapping by Smyth and Schillereff (1981, 1982), Hyde (1982) and Erdmer (1986a,b).*

Cambrian Coney Arm Group could not be found. However, it is texturally and chemically similar to granites of the Gull Lake intrusive suite and has provided a zircon age of 398 $^{+27}_{-7}$ Ma (Erdmer, 1986a) supporting the idea that it is related to the Gull Lake intrusive suite, as suggested by Heyl (1937) and Lock (1969). The present relative positions of the Gull Lake intrusive suite and the Devils Room granite (assuming that they were once juxtaposed) indicate a sinistral movement of about 15 km, along the Doucers Valley fault complex (Lock, 1969).

Carboniferous sedimentary rocks interpreted to represent continental successor basins (Hyde, 1979) unconformably overly the lower Paleozoic rocks (Figure 2) and postdate most deformation.

## Description of Units

*Gull Lake Intrusive Suite.* The Gull Lake intrusive suite consists of a number of distinct rock types including trondhjemite, gabbro and diabase, megacrystic and fine grained biotite granite. Smyth and Schillereff (1982) proposed the name Gull Lake intrusive suite and defined and described the various phases (Figure 3). This terminology replaces the earlier informal 'Gull Lake granite' (Lock, 1969) and 'Gales Brook stock' (Hyde, 1979).

The following descriptions are summarized from Smyth and Schillereff (1982) with minor additions based on cursory examination of thin-sections. Previously unnamed phases are here given informal names of nearby topographical features.

*Black Duck Ponds Trondhjemite.* A medium- to coarse-grained, light grey, massive to foliated phase outcrops east of Gull Lake and north of Gales Brook. This is the biotite granodiorite to tonalite of Smyth and Schillereff (1982). The high $Na_2O$ content and lack of K-feldspar indicate that trondhjemite is a better term. This phase, the oldest member of the Gull Lake intrusive suite, intrudes the Silurian Sops Arm Group on Gull Pond Brook and south of Davis Pond, and is cut by younger phases of the Gull Lake intrusive suite. It contains a foliation, suggesting that it intruded before or during Acadian deformation. Foliated trondhjemite screens within the Moose Lake granite (Figure 3) are believed to be inclusions of this unit.

*Diabase and Gabbro.* A Y-shaped body of diabase and gabbro forms the southern part of the Gull Lake intrusive suite. It consists of massive to weakly foliated, subophitic diabase and microgabbro having minor mafic dykes and patches of pegmatitic gabbro. The contact with the Black Duck Ponds trondhjemite is gradational over 500 m, but gabbro and diabase locally form intrusion breccias and small intrusions within the trondhjemite. In places, gabbro is seen to intrude diabase but the reverse also occurs (J. Tuach, personal communication, 1989). Intrusive contacts between the two, range from diffuse to sharp.

*Moose Lake Granite.* The Moose Lake granite consists of coarse grained to megacrystic biotite granite that forms a linear pluton along the western and southeastern margin of the suite. It intrudes the diabase–gabbro unit in several areas; stoping of the mafic unit by the granite occurs locally (J. Tuach, personal communication, 1989). Dykes of the Moose Lake granite cut cleaved sediments of the Sops Arm Group southeast of Moose Lake. The Moose Lake granite is a massive, pink to red rock containing microcline megacrysts up to 8-cm long. It is sheared and chloritic, where it is cut by the Doucers Valley and Birchy Ridge faults (Figures 2 and 3).

*Gull Pond Granite.* The Gull Pond granite is an oval-shaped pluton that outcrops west of Gull Pond (Figures 3 and 4). It intrudes the Sops Arm Group and the trondhjemitic and gabbroic phases of the Gull Lake intrusive suite. The Gull Pond granite is a fine- to medium-grained, locally porphyritic, pink, biotite ± muscovite granite, and is believed to be a high-level pluton related to the Moose Lake granite. Fine grained dykes of this granite radiate from it and cut the Sops Arm Group posttectonically.

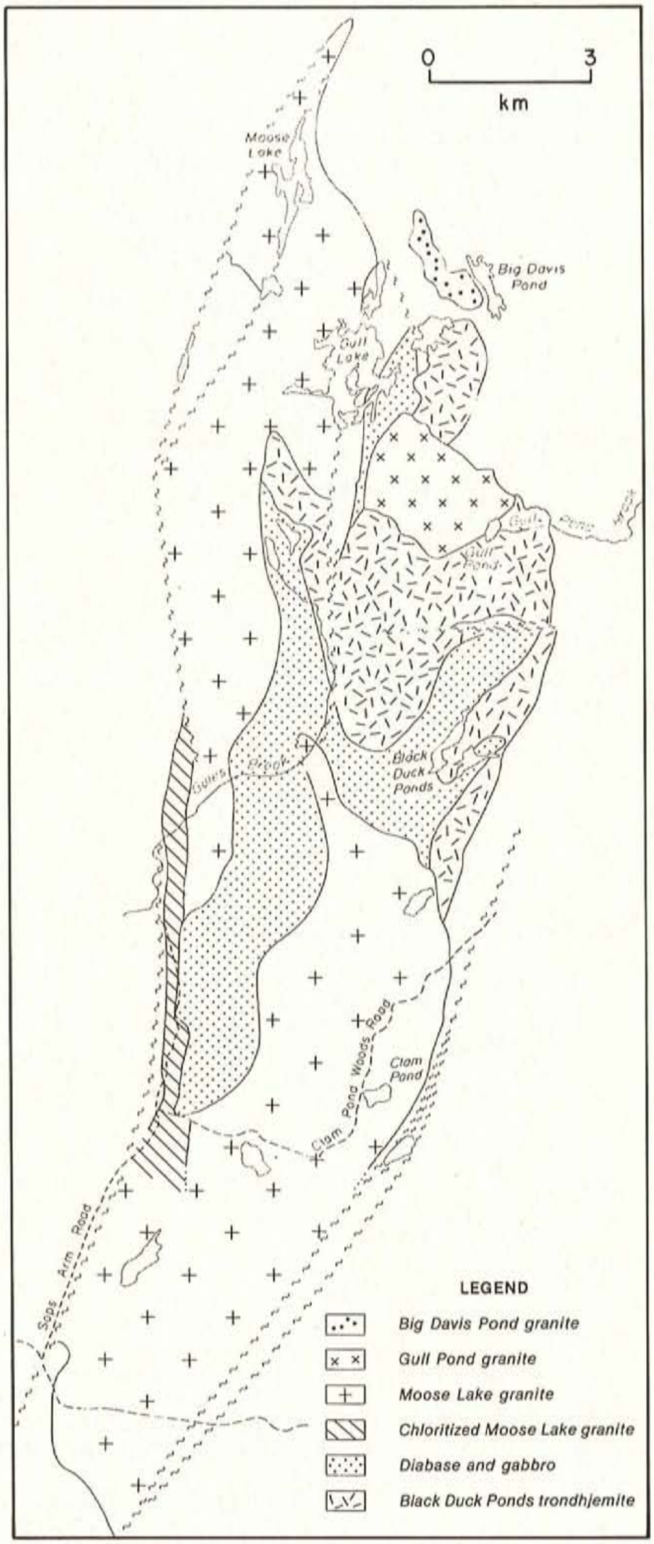


**Figure 3.** *Geology of the Gull Lake intrusive suite (after Smyth and Schillereff, 1981, 1982).*

*Big Davis Pond Granite.* This is a small, medium grained, alkali-feldspar granite that outcrops west of Big Davis Pond (Figure 3). It is a hypersolvus granite (containing one feldsparz–strongly perthitic microcline) and is characterized

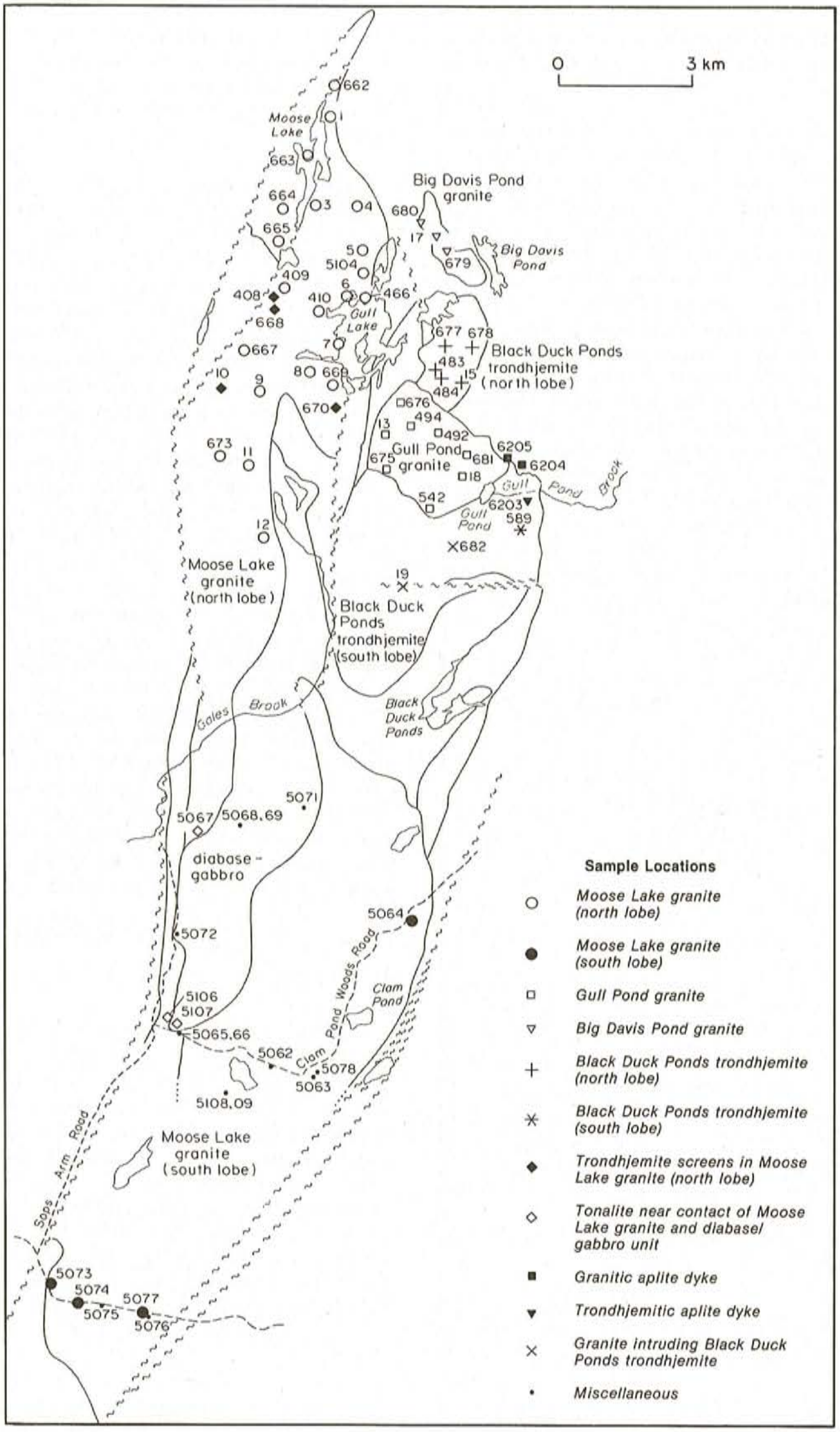


**Figure 4.** *Sample locations for geochemical data. Symbols on map correspond with symbols on geochemical plots and in Table 1.*

by graphic textures and miarolitic cavities indicative of intrusion at shallow levels. Minor fine grained muscovite occurs in patches.

*Devils Room Granite.* The Devils Room granite outcrops on the western side of the Doucers Valley fault complex (Figure 2), where it intrudes Precambrian rocks of the Long Range Inlier. The following description is summarized from Dunford (1984) and supersedes his preliminary divisions as reported in Smyth and Schillereff (1982). The Devils Room granite is characterized by euhedral pink to white K-feldspar megacrysts, set in a groundmass of quartz and plagioclase having minor biotite. K-feldspar megacrysts are up to 25-cm long and biotite forms phenocrysts up to 5-cm long. The size of the K-feldspar megacrysts decreases toward the centre of the pluton and the amount of biotite decreases in response to the introduction of muscovite (Figure 5). Much of the northern and western margin of the granite is characterized by a mylonite zone. This is followed by a narrow amphibolite zone, which occurs between the granite and the Precambrian rocks.

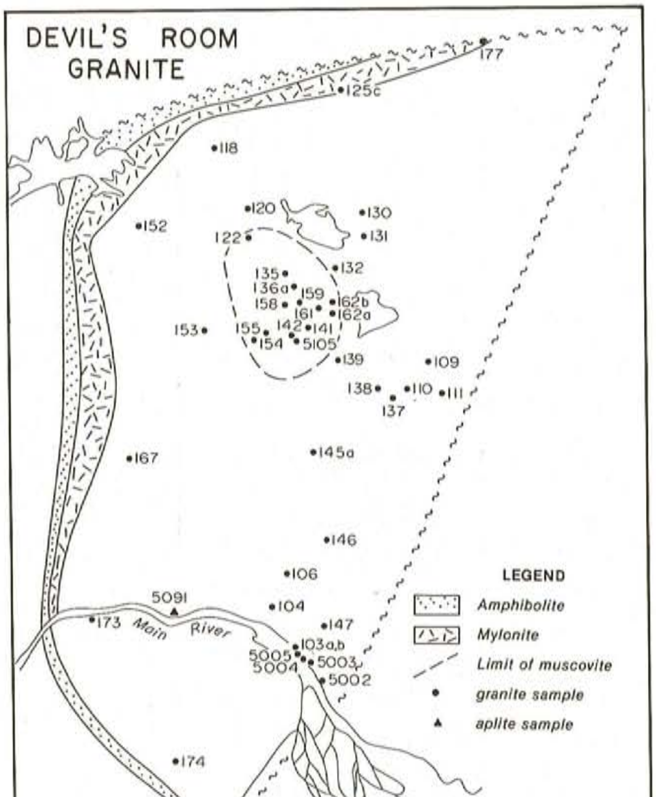


**Figure 5.** *Geology of the Devils Room Granite (from Dunford, 1984).*

### Mineralization

Smyth and Schillereff (1982) reported minor fluorite and pyrite occurrences in the Moose Lake granite, and Dunford (1984) reported fluorite occurrences in the Devils Room granite. In the latter, it occurs as fracture coatings and also, in the matrix of a 1-m-wide tuffisite zone (Tuach, 1986). Sample 5003 from the Devils Room granite (Table 1) contains fluorite mineralization.

Minor coarse grained molybdenite is found in granite pegmatite, quartz veins and pods within the Gull Pond granite and traces of molybdenite occur in small quartz veins in the Devils Room granite (Tuach, 1987). Molybdenite mineralization also occurs in aplite dykes, which cut the Gull Pond granite, the Black Duck Ponds trondhjemite and the Sops Arm Group in the Gull Pond Brook area (Dimmell, 1979). Assays of mineralized aplite float returned values as high as 1.8 percent Mo and a quartz–aplite vein containing pyrite, chalcopyrite and a grey metallic mineral returned an analysis of 0.37 oz/t Ag (Dimmell, 1979). Samples 6204 and 6205 from two of these dykes contain elevated Mo (Table 1). Dimmell (1979) also reported silt sample analyses in excess of 1000 ppm Mo, 600 ppm Pb, 500 ppm U and 60 ppm $WO_3$, from areas underlain by the Gull Lake intrusive suite.

Gold mineralization has been found in the Big Davis Pond granite and in the nearby carbonate member of the Simms Ridge Formation (McKenzie, 1987). Samples from a 25-cm-wide quartz–pyrite vein that cuts the granite returned assays of 0.65 and 0.42 oz/t Au, and were found to contain anomalous Ag, Bi, Pb and W. Two nearby quartz–pyrite–arsenopyrite–fluorite veins returned values of less than 40 ppb Au. The wall rock to the veins was not found to be mineralized. The surrounding carbonate member of the Simms Ridge Formation is cut by an extensive quartz–carbonate veinlet stockwork that contains minor galena, fluorite, chalcopyrite and malachite. A sample of this mineralization returned a value of 570 ppb Au (McKenzie, 1987).

## GEOCHEMISTRY

### Introduction

Eighty-one samples collected by W.R. Smyth, H.S. Schillereff and W. Dunford were analyzed, in 1981, by atomic absorption for most major elements and Ba, Sr, Rb, Cr, V, Cd, Cu, Zn, Ni, Ag, Be, Li, Mo, Pb and Co. FeO was determined by titration, $P_2O_5$ and W were analyzed by colourimetric techniques, and F was determined by the ion-selective electrode technique. Thirty samples collected by J. Tuach were analyzed in 1986 and 1987 for the same elements (with the exception of Be, Co, Cd and W) by the same methods. All samples were analyzed or re-analyzed within the last three years for Ga, Nb, Zr, Th, Y, La, and Ce by inductively-coupled plasma-mass spectrometry (ICP-MS) in order to provide an internally consistent dataset for these elements.

Sample locations are shown in Figures 4 and 5 and results are summarized in Table 1. Samples within each unit have been subdivided by rock type. Mean and standard deviation values are presented where the number of samples is greater than three. The majority of samples are from the northern

**Table 1.** Major and trace element data for the Gull Lake intrusive suite and Devils Room granite

| | Moose Lake Granite | | | | Gull Pond Granite | | Big Davis Pond Granite | | Devils Room Granite | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | North Lobe | | South Lobe | | | | | | Granite | | Aplite | Vein |
| Sample No. | x̄ | s̄ | x̄ | s̄ | x̄ | s̄ | x̄ | s̄ | x̄ | s̄ | 5091 | 5003 |
| Oxide (%) | | | | | | | | | | | | |
| $SiO_2$ | 72.40 | 2.70 | 71.90 | 0.90 | 73.40 | 1.30 | 73.60 | 1.40 | 73.20 | 1.30 | 76.10 | 72.20 |
| $TiO_2$ | 0.33 | 0.13 | 0.32 | 0.14 | 0.18 | 0.07 | 0.26 | 0.01 | 0.22 | 0.06 | 0.07 | 0.20 |
| $Al_2O_3$ | 14.18 | 0.82 | 13.77 | 0.25 | 14.38 | 0.37 | 12.93 | 0.50 | 14.22 | 0.47 | 13.21 | 10.45 |
| FeO | 0.93 | 0.48 | 0.53 | 0.41 | 0.52 | 0.28 | 0.34 | 0.25 | 0.64 | 0.24 | 0.25 | 0.67 |
| $Fe_2O_3$ | 0.79 | 0.24 | 1.31 | 0.59 | 0.48 | 0.11 | 1.46 | 0.33 | 0.60 | 0.15 | 0.33 | 0.49 |
| MnO | 0.04 | 0.01 | 0.05 | 0.03 | 0.03 | 0.01 | 0.03 | 0.03 | 0.04 | 0.01 | 0.02 | 0.03 |
| MgO | 0.65 | 0.36 | 0.57 | 0.46 | 0.30 | 0.15 | 0.09 | 0.03 | 0.44 | 0.22 | 0.09 | 0.63 |
| CaO | 1.12 | 0.51 | 0.63 | 0.21 | 0.83 | 0.20 | 0.45 | 0.57 | 0.95 | 0.27 | 0.97 | 4.83 |
| $Na_2O$ | 3.99 | 0.22 | 3.85 | 0.35 | 4.35 | 0.19 | 3.91 | 0.67 | 4.19 | 0.20 | 3.88 | 2.34 |
| $K_2O$ | 4.77 | 0.36 | 5.49 | 0.20 | 4.74 | 0.33 | 5.64 | 0.52 | 4.61 | 0.41 | 4.81 | 4.48 |
| $P_2O_5$ | 0.09 | 0.05 | 0.02 | 0.01 | 0.05 | 0.03 | 0.02 | 0.01 | 0.07 | 0.03 | 0.01 | 0.08 |
| LOI | 1.04 | 0.29 | 0.89 | 0.31 | 0.76 | 0.21 | 0.92 | 0.55 | 0.76 | 0.19 | 0.39 | 2.62 |
| Element (ppm) | | | | | | | | | | | | |
| Li | 56 | 37 | 19 | 6 | 57 | 25 | 6 | 1 | 95 | 25 | 44 | 63 |
| Be | 0.6 | 0.2 | | | 0.7 | 0.2 | 0.4 | 0.1 | 0.7 | 0.1 | | |
| F | 409 | 205 | 160 | 49 | 367 | 261 | 465 | 347 | 443 | 205 | 36 | 12100 |
| V | 37 | 17 | 20 | 5 | 19 | 7 | 9 | 2 | 24 | 10 | 11 | 41 |
| Cr | 7 | 4 | 5 | 2 | 2 | 1 | 1 | 0 | 4 | 2 | 5 | 7 |
| Co | 4 | 2 | | | 2 | 1 | 1 | 1 | 2 | 1 | | |
| Ni | 3 | 3 | 2 | 2 | 1 | 0 | 1 | 0 | 2 | 2 | 3 | 5 |
| Cu | 5 | 6 | 3 | 2 | 5 | 4 | 34 | 42 | 3 | 2 | 2 | 3 |
| Zn | 41 | 13 | 40 | 15 | 36 | 14 | 20 | 6 | 41 | 9 | 17 | 28 |
| Ga | 22 | 4 | 14 | 8 | 26 | 2 | 28 | 2 | 23 | 5 | 15 | 14 |
| Rb | 172 | 74 | 130 | 40 | 210 | 22 | 142 | 37 | 170 | 40 | 206 | 222 |
| Sr | 161 | 102 | 66 | 10 | 91 | 61 | 11 | 3 | 131 | 54 | 48 | 142 |
| Y | 12 | 9 | 27 | 15 | 10 | 3 | 31 | 2 | 7 | 2 | 3 | 7 |
| Zr | 121 | 55 | 157 | 61 | 117 | 39 | 605 | 82 | 106 | 19 | 75 | 71 |
| Nb | 21 | 8 | 16 | 6 | 21 | 4 | 29 | 3 | 16 | 3 | 7 | 7 |
| Mo | 3 | 1 | 3 | 1 | 3 | 2 | 3 | 1 | 2 | 1 | 2 | 2 |
| Ag | 1.1 | 0.4 | 0.1 | 0.0 | 1.0 | 0.0 | 1.0 | 0.0 | 1.0 | 0.4 | 0.1 | 0.1 |
| Cd | 0.1 | 0.0 | | | 0.1 | 0.0 | 0.1 | 0.1 | 0.1 | 0.0 | | |
| Ba | 395 | 248 | 426 | 86 | 253 | 164 | 153 | 79 | 305 | 136 | 25 | 378 |
| La | 34 | 16 | 37 | 23 | 20 | 12 | 76 | 21 | 26 | 10 | 11 | 16 |
| Ce | 63 | 33 | 88 | 41 | 43 | 29 | 193 | 21 | 41 | 16 | 11 | 30 |
| W | 1.1 | 0.2 | | | 1.4 | 0.7 | 1.8 | 0.5 | 0.8 | 0.4 | | |
| Pb | 25 | 12 | 10 | 3 | 39 | 6 | 5 | 4 | 34 | 6 | 55 | 17 |
| Th | 24 | 8 | 12 | 3 | 23 | 9 | 17 | 1 | 20 | 9 | 35 | 16 |
| n | 21-22* | | 4 | | 8** | | 3 | | 37-42 | | 1 | 1 |
| Symbols | ○ | | ● | | □ | | ▽ | | ● | | ▲ | ● |

Mean (x) and standard deviation (s) are presented where the number of samples is greater than 3.
Sample numbers are given for individual analyses.
n–number of samples except *W=5 and **W=3. Symbol–symbol on Figure 4 and geochemical diagrams.

**Table 1.** *(Continued)*

| | Black Duck Ponds Trondhjemite | | | | Trondhjemite Screens in Moose Lake Granite | | Miscellaneous | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | North Lobe | | South Lobe | | | | Granite | Aplite Dyke | Aplite Dyke | Aplite Dyke | Tonalite | |
| Sample No. | $\bar{x}$ | $\bar{s}$ | 589 | 19 | $\bar{x}$ | $\bar{s}$ | 682 | 6204 | 6205 | 6203 | $\bar{x}$ | $\bar{s}$ |
| Oxide (%) | | | | | | | | | | | | |
| $SiO_2$ | 74.10 | 0.50 | 77.20 | 75.30 | 77.40 | 1.10 | 74.50 | 74.60 | 75.60 | 75.90 | 71.70 | 3.20 |
| $TiO_2$ | 0.30 | 0.02 | 0.21 | 0.22 | 0.14 | 0.04 | 0.08 | 0.04 | 0.03 | 0.01 | 0.29 | 0.06 |
| $Al_2O_3$ | 12.72 | 0.13 | 12.55 | 13.25 | 12.60 | 0.41 | 13.75 | 14.02 | 13.49 | 14.48 | 13.79 | 1.06 |
| FeO | 1.94 | 0.37 | 1.60 | 1.23 | 0.82 | 0.42 | 0.26 | 0.27 | 0.26 | 0.01 | 2.26 | 0.90 |
| $Fe_2O_3$ | 1.21 | 0.27 | 0.67 | 1.13 | 0.74 | 0.25 | 0.34 | 0.28 | 0.27 | 0.21 | 1.21 | 0.08 |
| MnO | 0.05 | 0.01 | 0.05 | 0.05 | 0.04 | 0.02 | 0.02 | 0.03 | 0.02 | 0.06 | 0.08 | 0.02 |
| MgO | 0.70 | 0.09 | 0.58 | 0.54 | 0.46 | 0.08 | 0.12 | 0.07 | 0.04 | 0.02 | 0.86 | 0.33 |
| CaO | 1.01 | 0.43 | 0.71 | 2.08 | 1.25 | 0.46 | 0.61 | 0.53 | 0.67 | 0.67 | 3.25 | 0.87 |
| $Na_2O$ | 5.53 | 0.21 | 4.43 | 4.57 | 5.02 | 0.21 | 4.07 | 4.68 | 4.66 | 6.14 | 4.22 | 0.25 |
| $K_2O$ | 0.59 | 0.11 | 1.37 | 0.86 | 0.81 | 0.23 | 5.47 | 4.77 | 4.15 | 1.96 | 0.57 | 0.05 |
| $P_2O_5$ | 0.05 | 0.01 | 0.02 | 0.04 | 0.02 | 0.01 | | 0.01 | 0.01 | 0.01 | 0.04 | 0.03 |
| LOI | 1.09 | 0.21 | 1.03 | 0.93 | 0.92 | 0.06 | 0.65 | 0.60 | 0.56 | 0.71 | 1.31 | 0.20 |
| Element (ppm) | | | | | | | | | | | | |
| Li | 21 | 7 | 17 | 14 | 34 | 23 | 36 | 14 | 32 | 15 | 13 | 2 |
| Be | 0.2 | 0.0 | 0.3 | 0.2 | 0.3 | 0.1 | 0.9 | | | | | |
| F | 285 | 128 | 189 | 92 | 127 | 45 | 144 | 86 | 123 | 58 | 80 | |
| V | 22 | 3 | 28 | 36 | 11 | 5 | 17 | 0 | 12 | 5 | 38 | 7 |
| Cr | 3 | 2 | 1 | 1 | 1 | 0 | 2 | 2 | 2 | 2 | 5 | 4 |
| Co | 6 | 7 | 3 | 3 | 1 | 1 | 1 | | | | | |
| Ni | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 |
| Cu | 8 | 8 | 2 | 3 | 5 | 1 | 3 | 11 | 12 | 4 | 8 | 2 |
| Zn | 25 | 5 | 32 | 30 | 27 | 11 | 30 | 11 | 13 | 5 | 50 | 13 |
| Ga | 17 | 2 | 14 | 14 | 13 | 3 | 31 | 11 | 10 | 31 | 8 | 6 |
| Rb | 14 | 9 | 28 | 7 | 16 | 7 | 284 | 248 | 380 | 138 | 17 | 2 |
| Sr | 69 | 23 | 42 | 109 | 58 | 28 | 18 | 21 | 30 | 20 | 135 | 19 |
| Y | 19 | 11 | 4 | 21 | 12 | 7 | 5 | 8 | 5 | 16 | 16 | 1 |
| Zr | 66 | 5 | 45 | 22 | 68 | 20 | 76 | 99 | 73 | 108 | 31 | 6 |
| Nb | 4 | 1 | 5 | 3 | 5 | 0 | 26 | 53 | 36 | 108 | 1 | 0 |
| Mo | 3 | 1 | 5 | 6 | 2 | 1 | 1 | 323 | 181 | 7 | 2 | 1 |
| Ag | 1.0 | 0.0 | 1.0 | 1.0 | 1.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| Cd | 0.1 | 0.0 | 0.1 | 0.1 | 0.1 | 0.0 | 0.1 | | | | | |
| Ba | 64 | 13 | 156 | 138 | 140 | 73 | 32 | 31 | 66 | 16 | 119 | 10 |
| La | 6 | 1 | 7 | 9 | 8 | 1 | 4 | 0 | 0 | 0 | 3 | 2 |
| Ce | 8 | 3 | 3 | 9 | 12 | 5 | 12 | 0 | 0 | 0 | 9 | 7 |
| W | 1.2 | 0.3 | 1.6 | 1.4 | 1.0 | | | | | | | |
| Pb | 2 | 1 | 1 | 1 | 5 | 7 | 49 | 52 | 54 | 52 | 1 | 0 |
| Th | 3 | 3 | 4 | 3 | 3 | 1 | 28 | 11 | 10 | 36 | 1 | 0 |
| n | 5 | | 1 | 1 | 4* | | 1 | 1 | 1 | 1 | 3 | |
| Symbols | + | | * | | ♦ | | × | ■ | ■ | ▼ | ◇ | |

n—number of samples except *W=1.

**Table 1.** *(Continued)*

| | Miscellaneous | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diabase | Diabase | Gabbro | Gabbro | Anorthosite | Pegmatitic Gabbro | Quartz-Monzonite | Quartz-Monzonite | Syenite | Syenite | Quartz Schist | Quartz Schist |
| Sample No. | 5069 | 5109 | 5072 | 5076 | 5066 | 5068 | 5071 | 5108 | 5063 | 5065 | 5062 | 5075 |
| Oxide (%) | | | | | | | | | | | | |
| $SiO_2$ | 50.90 | 55.20 | 47.20 | 47.50 | 61.80 | 58.20 | 62.10 | 62.60 | 69.50 | 62.40 | 73.30 | 75.10 |
| $TiO_2$ | 0.20 | 2.23 | 0.32 | 2.14 | 0.60 | 0.17 | 0.82 | 1.10 | 0.17 | 0.81 | 1.09 | 1.21 |
| $Al_2O_3$ | 11.20 | 14.34 | 16.13 | 15.84 | 16.72 | 15.31 | 15.64 | 15.20 | 15.74 | 15.60 | 11.43 | 9.69 |
| FeO | 7.30 | 6.35 | 8.33 | 7.78 | 3.64 | 3.22 | 2.58 | 3.76 | 0.79 | 3.95 | 2.26 | 2.05 |
| $Fe_2O_3$ | 1.03 | 2.85 | 2.86 | 3.49 | 2.06 | 0.80 | 2.78 | 1.71 | 0.10 | 1.58 | 2.66 | 2.60 |
| MnO | 0.18 | 0.16 | 0.22 | 0.26 | 0.14 | 0.12 | 0.14 | 0.11 | 0.02 | 0.21 | 0.07 | 0.12 |
| MgO | 14.92 | 3.18 | 8.55 | 7.18 | 1.12 | 7.26 | 0.71 | 1.45 | 0.42 | 0.60 | 1.25 | 1.17 |
| CaO | 10.03 | 5.80 | 9.72 | 8.42 | 3.91 | 8.97 | 2.30 | 3.31 | 0.97 | 2.28 | 0.80 | 1.39 |
| $Na_2O$ | 1.11 | 3.51 | 2.26 | 3.59 | 5.57 | 2.09 | 4.04 | 3.92 | 3.92 | 4.43 | 1.78 | 1.83 |
| $K_2O$ | 0.37 | 2.72 | 0.59 | 1.05 | 1.39 | 1.28 | 5.10 | 4.20 | 7.21 | 5.78 | 2.68 | 1.70 |
| $P_2O_5$ | 0.01 | 0.36 | 0.01 | 0.24 | 0.14 | 0.01 | 0.23 | 0.32 | 0.09 | 0.18 | 0.06 | 0.03 |
| LOI | 2.47 | 2.05 | 2.51 | 1.81 | 1.93 | 2.23 | 1.92 | 1.30 | 0.66 | 0.85 | 2.11 | 1.34 |
| Element (ppm) | | | | | | | | | | | | |
| Li | 23 | 24 | 15 | | 21 | 18 | 16 | 18 | 18 | 16 | 16 | 21 |
| Be | | | | | | | | | | | | |
| F | 108 | | 42 | 1057 | 326 | 209 | 189 | | 95 | 319 | 204 | 65 |
| V | 202 | 227 | 322 | 298 | 44 | 102 | 29 | 61 | 18 | 22 | 95 | 104 |
| Cr | 842 | 16 | 98 | 77 | 3 | 196 | 5 | 7 | 6 | 3 | 56 | 63 |
| Co | | | | | | | | | | | | |
| Ni | 184 | 6 | 31 | 46 | 1 | 61 | 1 | 3 | 1 | 1 | 21 | 23 |
| Cu | 84 | 17 | 53 | 24 | 7 | 29 | 5 | 10 | 5 | 6 | 7 | 6 |
| Zn | 87 | 109 | 145 | 151 | 99 | 40 | 75 | 88 | 24 | 75 | 55 | 53 |
| Ga | 2 | 22 | 19 | 25 | 3 | 1 | 4 | 20 | 5 | 10 | 11 | 13 |
| Rb | 17 | 79 | 24 | 42 | 40 | 55 | 48 | 94 | 162 | 69 | 75 | 27 |
| Sr | 46 | 258 | 140 | 224 | 118 | 108 | 103 | 243 | 297 | 66 | 105 | 162 |
| Y | 6 | 43 | 5 | 33 | 31 | 11 | 35 | 38 | 8 | 35 | 10 | 10 |
| Zr | 34 | 64 | 45 | 83 | 63 | 39 | 39 | 118 | 60 | 61 | 29 | 34 |
| Nb | 1 | 11 | 1 | 3 | 9 | 2 | 10 | 12 | 4 | 11 | 5 | 5 |
| Mo | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 3 | 4 | 3 | 4 |
| Ag | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.4 | 0.1 |
| Cd | | | | | | | | | | | | |
| Ba | 60 | 447 | 76 | 159 | 189 | 99 | 681 | 877 | 1195 | 686 | 772 | 654 |
| La | 2 | 45 | 2 | 18 | 40 | 9 | 51 | 49 | 22 | 64 | 23 | 23 |
| Ce | 6 | 95 | 5 | 37 | 79 | 19 | 101 | 102 | 44 | 124 | 40 | 39 |
| W | | | | | | | | | | | | |
| Pb | 1 | 10 | 37 | 3 | 5 | 1 | 2 | 16 | 55 | 8 | 4 | 11 |
| Th | 1 | 2 | 1 | 1 | 3 | 4 | 6 | 6 | 7 | 3 | 7 | 7 |
| n | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Symbols | • | • | • | • | • | • | • | • | • | • | • | • |

half of the suite, and provide representative analyses of the Black Duck Ponds trondhjemite, the Devils Room granite, the Gull Pond granite, the Big Davis Pond granite and the northern lobe of the Moose Lake granite. Several samples from the southern lobe of the Moose Lake granite were also analyzed. A number of miscellaneous samples from within the Moose Lake granite may be screens. Several samples from the diabase–gabbro unit were also analyzed.

### Results

The Black Duck Ponds trondhjemite can be separated from the granites on the basis of its major-element chemistry. Samples of this unit plot in the trondhjemite field on the classification scheme of O'Connor (1965) and in the tonalite field of the Streckeisen and LeMaitre (1979) classification scheme (Figure 6). The latter diagram does not include plagioclase composition as a classification criterion and hence has no field for trondhjemite.

Most of the trondhjemite samples are from the smaller northern lobe; two are from the southern lobe and four are from foliated trondhjemite screens, which outcrop within the northern lobe of the Moose Lake granite (Figure 4). The samples from the northern lobe generally form a tight cluster on Harker diagrams (Figure 7). The two samples from the southern lobe and the screens within the Moose Lake granite have higher $SiO_2$, slightly higher $K_2O$, and lower FeO*, MgO and $Na_2O$ (Figure 7 and Table 1). No consistent differences in trace-element contents are apparent, based on these limited data.

Samples from the Moose Lake granite (north lobe–open circles; south lobe–filled circles), Gull Lake granite (open squares) and Big Davis Pond granite (open triangles) are plotted in Figure 7 along with fields for the Devils Room granite. The Moose Lake granite shows the broadest compositional range, particularly in $SiO_2$, $Al_2O_3$, MgO and CaO. The Gull Pond granite has generally higher $Al_2O_3$ and lower FeO* and MgO when compared with Moose Lake granite of similar $SiO_2$ content and it has a similar trace-element composition (Figure 7). The Big Davis Pond granite has lower $Al_2O_3$, MgO and CaO and higher average $K_2O$ than the Moose Lake granite. It also differs in trace elements, i.e., has lower Li and Pb and higher La, Ce, Zr, Y, and Nb. Data for the Devils Room granite plot in fields that generally overlap fields for the Moose Lake and Gull Pond granites.

Analyses show that the diabase–gabbro unit is compositionally varied and includes rocks such as Mg-rich diabase, anorthosite and quartz syenite (Table 1 and Figure 6b).

Three unfoliated tonalite samples, from near the contact between the Moose Lake granite and the diabase–gabbro unit, plot in the tonalite fields on both classification diagrams (Figure 6). They contain a higher amount of mafic minerals and have lower average $SiO_2$ and $Na_2O$, and higher average $Al_2O_3$, FeO*, MgO and CaO than the Black Duck Ponds trondhjemite. The geochemical differences and contrasting deformation state, suggest that they are unrelated to the trondhjemite.

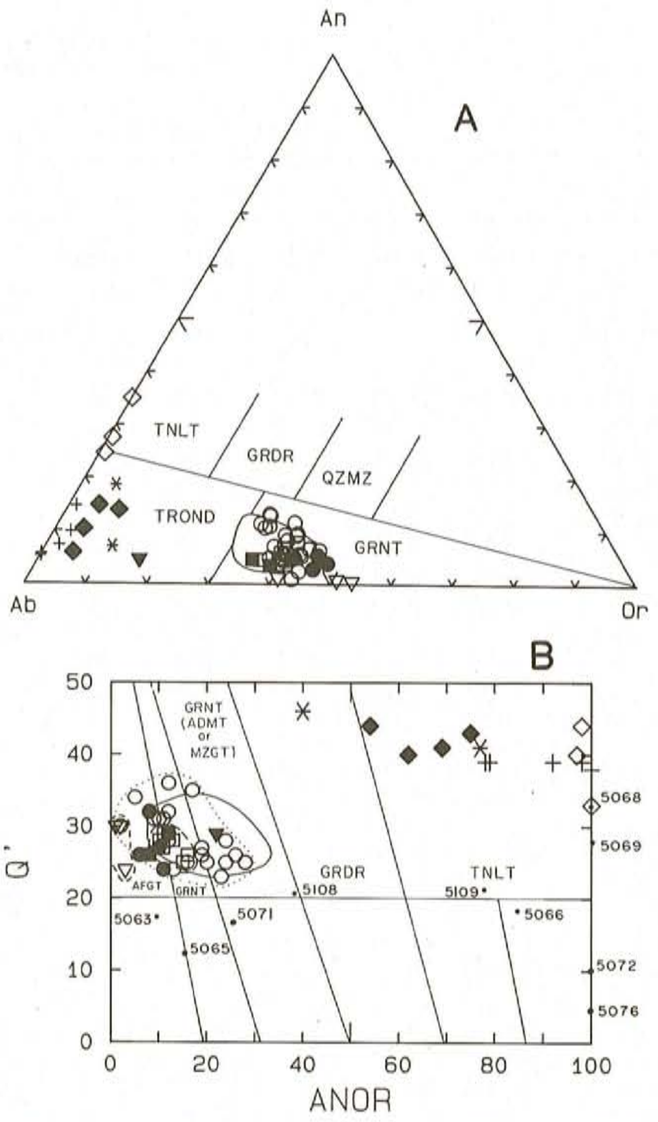


**Figure 6.** *a) Classification diagram of O'Connor (1965); b) classification diagram of Streckeisen and Lemaitre (1979). Symbols as in Figure 4. Sample numbers on Figure 6b refer to individual analyses presented in Table 1. The dotted, long-dashed and short-dashed lines enclose data for the Moose Lake (north lobe), Gull Pond and Big Davis Pond granites respectively. The solid line on Figures 6a and 6b is the field for the Devils Room granite. For clarity, individual analyses of the latter have not been plotted.*

### Classification

Granites can be classified as I-, S- (Chappell and White, 1974) or A-type (Loiselle and Wones, 1979; Collins *et al.*, 1982) on the basis of their mineralogical and chemical characteristics. Theoretically, S-type granites are derived from sedimentary source rocks and I-type granites are derived from igneous source rocks. A-type granites (a subset of I-type) are alkaline to peralkaline, are supposedly derived from recycled dehydrated continental crust and are associated with an anorogenic environment. Table 2 shows average compositions of some I-type and A-type granites as compiled by Whalen *et al.* (1987). A-type granites are characterized by high Ga, Nb, Y, Zr, Zn and REE and lower $Al_2O_3$, MgO, CaO and V. The Moose Lake, Gull Pond and Devils Room granites have elemental abundances typical of I-type granites, but the Big Davis Pond granite shows typical A-type chemistry, except for Zn, which is actually lower than in the other phases. Gallium abundance values are high for all the granites but there are some doubts about the accuracy and reproducibility of Ga analysis by ICP-MS.

The Moose Lake (north lobe), Gull Pond and Devils Room granites have virtually identical average A/CNK ratios (1.03, 1.04 and 1.04 respectively) and agpaitic indices (0.83, 0.85 and 0.84) reflecting a metaluminous and subalkaline character. The Big Davis Pond granite is more alkali-rich, and has an average A/CNK ratio of 0.97 and an agpaitic index of 0.97.

The Gull Lake intrusive suite (excluding the Black Duck Ponds trondhjemite) postdates the Taconian and Acadian orogenic events and can thus be classified as a post-collisional granite. Figure 8 shows the distribution of the Moose Lake, Gull Pond and Big Davis Pond granites (and a field for Devils Room granite data) on a plot of Rb vs Y + Nb, along with a field for data from several post-collision granites (Pearce *et al.*, 1984). The Moose Lake, Gull Pond and Devils Room granite data fall mostly within the post-collision granite field, but the Big Davis Pond granite falls within the within-plate granite field. Post-collision granites commonly contain biotite ± hornblende and exhibit most of the characteristics of I-type granites whereas within-plate granites are dominantly of the A-type (Pearce *et al.*, 1984).

## Interpretation

The similar variation of elements on the Harker diagrams (Figure 7) suggests that the Moose Lake, Devils Room and Gull Pond granites had a similar petrogenesis. This supports the correlation of the Devils Room granite with the Gull Lake intrusive suite.

Plots of Ba and Rb vs Sr (Figure 9) can be used to assess the possible crystallization history of the granites. Fractionation trends for pertinent phases assume perfect separation of crystals and liquid, and are based on partition coefficients compiled by Hanson (1978). The Moose Lake and Devils Room granites show indistinct trends that could have been produced by a combination of plagioclase and K-feldspar fractionation. The Gull Pond granite, however, shows a more clearly defined trend that corresponds to that expected from fractionation of K-feldspar only.

The differing trace-element characteristics of the Big Davis Pond granite (Figure 7 and Table 1) and its departure from the other granites on the Ba *vs* Sr diagram (Figure 9c) combined with its hypersolvus nature, indicate that it had a somewhat different crystallization history and was not produced by simple differentiation of the other phases. It may also have had different source rocks, as suggested by its A-type chemistry. Collins *et al.* (1982) interpret A-type granites to result from partial melting of rocks, from which I-type granites have already been extracted. The source rocks for the Big Davis Pond granite may have been residual material ('restite') remaining after generation of the Gull Lake intrusive suite parental magmas.

The diabase–gabbro unit includes a wide variety of rock types and has variable composition. This variability in composition and mineralogy suggests that some of these rocks may be cumulates. The presence of anorthosite supports the idea that plagioclase fractionation occurred, and the Mg-rich diabase, which contains about 80 percent amphibole, may have formed by accumulative processes. The complex intrusive relationships suggest that hybrid rocks may also be present. Textures present in Sample 5065 (Table 1) suggest that this syenite may result from potassic alteration. Further interpretation of the mafic phases and miscellaneous samples is difficult, without systematic internal mapping and sampling of the diabase–gabbro unit and the southern lobe of the Moose Lake granite.

Coyle and Strong (1987) have proposed that the post-orogenic Siluro–Devonian volcanic–sedimentary sequences and related granitoid rocks of west-central Newfoundland represent several ancient caldera complexes. One of these, which they named the 'Sops Arm caldera', includes the Gull Lake intrusive suite, Devils Room granite and Sops Arm Group, together with the Wild Cove Pond igneous suite and the Mic Mac Lake Group of the Baie Verte Peninsula. The authors suggest that this eruptive activity resulted from large-scale crustal melting of diverse source rocks in response to latent heat and mantle-generated basaltic magmatism related to the last stages of collision. Similarly, Pearce *et al.* (1984) proposed that post-collision granites are commonly derived from melting of a mixture of mantle and crustal sources in response to thermal relaxation or uplift following collision. They further pointed out that geochemical discrimination of such granites is difficult because of their variable chemistry.

The Black Duck Ponds trondhjemite shows similarities to the ophiolitic Coney Head Complex (Williams, 1977), which is dominantly composed of trondhjemite and tonalite. However, the former shows intrusive contacts with the Silurian Sops Arm Group (Smyth and Schillereff, 1982) indicating that it is younger, and is not part of the ophiolite. The Black Duck Ponds trondhjemite is unlikely to have been produced in the same magma chamber as the rest of the Gull Lake intrusive suite because it predates, but is more felsic than, the gabbro–diabase unit, which appears to have been produced by accumulative processes. It is chemically similar to the Twillingate trondhjemite (Table 2), which Payne and Strong (1979) interpret to result from partial melting of a low-K basalt under amphibolite-facies conditions, and it may have had a similar origin. It is interesting to note that there is a spatial association in west-central Newfoundland between

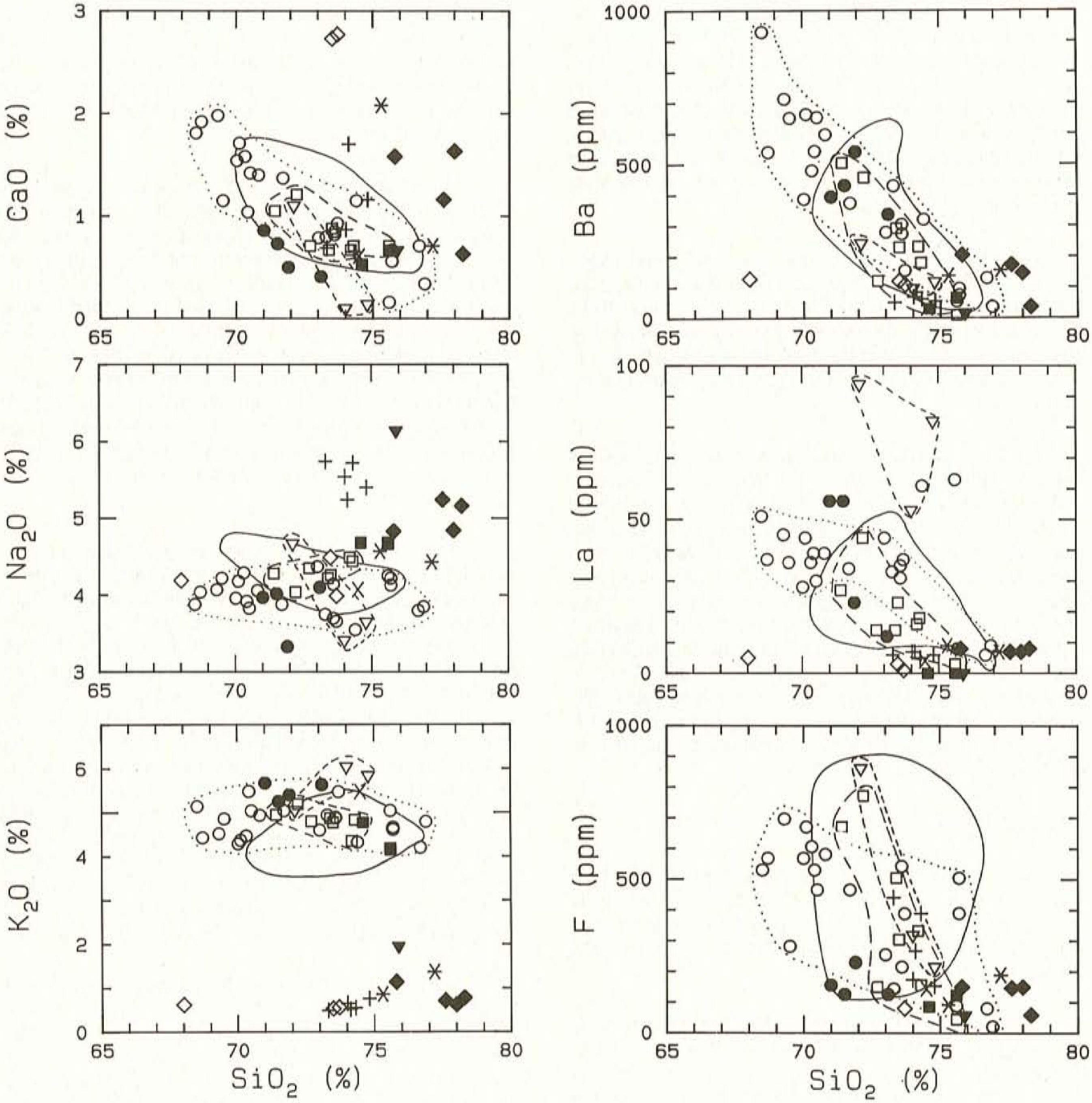


**Figure 7.** *Harker diagrams for selected major and trace elements. Fields and symbols as for Figures 4 and 6b. Spurious analyses are excluded from fields.*

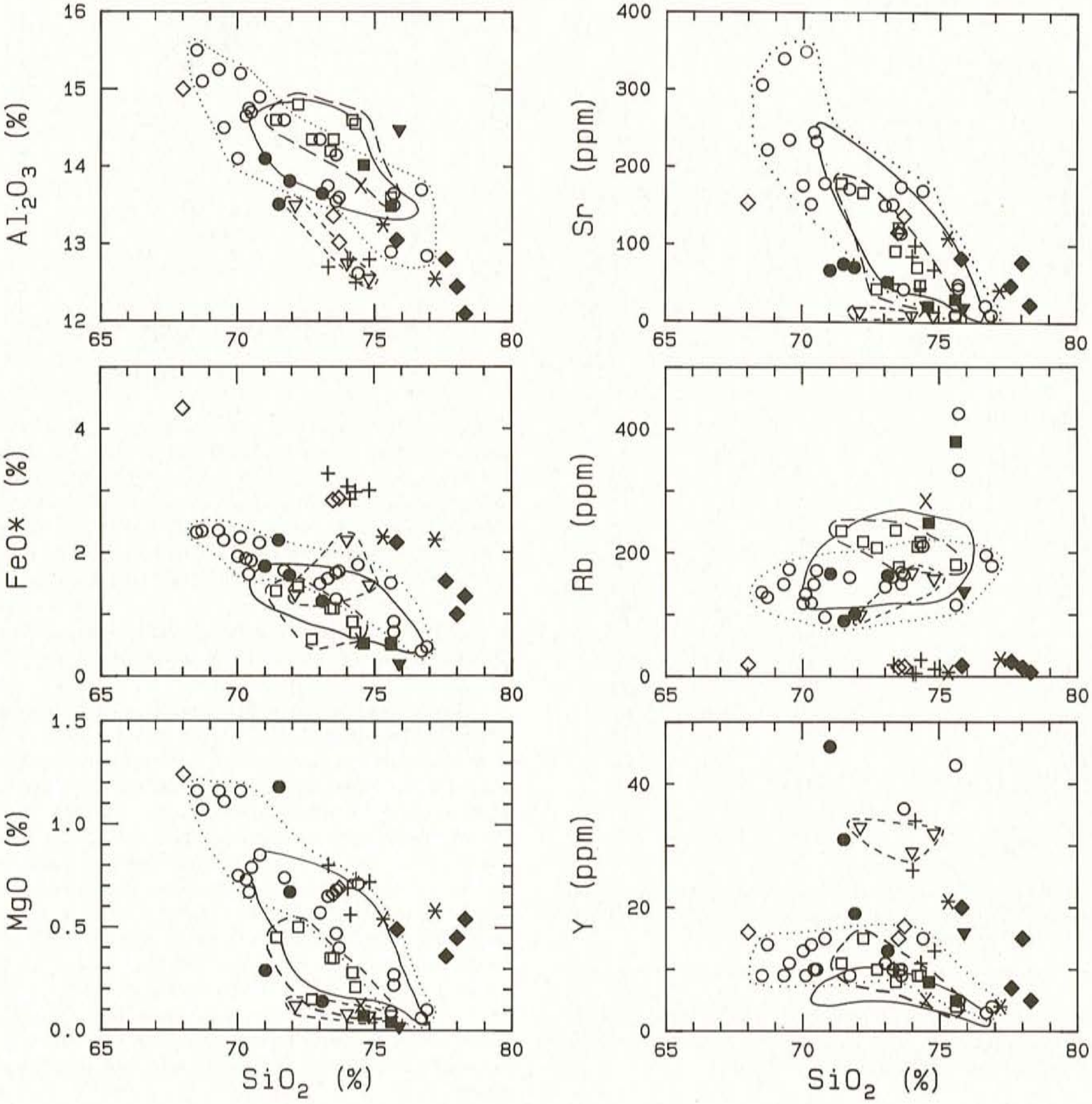


**Figure 7.** *(Continued).*

**Table 2.** Average analyses of Twillingate trondhjemite and I- and A-type granites

| | Twillingate Trondhjemite | I-type | Felsic I-type | A-type |
|---|---|---|---|---|
| Oxide (%) | | | | |
| $SiO_2$ | 74.45 | 69.17 | 73.39 | 73.81 |
| $TiO_2$ | 0.22 | 0.43 | 0.26 | 0.26 |
| $Al_2O_3$ | 13.02 | 14.33 | 13.43 | 12.4 |
| $Fe_2O_3$ | 2.62* | 1.04 | 0.6 | 1.24 |
| FeO | | 2.29 | 1.32 | 1.58 |
| MnO | 0.07 | 0.07 | 0.05 | 0.06 |
| Mgo | 0.28 | 1.42 | 0.55 | 0.2 |
| CaO | 1.85 | 3.2 | 1.71 | 0.75 |
| $Na_2O$ | 5.03 | 3.13 | 3.33 | 4.07 |
| $K_2O$ | 0.47 | 3.4 | 4.13 | 4.65 |
| $P_2O_5$ | 0.01 | 0.11 | 0.07 | 0.04 |
| Element (ppm) | | | | |
| V | | 60 | 22 | 6 |
| Ni | | 7 | 2 | 1 |
| Cu | 17 | 9 | 4 | 2 |
| Zn | 39 | 49 | 35 | 120 |
| Ga | 14 | 16 | 16 | 24.6 |
| Rb | 10 | 151 | 194 | 169 |
| Sr | 97 | 247 | 143 | 48 |
| Y | | 28 | 34 | 75 |
| Zr | 88 | 151 | 144 | 528 |
| Nb | 5 | 11 | 12 | 37 |
| Ba | 74 | 538 | 510 | 352 |
| Ce | | 64 | 68 | 137 |
| Pb | 3 | 19 | 23 | 24 |
| Th | | 18 | 22 | 23 |
| No. Samp. | 33 | 991 | 421 | 148 |

Twillingate trondhjemite data from Payne and Strong (1979)
I- and A-type granite data compiled by Whalen *et al.* (1987)
* Total iron as $Fe_2O_3$.

such tonalite–trondhjemite bodies ('Twillingate type' of Williams *et al.*, 1989) and Siluro–Devonian granites ('Topsails type'–Williams *et al.*, 1989).

**Economic Inplications**

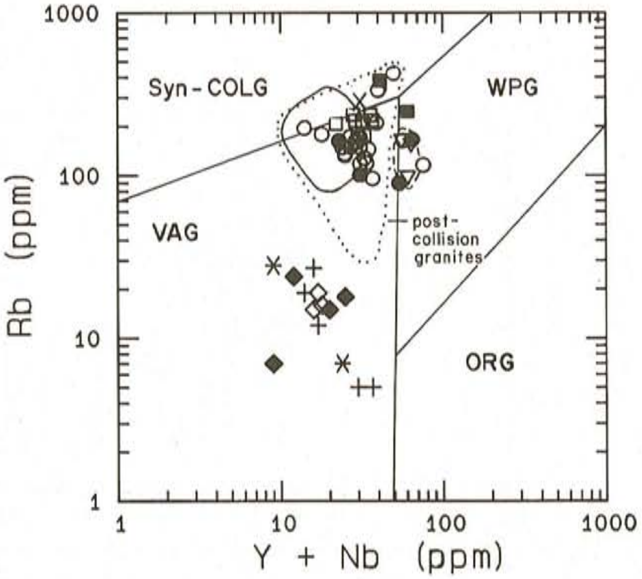


**Figure 8.** *Rb vs Y + Nb classification diagram. Dotted line encloses field for several 'post-collision' granites. Fields are also shown for syn-collision granites (syn-COLG), within-plate granites (WPG), volcanic-arc granites (VAG) and ocean ridge granites (ORG). From Pearce* et al. *(1984). Symbols as in Figure 4. Field for Devils Room granite enclosed by solid line; field for Big Davis Pond granite enclosed by dashed line.*

The Gull Lake intrusive suite may be of interest to gold prospectors in light of the gold occurrences hosted by (and genetically-related to?), the Big Davis Pond granite. However, the latter may not be genetically related to the rest of the Gull Lake intrusive suite. Nevertheless, a sample from the western part of the Moose Lake granite is weakly anomalous (90 ppb Au) and the White Bay area is host to numerous gold occurrences. The Gull Lake intrusive suite should certainly be explored for gold, as it may be a feeder for the Sops Arm Group, which is host to several gold occurrences (Figure 2).

There is not likely to be significant granophile element mineralization within the Gull Lake intrusive suite. The known molybdenum and base-metal mineralization appears to be of minor extent and confined to the late aplite dykes, which are related to the Gull Pond granite. Although minor fluorite mineralization occurs in the Gull Lake intrusive suite and the Devils Room granite, the potential for significant fluorite mineralization is not good because fluorine appears to behave compatibly in the Gull Lake intrusive suite. It also shows no apparent trend in the Devils Room granite (Figure 7) and would therefore not be significantly enriched in late phases. The potential for exotic-element (e.g., REE, Zr, Nb and Y) mineralization is also poor, as none of the samples analyzed display enhanced levels of these elements (Table 1), and such mineralization is typically hosted by peralkaline granites.

## CONCLUSIONS

The Moose Lake, Devils Room and Gull Pond granites are mineralogically and chemically similar post-collisional, I-type granites. They are subsolvus (contain both K-feldspar and plagioclase), subalkaline and metaluminous and appear to have evolved from the same parent magma, which may have produced the diabase–gabbro unit by accumulation of plagioclase and mafic phases.

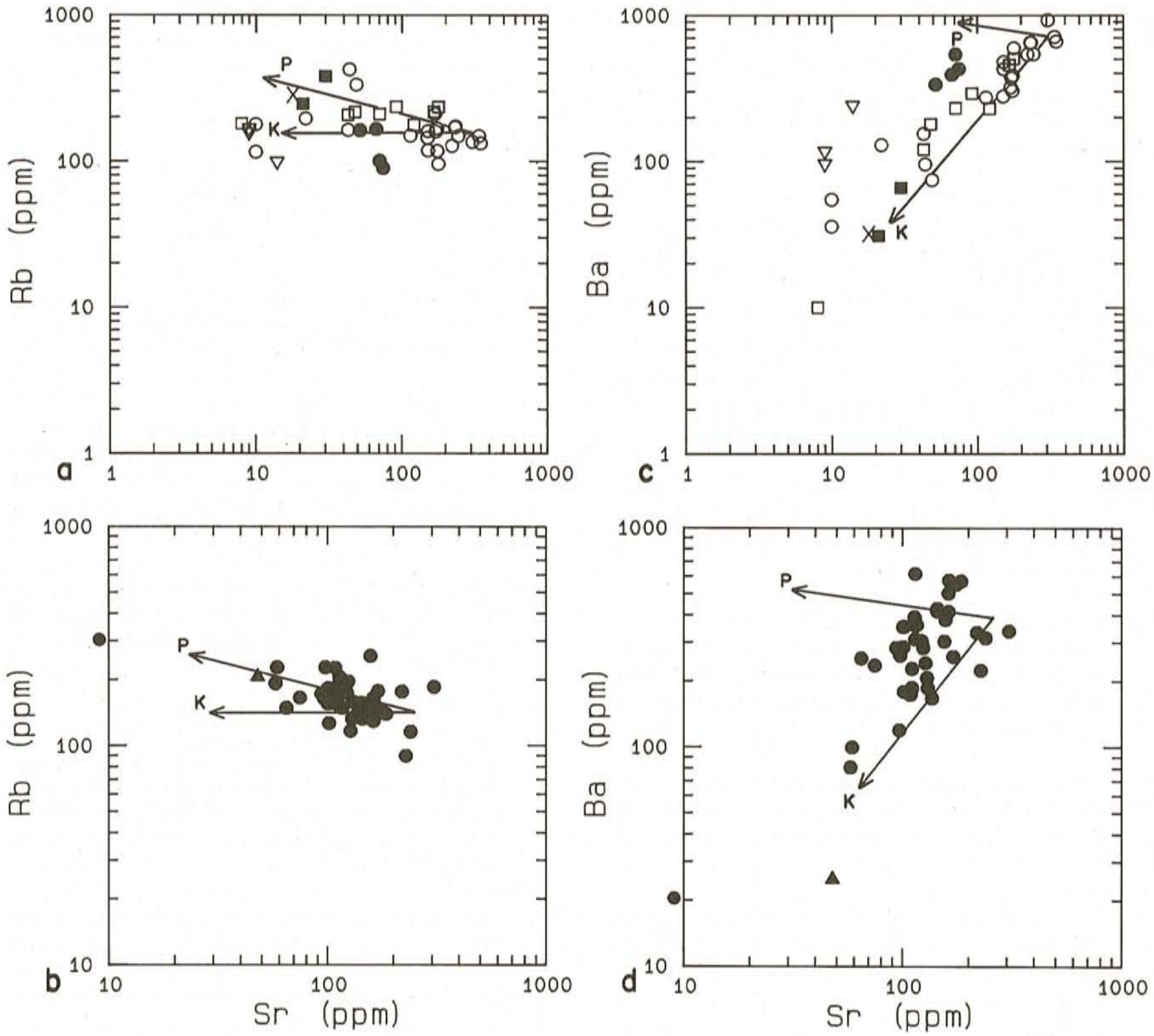


**Figure 9.** *Rb* vs *Sr for Gull Lake intrusive suite (a) and Devils Room granite (b); Ba* vs *Sr for Gull Lake intrusive suite (c) and Devils Room granite (d). Vectors show idealized perfect fractionation trends for K-feldspar (K) and plagioclase (P) based on partition coefficients compiled by Hanson (1978).*

The Big Davis Pond granite, which is probably the youngest phase, is mineralogically and geochemically distinct and shows characteristics of A-type granites. It is a high-level, hypersolvus, leucocratic alkali-feldspar granite and may have been produced by partial melting of a depleted source.

The Black Duck Ponds trondhjemite is the oldest phase and is unlikely to be genetically related to the rest of the Gull Lake intrusive suite. It may have been produced by partial melting of mafic rocks.

Although minor molybdenite and fluorite mineralization occurs in both the Gull Lake intrusive suite and the Devils Room granite, the potential for significant granophile element mineralization is low. However, anomalous gold mineralization occurs in the Big Davis Pond granite, and the Gull Lake intrusive suite should be explored for gold, especially since it may be a feeder for the Sops Arm Group, which hosts several gold occurrences.

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*NOTE: Geological Survey Branch file numbers are included in square brackets.*