Late Neoproterozoic granitoid and metavolcanic rocks of the Indian Brook Area, southeastern Cape Breton Highlands, Nova Scotia

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Late Neoproterozoic granitoid rocks constitute most of the Indian Brook area of the southeastern Cape Breton Highlands. They are divided into seven map units based on field relations, texture, and mineralogy. Although sharp lithological contacts have been mapped in the field, the plutons are chemically gradational, and are inferred to be a comagmatic suite, related by crystal fractionation processes and/or variable amounts of melting of similar source rocks. Composition in the largest pluton, the ca. 100 km^2 Indian Brook Granodiorite varies from more mafic in the northwest to more felsic in the southeast, consistent with pressures estimated from the Al-in-hornblende geobarometer which suggest that the western part represents the deeper part of the pluton. Volcanic rocks of the Price Point Formation and the chemically similar Murray Mountain Quartz Monzodiorite occur in the southeastern part of the area, and are inferred to represent the highest level of emplacement and accompanying extrusion of magma. The granitoid and volcanic rocks have petrochemical features consistent with origin in a continental margin subduction zone, like other units of similar age in the Bras d'Or terrane.

La roche granitoïde Néoprotérozoique tardif constituent la majeure partie de la région d'Indian Brook au sud-est des hautes terres du Cap Breton. Elles sont divisées en sept unités de carte basées sur des observations sur le terrain, la texture, et la minéralogie. Bien que de forts contacts lithologiques aient été tracés dans sur le terrain, les plutons sont chimiquement graduels, et sont déduis pour être un groupe comagmatique, associée par les processus de cristallisation fractionnée et/ou des quantités variables de la fonte de roche similaire à la source. La composition dans le plus grand pluton, c.100 km^2 de granodiorite D'Indian Brook a une variation de mafique dans le nord-ouest à felsique dans le du sud-est, conformé à des pressions estimées à partir du géobaromètre d'Al-dans-hornblende qui suggèrent que la partie occidentale représente une part plus profonde du pluton. Les roches volcaniques de la Formation Price Point et les roches chimiquement semblables de Murray Mountain Quartz Monzodiorite on lieu dans la partie sud-est de la zone, et sont impliquées pour représenter le niveau le plus élevé de la mise en place et l'accompagnement de l'extrusion de magma. Les roches granitoïdes et volcaniques ont les dispositifs pétrochimiques conformés à l'origine dans une zone continentale de subduction de marge, comme d'autres unités d'âge semblable dans le terrane de Bras d'Or.

[Traduit par la rédaction]

INTRODUCTION

Late Neoproterozoic granitoid plutons and minor metavolcanic rocks form most of the southeastern Cape Breton Highlands (Fig. 1). Although the area has been mapped in detail (Barr *et al.* 1992; Lynch and Lafrance 1996), previous petrological studies are limited. Barr *et al.* (1982) reported petrochemical data from only the southernmost part of the area, and Macdonald and Barr (1985) presented a revised interpretation of the geology of the same area, with limited new geochemical data. Some chemical data for the area were presented by Farrow and Barr (1992) and Dostal *et al.* (1996), but they were part of more regional studies and did not emphasize units of the southeastern highlands. Hence the present study was undertaken to focus on the petrology, petrogenesis, and tectonic setting of Late Neoproterozoic units in this area.

Further study was needed to help resolve differing interpretations of these units. In one interpretation (e.g., Barr and Raeside 1989; Farrow and Barr 1992; Raeside and Barr 1990) the plutonic and volcanic rocks are considered to be typical of the Bras d'Or terrane, and therefore unrelated to rocks of similar age in the Mira terrane of southeastern Cape Breton Island (Fig. 1, inset). In contrast, Dostal *et al.* (1996) did not recognize these separate terranes, and related all of the Late Neoproterozoic plutonic and volcanic rocks to a single evolving subduction zone. Different interpretations have also been made of the relationship between the mainly granodioritic and granitic plutons of the southeastern Cape Breton Highlands and the mainly dioritic and tonalitic plutons farther to the northwest. Based on geobarometric and geochronologic data, Farrow and Barr (1992) postulated that all of these rocks are related, and represent different levels of erosion within a continental margin subduction zone. In contrast, Lynch (1996) proposed the presence of a major fault (part of his Highlands Shear Zone) along the western margin of the Indian Brook Granodiorite. Rocks to the northwest of this structure were designated part of the southern lobe of the

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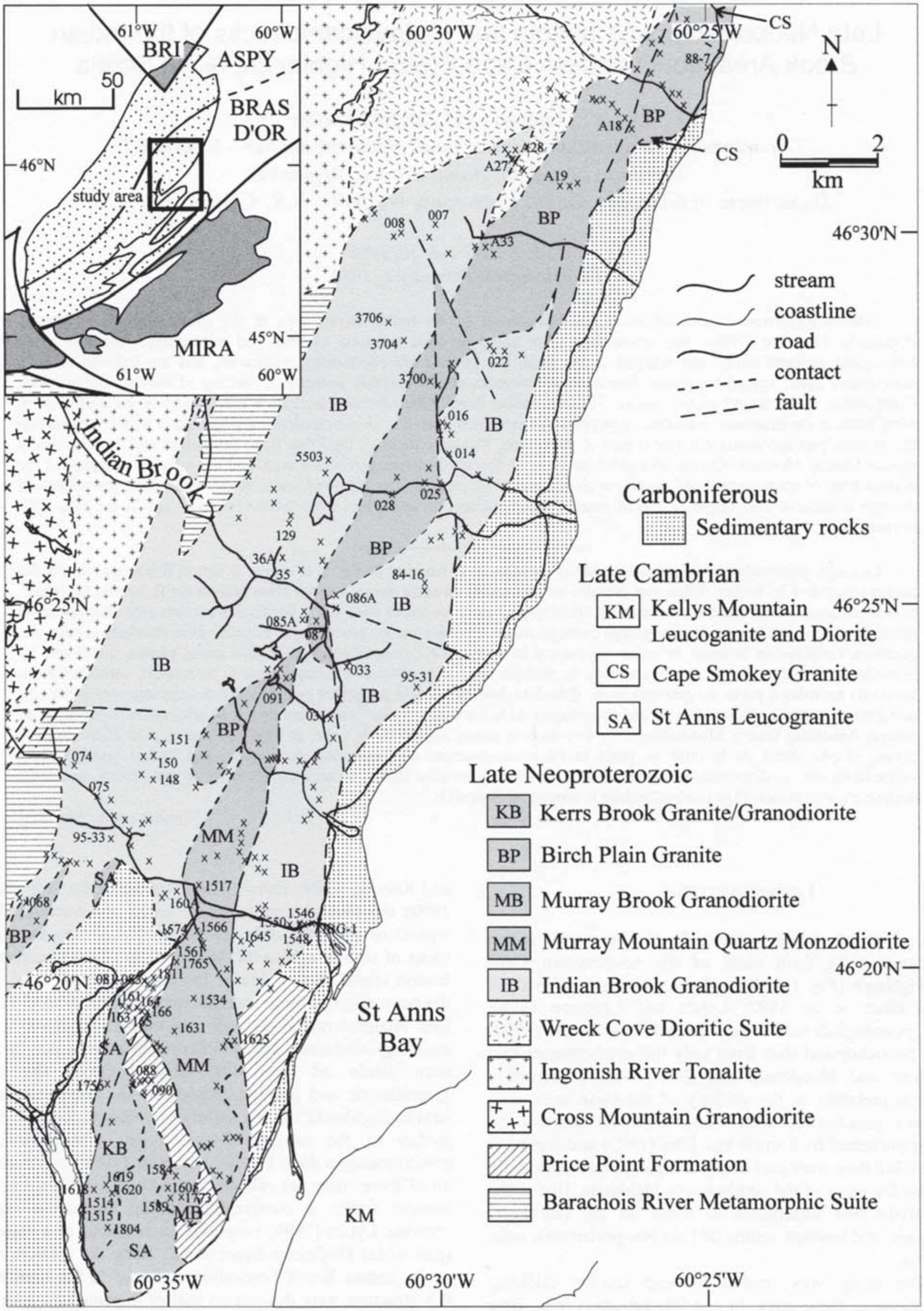


Fig. 1. Simplified geological map of the southeastern Cape Breton Highlands, after Barr *et al.* (1992). Sample locations are shown by x's; numbered localities are locations of samples listed in Table 1 and/or Table 4 (designated by last few digits of the sample number). Inset map shows terranes in Cape Breton Island, after Barr *et al.* (1995); BRI, Blair River Inlier.

Cabot Nappe, inferring that they are unrelated to those to the southeast.

The purpose of this paper is to describe the petrochemical characteristics of the major Late Neoproterozoic plutonic units of the southeastern Cape Breton Highlands (Barr *et al.* 1992), including the Indian Brook Granodiorite, Birch Plain Granite, Murray Mountain Quartz Monzodiorite, Murray Brook Granodiorite, and Kerrs Brook Granite, as well as associated low-grade metavolcanic rocks of the Price Point Formation (Fig. 1). Amphibole compositions in the Indian Brook Granodiorite are used to assess the depth of emplacement using the Al-in-hornblende geobarometer (Hammarstrom and Zen 1986; Schmidt 1992). The data are used to discuss the relationships among and petrogenesis of the volcanic and plutonic rocks. They do not resolve all of the conflicting interpretations noted above, but provide a contribution toward that goal.

GEOLOGICAL SETTING

The study area is part of the Bras d'Or terrane (Fig. 1, inset) of Barr and Raeside (1989). This terrane is characterized by low-pressure, high-grade metamorphic rocks, variably metamorphosed continental margin clastic-carbonate sequences, relatively minor metavolcanic rocks, and Late Neoproterozoic plutonic rocks (Raeside and Barr 1990). The terrane has been tentatively correlated with similar areas in both southern Newfoundland and New Brunswick (Raeside and Barr 1990; Barr and White 1996; White and Barr 1996; Barr *et al.* 1995, 1998), but its regional significance and relationship to the adjacent Mira terrane are controversial (e.g., Keppie *et al.* 1990; Barr *et al.* 1990; Dostal *et al.* 1996; Keppie *et al.* 1998).

The southeastern highlands part of the Bras d'Or terrane (Fig. 1) consists mainly of an elongate granodioritic pluton, ca. 100 km^2 in area, named the Indian Brook Granodiorite (Barr *et al.* 1985; 1992). The granodiorite is divided into eastern and western parts by the Birch Plain Granite and, farther south, the Murray Mountain Quartz Monzodiorite (Fig. 1). The Price Point Formation occurs in the southern part of the area, adjacent to the Murray Mountain Quartz Monzodiorite. Smaller plutonic units in the area include the Kerrs Brook Granite, Murray Brook Granodiorite, and Late Cambrian St. Anns Leucogranite (Fig. 1), as well as abundant granitoid dykes and plutons too small to show on Figure 1. These various plutonic units have been distinguished from one another based on detailed mapping and petrographic study, including modal mineralogy (Barr *et al.* 1982, 1985, 1992; Macdonald and Barr 1985). The distinctive features of these plutons indicate that Lynch and Lafrance (1996) were not justified in re-assigning all or parts of these units to the Indian Brook Granodiorite.

Relative ages of these granitoid units on the basis of field relationships are not definitive. Macdonald and Barr (1985) inferred an intrusive sequence based on the composition of cross-cutting granitoid dykes; however, re-examination of the dyke samples during the present study suggests that their postulated correlation with specific granitoid units is uncertain. Nevertheless, it seems likely that, with the exception of the younger St. Anns Leuocogranite (see below), the Price Point Formation and associated granitoid units are comagmatic. Their age is interpreted to be approximately 575 - 565 Ma, based on U-Pb dating of zircon and titanite which has demonstrated maximum and minimum ages of crystallization of 575 Ma and 564 Ma for the Indian Brook Granodiorite (Dunning *et al.* 1990). In contrast, the St. Anns Leucogranite is inferred to be Late Cambrian in age because it is identical in appearance and composition to the Kellys Mountain Leucogranite, located southeast of St. Anns Bay (Fig. 1), which has yielded a U-Pb (zircon) age of 493 Ma (Dunning *et al.* 1990). Hence the St. Anns Leucogranite is not included in the present study.

On its western margin, the Indian Brook Granodiorite is in contact (from north to south) with the Wreck Cove Dioritic Suite, Ingonish River Tonalite, and Barachois River Metamorphic Suite (Barr *et al.* 1992). The Wreck Cove and Ingonish River units are two of the ca. 565 - 555 Ma plutonic units that comprise most of the northwestern part of the Bras d'Or terrane (Farrow 1989; Farrow and Barr 1992). The Barachois River Metamorphic Suite (termed the Barachois River gneissic complex by Lynch and Lafrance 1996) consists of potassium feldspar augen gneiss interlayered with semipelitic gneiss and rare mafic gneiss; it is of uncertain age and origin (Raeside and Barr 1992). Because xenoliths of all of these units were observed in the western part of the Indian Brook Granodiorite, Barr *et al.* (1992) inferred that the Indian Brook Granodiorite intruded the adjacent units. In contrast, Lynch and Lafrance (1996) showed a thrust fault along the western margin of the Indian Brook Granodiorite, with the western units thrust over the Indian Brook Granodiorite. Field observations to justify this interpretation have not been published, but it appears incompatible with the observed xenoliths in the Indian Brook Granodiorite.

Locally, Carboniferous sedimentary rocks unconformably overlie or are in faulted contact with the metamorphic, volcanic, and plutonic rocks around the periphery of the area (Fig. 1).

PETROGRAPHY

Indian Brook Granodiorite

The Indian Brook Granodiorite is the largest unit in the study area. It is typically composed of dark red, medium- to coarse-grained granodiorite which contains 15 to 20% mafic minerals, including both hornblende and biotite. Other major minerals are plagioclase (oligoclase-andesine), perthitic microcline, and quartz. The texture is inequigranular, with a framework of euhedral and subhedral plagioclase and mafic minerals separated by interstitial microcline and quartz. Abundant large (up to 2 mm in length) interstitial grains of titanite are typically present; other accessory minerals include zircon, apatite, and magnetite. The western part of the unit generally contains more mafic minerals than the eastern part. Alteration is more intense in the eastern part, and includes moderate to intense saussuritization and sericitization of plagioclase, chloritization of biotite and hornblende, replacement of hornblende by actinolite, and pervasive epidotization and hematitization.

Birch Plain Granite

The Birch Plain Granite is medium grained, pale pink to red, and contains less than 10% biotite; no hornblende is present. Other major minerals are plagioclase (oligoclase), strongly perthitic microcline, and quartz. The texture is mainly medium to coarse grained and equigranular, although locally it is porphyritic with phenocrysts of microcline up to 3 to 4 cm in length. Allanite and zircon are abundant accessory phases, together with titanite, apatite and magnetite. In places, a weak to moderately strong foliation is present, defined mainly by biotite alignment. It is not clear whether this is a magmatic or tectonic foliation.

Kerrs Brook Granite

The Kerrs Brook Granite is similar in appearance to the Indian Brook Granodiorite but generally has fewer mafic minerals (less than 15%), and is more granitic. In contrast to the Birch Plain Granite, the mafic minerals include both hornblende and biotite. Texture is coarse grained and allotriomorphic equigranular. Titanite, apatite, and magnetite are abundant accessory phases.

Murray Brook Granodiorite

The Murray Brook Granodiorite is similar to the Indian Brook Granodiorite in texture and mineralogy, but forms a separate body in the southern part of the study area. It could be part of the Indian Brook Granodiorite, but Macdonald and Barr (1985) interpreted it to be a separate unit, based in part on the presence of intense hydrothermal alteration, quartz-calcite veining, and sulphide mineralization.

Murray Mountain Quartz Monzodiorite

The Murray Mountain Quartz Monzodiorite varies in texture from fine-grained porphyritic to medium-grained inequigranular, and contains abundant hornblende and biotite (20 to 25% in total). Quartz and minor perthitic K-feldspar are interstitial. In places, these interstitial minerals are somewhat intergrown, approaching a granophyric texture. These features, as well as the close association with volcanic rocks of the Price Point Formation, suggest that the pluton was emplaced at a shallow crustal level.

Price Point Formation

The Price Point Formation consists dominantly of lithic and crystal tuff of andesitic and dacitic composition. Possible flows of similar composition are a minor component and occur mainly in the western part of the unit. Mafic dykes are present, but similar dykes also occur in the associated plutons, so it is not clear that they are part of the volcanic package. Most of the volcanic rocks consist mainly of subhedral plagioclase and amphibole crystals. The rocks have been affected by low-grade metamorphism and alteration, and contain abundant chlorite, epidote, actinolite, calcite, quartz, sericite, and opaque minerals. Plagioclase is moderately saussuritized.

WHOLE-ROCK GEOCHEMISTRY

Indian Brook Granodiorite

A total of 28 analyses are available from the Indian Brook Granodiorite (Table 1), and an additional 2 analyses from the pluton were reported by Dostal *et al.* (1996). Because of the large size of the pluton, the samples are divided into four groups based on geographic area in order to assess internal variations within the pluton - northwest of Indian Brook, southest of Indian Brook, northeast of Indian Brook, and southeast of Indian Brook (Fig. 1). Dostal *et al.* (1996) did not report specific sample locations but their two samples are likely to be from the southeastern area which includes the major road section through the unit.

On average (Table 2), the 8 samples from the northwestern part of the unit have lowest SiO_2 contents (average 62.5%), whereas the 8 samples from the southeastern area (6 from this study and two from Dostal *et al.* 1996) have the highest SiO_2 contents (average 67%). Most major elements show correlation with SiO_2 (e.g., Fig. 2), and hence the samples from the southeastern area are generally lower in TiO_2, Al_2O_3, $Fe_2O_3^t$, MnO, MgO, CaO, and P_2O_5, and higher in K_2O than the samples from the northwestern area of the pluton, and samples from the other two areas have intermediate compositions (Table 2; Fig. 2). On a Q-A-P diagram using CIPW normative mineralogy (Fig. 3), the samples are mainly granodiorite, but range from quartz monzodiorite (northwestern area) to monzogranite (southeastern area). Among the trace elements, the samples from the southeastern area are lower in Sr, V, and Pb, but higher in Rb, Th, and Nb (Table 2). Other elements such as Pb, Zr, Ga, Y, and Nb do not show significant variation. Overall, the chemical characteristics of the granitic part of the pluton (southeastern part) are similar to those of the average I-type granite of Whalen *et al.* (1987), although lower in Pb (Fig. 4a).

Birch Plain Granite

Nine samples from the Birch Plain Granite range in SiO_2 from 70 to 74.7%, with an average value of 71.9%. They show some compositional overlap with granitic samples from the southeastern part of the Indian Brook Granodiorite, and lie on the same trends on silica variation diagrams (Fig. 2) and on the Q-A-P diagram (Fig. 3). Hence, although contacts appear sharp between these units in the field, chemical relationships appear gradational. With respect to trace element components, the granite samples tend to contain lower Zn, Sr, P, Zr, V, Ga, and Y compared to the Indian Brook Granodiorite, consistent with the higher SiO_2 content (Table 2). The average Birch Plain Granite is similar in Ba, K, Nb, Zn, P, Zr, V, and Ga to the average felsic I-type granite of Whalen *et al.* (1987), but lower in Pb, Rb, and Th and higher in Sr (Fig. 4b).

Kerrs Brook Granite

Nine samples from the Kerrs Brook Granite, including 2 samples from Dostal *et al.* (1996), show a narrow range in

Table 1. Geochemical data[1] from the Indian Brook area.

SAMPLE	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total	Ba	Rb	Sr	Y	Zr	Nb	Th	Pb	Ga	Zn	Cu	Ni	V	Cr
Indian Brook Granodiorite (northwestern part)																										
K9-A27	57.55	0.61	16.53	7.04	0.15	3.81	7.12	3.24	1.83	0.17	1.50	99.55	329	46	452	18	167	8	2	5	18	76	38	9	222	56
K9-A28	61.32	0.53	16.13	6.06	0.13	2.79	5.65	3.34	2.73	0.17	0.99	99.84	308	74	350	15	142	13	<10	<10	16	72	105	8	145	36
AM84-007	61.99	0.55	15.14	6.48	0.13	3.27	6.04	2.69	2.65	0.14	0.80	99.87	367	76	350	22	81	8	<10	<10	12	61	43	15	186	37
AM84-008	69.03	0.38	14.82	3.38	0.08	1.28	3.34	3.16	3.19	0.12	0.60	99.38	428	75	327	17	113	8	<10	<10	15	36	12	5	74	7
CW86-3704	60.55	0.67	16.15	6.71	0.13	2.75	6.19	3.15	1.93	0.22	1.30	99.75	343	53	457	26	128	7	7	13	20	71	59	8	193	13
CW86-3706	65.46	0.51	15.72	5.08	0.11	1.94	4.67	3.60	1.70	0.20	1.20	100.18	158	45	376	21	122	10	<10	<10	15	56	45	5	124	11
RR84-129	67.01	0.40	16.10	3.52	0.10	1.42	3.50	3.88	2.43	0.16	0.97	99.49	553	60	468	17	186	8	6	12	16	54	11	5	52	37
RR87-5503	56.73	0.73	16.97	7.91	0.18	3.58	6.07	4.10	1.32	0.32	1.60	99.51	399	43	500	22	155	5	*	*	17	96	20	10	228	14
Indian Brook Granodiorite (southwestern part)																										
K7A-1811	55.44	0.79	17.39	7.60	0.12	2.73	5.56	3.19	2.80	0.25	2.78	98.36	514	65	672	25	142	9	<10	<10	21	68	87	7	195	37
AM84-074	61.98	0.57	15.71	6.55	0.12	3.16	6.29	2.96	1.52	0.16	0.30	99.31	359	43	408	20	94	5	<10	<10	13	59	42	9	193	30
AM84-085A	69.38	0.38	14.22	3.32	0.09	1.22	2.96	3.13	3.85	0.12	0.70	99.37	398	110	277	17	115	9	<10	<10	11	39	10	5	77	14
AM84-148	66.46	0.51	14.52	5.35	0.11	2.53	4.05	3.05	3.11	0.15	1.20	101.05	410	72	294	17	118	7	<10	<10	13	62	14	6	161	27
AM84-150	59.47	0.74	15.73	8.28	0.16	3.88	6.80	2.91	1.23	0.18	0.80	100.18	265	32	396	25	102	7	<10	<10	17	77	28	10	241	26
AM84-151	67.25	0.41	15.30	3.90	0.11	1.51	3.32	3.66	2.68	0.15	1.40	99.69	362	70	361	19	121	8	<10	<10	14	47	10	5	87	7
AM84-160A	64.84	0.54	14.78	5.25	0.11	2.11	4.35	3.08	3.55	0.18	0.90	99.70	457	106	362	27	164	10	<10	20	14	53	42	5	119	5
SMB95-33	69.20	0.49	15.15	3.78	0.09	1.60	3.80	3.71	1.22	0.16	1.40	100.60	408	35	542	9	126	5	<10	<10	17	51	8	5	98	10
Indian Brook Granodiorite (northeastern part)																										
AM84-014	64.19	0.54	15.16	5.05	0.12	2.47	3.82	3.24	3.90	0.16	1.21	99.86	524	109	356	26	161	10	12	14	17	69	58	11	140	35
AM84-022	63.66	0.54	14.51	5.04	0.11	2.09	4.16	2.86	3.76	0.16	1.20	98.09	472	114	355	25	151	8	<10	<10	17	51	63	5	117	10
AM84-031	63.43	0.66	15.36	5.83	0.13	2.56	5.09	3.09	3.24	0.20	0.80	100.41	453	94	448	27	154	8	<10	<10	16	67	56	7	141	17
AM84-033	65.56	0.56	15.17	5.18	0.11	2.07	4.18	3.13	3.74	0.17	0.70	100.58	472	111	380	25	159	12	12	<10	16	50	53	5	124	10
SB84-016	61.61	0.66	15.37	6.77	0.14	2.98	3.82	3.11	3.83	0.23	1.80	100.32	539	114	374	28	143	9	9	<10	15	58	80	5	173	11
SMB95-31	70.18	0.37	13.94	3.20	0.06	1.22	1.98	3.20	4.44	0.11	1.50	100.21	675	127	314	18	123	9	10	22	14	34	31	5	63	10
Indian Brook Granodiorite (southeastern part)																										
K7A-1546	71.68	0.37	11.68	3.52	0.06	1.14	2.07	2.46	4.42	0.10	3.06	100.56	267	123	60	25	217	10	43	<10	14	62	5	7	48	57
K7A-1548	67.59	0.42	13.54	3.42	0.07	1.16	2.90	3.43	4.08	0.13	2.94	99.68	*	*	*	*	*	*	*	*	*	*	*	*	*	*
K7A-1550	65.15	0.48	15.96	4.49	0.08	1.09	3.72	3.46	3.34	0.14	1.70	99.61	459	108	335	25	157	12	11	<10	14	49	78	14	94	37
K7A-1625	66.66	0.16	14.92	2.53	0.05	1.63	2.52	3.21	3.89	0.06	1.56	97.19	487	143	216	21	113	11	27	<10	14	36	5	6	43	41
K7A-1645	63.41	0.54	15.47	5.00	0.08	1.52	3.26	3.05	4.14	0.13	3.26	99.86	547	135	288	25	177	10	10	<10	15	71	5	8	137	51
IBG-1	63.85	0.54	15.49	5.08	0.11	2.44	4.18	3.23	3.57	0.17	1.10	99.76	514	110	406	25	167	10	12	*	18	57	51	6	116	23
Birch Plain Granite																										
K9-A18	73.02	0.22	13.44	2.00	0.07	0.64	1.63	3.64	4.23	0.06	0.74	99.69	489	130	247	11	114	12	14	8	15	28	2	8	32	26
K9-A19	72.36	0.27	13.89	2.43	0.09	0.89	2.02	3.42	3.74	0.07	0.74	99.92	449	123	254	19	124	12	15	7	16	33	*	12	32	23
K8-A33	71.75	0.23	13.60	1.89	0.09	0.58	1.74	3.17	4.30	0.07	0.70	98.13	343	130	208	17	91	12	18	15	12	34	6	5	26	10
AM84-025	74.69	0.18	13.45	1.33	0.06	0.39	1.54	3.08	4.51	0.05	0.40	99.70	354	150	189	12	90	11	16	13	10	15	5	5	16	7
AM84-028	70.97	0.32	14.44	2.56	0.10	1.17	2.16	3.65	3.44	0.09	0.69	99.59	428	110	296	18	139	11	15	12	14	41	8	4	35	35
AM84-068	70.04	0.30	15.33	2.70	0.08	0.89	2.51	3.34	4.04	0.13	0.80	100.14	472	95	333	16	135	9	16	14	14	30	6	5	37	8
AM84-087	70.82	0.28	14.43	2.43	0.07	1.07	1.85	3.63	4.00	0.07	1.20	99.85	456	106	308	20	126	12	14	10	14	39	7	4	34	32
CBH88-7	73.09	0.16	13.51	1.17	0.04	0.92	1.21	3.65	4.56	0.10	0.80	99.21	393	144	160	18	87	7	*	*	12	18	9	5	9	12
CW86-3700	70.11	0.16	15.75	1.36	0.05	0.49	1.02	3.06	7.34	0.07	0.80	100.21	1214	171	279	10	67	6	<10	13	13	20	5	5	22	7

Continued on next page.

Table 1. Contd.

SAMPLE	SiO_2	TiO_2	AL_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total	Ba	Rb	Sr	Y	Zr	Nb	Th	Pb	Ga	Zn	Cu	Ni	V	Cr
Kerrs Brook Granite/Granodiorite																										
K7A-1514	70.11	0.32	15.33	3.20	0.10	1.22	2.49	3.82	3.18	0.14	1.17	100.89	449	90	327	21	121	8	<10	10	16	60	5	5	59	27
K7A-1515	70.24	0.30	14.62	3.02	0.07	1.05	1.76	3.85	3.54	0.10	1.78	100.13	448	97	330	23	116	8	<10	176	15	76	5	7	56	41
K7A-1618	67.53	0.30	14.83	4.12	0.10	1.45	3.64	3.40	2.87	0.13	1.75	99.89	396	90	317	19	118	8	<10	<10	16	64	5	6	93	40
K7A-1619	69.72	0.23	14.90	2.85	0.06	0.99	1.13	4.03	3.51	0.12	1.55	98.92	509	110	333	21	126	9	<10	<10	15	40	7	5	58	28
K7A-1620	67.67	0.28	15.18	3.13	0.10	1.12	2.28	3.92	3.16	0.12	1.48	98.23	430	95	328	20	126	8	<10	<10	15	62	5	5	59	33
K7A-1756	67.15	0.41	14.29	4.05	0.09	1.60	3.14	3.35	3.38	0.12	1.69	99.04	541	101	320	22	136	11	<10	<10	13	59	31	10	87	33
K7A-1804	67.23	0.32	15.37	3.78	0.09	1.37	2.99	3.44	3.43	0.12	1.94	99.92	475	94	328	22	148	9	<10	<10	17	68	5	5	71	33
Murray Mountain Quartz Monzodiorite																										
K7A-1517	65.32	0.62	14.52	5.22	0.11	1.97	3.82	3.27	3.63	0.15	1.43	99.77	505	116	382	22	139	7	14	<10	18	56	73	6	122	38
K7A-1534	60.92	0.67	16.26	6.31	0.12	2.90	5.10	3.37	2.91	0.15	2.14	100.47	434	79	374	26	138	8	<10	<10	18	70	49	12	173	67
K7A-1561	54.71	0.90	17.35	8.37	0.15	3.62	6.07	3.42	2.46	0.23	3.19	100.00	448	60	506	23	116	6	<10	<10	19	91	58	13	261	28
K7A-1566	56.35	0.87	18.63	8.06	0.17	3.48	5.68	3.21	2.33	0.23	1.84	100.38	503	55	492	25	106	7	<10	<10	20	84	107	9	249	20
K7A-1574	52.95	1.20	17.00	9.18	0.18	3.97	7.61	3.09	1.81	0.29	2.90	99.66	270	60	562	21	97	5	<10	<10	22	121	98	17	267	47
K7A-1631	62.19	0.64	14.86	5.81	0.07	1.85	4.52	2.62	2.93	0.14	3.43	98.75	120	89	111	19	146	7	<10	<10	18	61	14	15	168	73
K7A-1765	55.92	0.80	17.19	7.09	0.17	3.96	6.86	2.21	2.16	0.26	2.24	98.37	405	56	496	22	115	6	<10	<10	19	105	65	13	245	28
AM84-091	60.37	0.58	15.61	6.14	0.11	2.82	5.35	3.04	2.98	0.17	1.50	98.66	409	91	378	23	138	7	<10	<10	16	53	48	11	167	30
Murray Brook Granodiorite																										
K7A-1584	66.17	0.28	16.55	3.68	0.09	1.93	3.95	3.84	1.80	0.12	2.07	100.26	353	55	233	13	94	7	<10	<10	17	50	5	33	58	54
K7A-1589	68.17	0.25	14.92	2.99	0.04	1.62	1.24	4.63	2.40	0.11	2.92	99.06	245	85	131	14	92	8	<10	<10	14	58	332	21	50	45
K7A-1605	63.92	0.27	17.40	3.08	0.06	1.65	3.69	4.21	1.84	0.11	2.21	98.22	294	49	281	14	103	9	<10	<10	15	48	31	24	49	62
K7A-1773	67.22	0.18	15.29	3.18	0.06	1.49	3.16	4.05	2.43	0.07	2.29	99.24	395	65	248	14	93	9	<10	<10	16	44	5	18	43	53
Price Point Formation																										
K7-A81	59.50	0.75	16.40	7.52	0.16	2.91	6.83	2.26	1.90	0.43	2.00	100.66	386	80	481	27	157	10	8	15	18	99	*	7	203	35
K7-A82	52.96	1.33	17.83	10.20	0.19	3.29	7.51	3.16	1.74	0.44	2.47	101.12	456	67	456	43	190	15	5	21	21	166	*	12	244	8
K7-A83	58.48	0.81	16.21	8.18	0.17	2.84	6.94	2.83	2.83	0.28	1.48	101.05	617	69	515	31	156	10	9	11	18	101	*	10	207	22
K7-A88	56.73	0.90	15.54	10.25	0.18	3.55	7.10	2.65	1.70	0.36	2.39	101.35	597	48	449	28	141	9	7	10	18	125	*	14	291	61
K7-A90	58.61	0.77	15.40	8.61	0.13	3.05	6.78	3.07	2.62	0.39	1.63	101.06	630	61	460	32	167	10	10	14	16	85	*	9	254	29
AM84-161	56.41	0.75	16.31	9.97	0.22	3.50	5.46	3.09	2.20	0.30	2.60	100.81	487	54	483	28	131	9	6	11	18	114	112	11	266	60
AM84-163	61.36	0.69	16.43	7.28	0.14	2.93	4.88	3.01	2.20	0.23	1.88	101.03	424	52	497	29	167	12	12	18	18	107	73	3	200	45
AM84-164	59.51	0.67	16.29	8.80	0.18	3.58	5.92	2.74	1.28	0.22	1.82	101.01	370	52	466	29	169	11	9	16	18	120	95	10	234	41
AM84-165	58.14	0.64	16.48	8.73	0.24	4.11	5.59	3.34	0.87	0.25	1.70	100.09	376	34	669	29	158	10	5	9	16	109	54	8	235	32
AM84-166	58.33	0.81	18.05	7.92	0.17	2.62	4.44	3.43	2.75	0.27	1.91	100.70	577	75	480	23	134	9	6	15	17	103	114	2	201	31

[1] Analyses by standard X-Ray Fluorescence techniques at the Nova Scotia Regional Geochemical Centre, except major element data in K7A samples, which are from Barr *et al.* (1982). Abbreviations: LOI, loss-on-ignition; Fe_2O_3 is total iron expressed as Fe_2O_3; * means not determined.

Table 2. Average chemical analyses[1] with standard deviations.

SAMPLE	IBG-NW	IBG-SW	IBG-NE	IBG-SE	BPG	KBG	MMQMD	MBG	PPF
n	8	8	6	8	9	9	8	4	16
wt. %									
SiO_2	62.46 ± 4.39	64.25 ± 4.94	64.77 ± 2.94	66.96 ± 2.78	71.87 ± 1.56	68.69 ± 1.28	58.59 ± 4.24	66.37 ± 1.83	57.18 ± 3.14
TiO_2	0.55 ± 0.12	0.55 ± 0.15	0.56 ± 0.11	0.41 ± 0.12	0.24 ± 0.06	1.31 ± 0.05	0.78 ± 0.21	0.25 ± 0.05	0.80 ± 0.18
Al_2O_3	15.95 ± 0.70	15.35 ± 0.98	14.92 ± 0.57	14.45 ± 1.37	14.20 ± 0.86	14.93 ± 0.34	16.43 ± 1.38	16.04 ± 1.14	16.96 ± 1.19
Fe_2O_3	5.77 ± 1.64	5.50 ± 1.84	5.18 ± 1.18	3.86 ± 0.91	1.99 ± 0.58	3.36 ± 0.49	7.02 ± 1.39	3.23 ± 0.31	8.38 ± 1.71
MnO	0.13 ± 0.03	0.11 ± 0.02	0.11 ± 0.03	0.08 ± 0.02	0.07 ± 0.02	0.09 ± 0.02	0.14 ± 0.04	0.06 ± 0.02	0.17 ± 0.04
MgO	2.61 ± 0.96	2.34 ± 0.91	2.23 ± 0.60	1.60 ± 0.48	0.78 ± 0.27	1.37 ± 0.29	3.07 ± 0.83	1.67 ± 0.19	3.43 ± 0.81
CaO	5.32 ± 1.35	4.64 ± 1.41	3.84 ± 1.02	2.84 ± 0.82	1.74 ± 0.46	2.38 ± 0.79	5.63 ± 1.22	3.01 ± 1.22	6.07 ± 1.46
Na_2O	3.40 ± 0.45	3.21 ± 0.31	3.11 ± 0.13	3.24 ± 0.40	3.40 ± 0.25	3.69 ± 0.25	3.03 ± 0.41	4.18 ± 0.33	3.08 ± 0.39
K_2O	2.22 ± 0.63	2.50 ± 1.04	3.82 ± 0.38	4.01 ± 0.39	4.46 ± 1.14	3.23 ± 0.26	2.65 ± 0.57	2.12 ± 0.34	2.03 ± 0.83
P_2O_5	0.19 ± 0.06	0.17 ± 0.04	0.17 ± 0.04	0.12 ± 0.03	0.08 ± 0.02	0.12 ± 0.01	0.20 ± 0.06	0.10 ± 0.02	0.29 ± 0.08
ppm									
Ba	361 ± 112	397 ± 73	523 ± 82	476 ± 100	511 ± 269	465 ± 42	387 ± 130	322 ± 66	448 ± 141
Rb	59 ± 14	67 ± 30	112 ± 11	131 ± 17	129 ± 24	94 ± 8	76 ± 22	64 ± 16	61 ± 24
Sr	410 ± 66	414 ± 132	371 ± 44	265 ± 108	253 ± 58	329 ± 8	413 ± 141	223 ± 65	507 ± 73
Y	20 ± 4	20 ± 6	25 ± 4	24 ± 2	16 ± 4	21 ± 2	23 ± 2	14 ± 1	27 ± 6
Zr	137 ± 33	123 ± 22	149 ± 14	162 ± 32	108 ± 25	126 ± 10	124 ± 18	96 ± 5	151 ± 31
Nb	8 ± 2	8 ± 2	9 ± 2	10 ± 1	10 ± 2	7.8 ± 2.7	7 ± 1	8 ± 1	8 ± 4
Th	8 ± 3	10 ± 1	10.5 ± 1.2	20 ± 12	15 ± 2	9.9 ± 0.7	11 ± 1	10 ± 1	7 ± 3
Pb	10 ± 2	11 ± 4	13 ± 5	10 ± 1	12 ± 3	34 ± 63	10 ± 1	10 ± 1	14 ± 4
Ga	16 ± 2	15 ± 3	16 ± 1	15 ± 2	13 ± 2	15 ± 1	19 ± 2	16 ± 1	18 ± 1
Zn	65 ± 18	57 ± 12	55 ± 13	54 ± 13	29 ± 9	58 ± 12	80 ± 25	50 ± 6	111 ± 27
Cu	42 ± 31	30 ± 27	57 ± 16	29 ± 34	6 ± 2	9 ± 10	64 ± 30	93 ± 160	90 ± 26
Ni	8 ± 3	7 ± 2	6 ± 2	7 ± 3	6 ± 3	6 ± 2	12 ± 3	24 ± 7	14 ± 13
V	153 ± 66	146 ± 60	126 ± 37	83 ± 35	27 ± 10	66 ± 15	207 ± 55	50 ± 6	228 ± 60
Cr	26 ± 17	20 ± 12	16 ± 10	41 ± 11	18 ± 11	34 ± 5	41 ± 19	54 ± 7	37 ± 14

[1]Data are from Table 1, with additional data from Dostal et al. (1996) as described in the text. Unit abbreviations are as listed on Figure 2. Number of samples is less for some trace elements which were not determined in all samples (see Table 1).

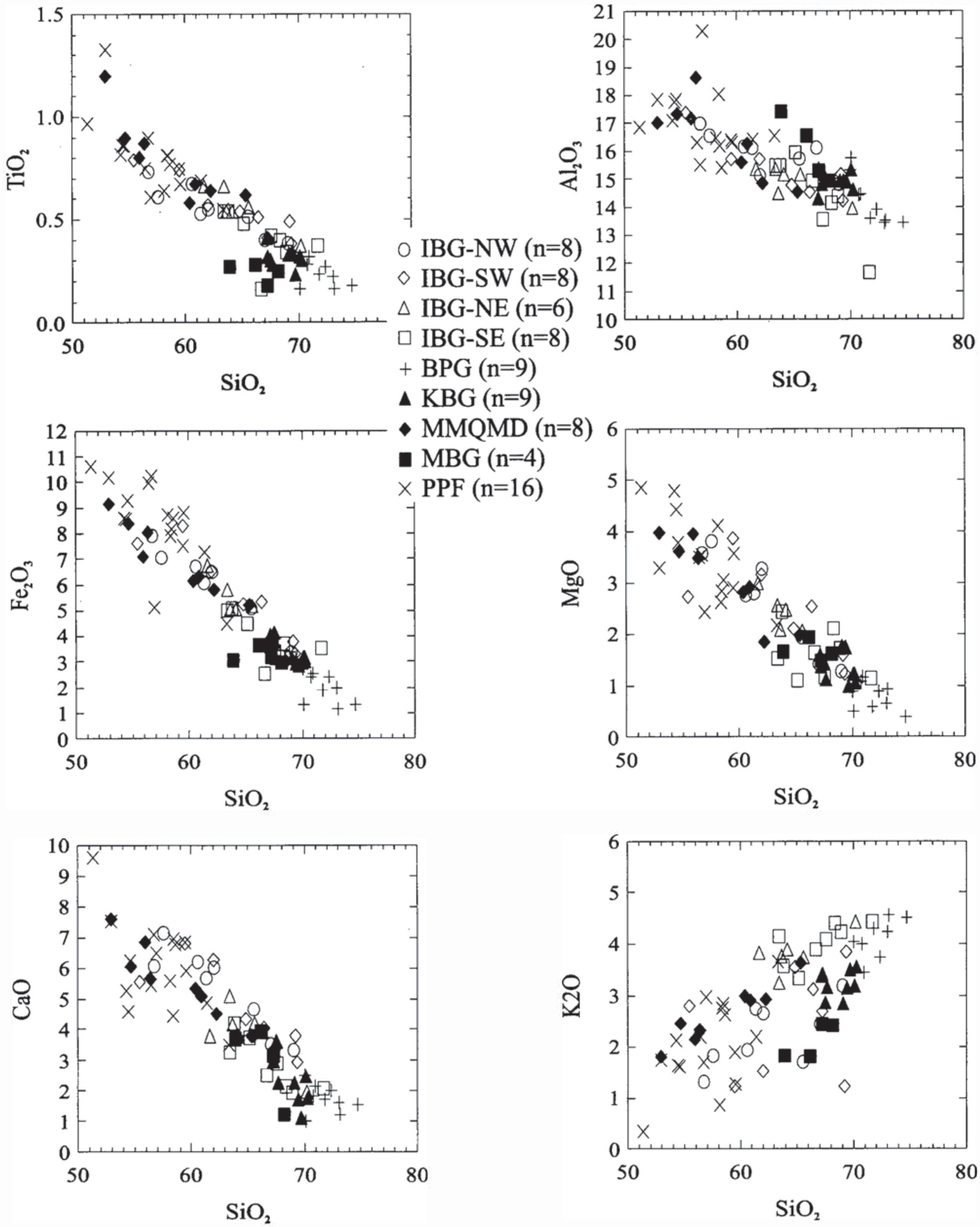


Fig. 2. Selected silica variation diagrams for analysed samples from the Indian Brook area. Abbreviations: IBG-NW, northwestern part of the Indian Brook Granodiorite; IBG-SW, southwestern part of the Indian Brook Granodiorite; IBG-NE, northeastern part of the Indian Brook Granodiorite; IBG-SE, southeastern part of the Indian Brook Granodiorite; KBG, Kerrs Brook Granite; PBG, Birch Plain Granite; MBG, Murray Brook Granodiorite; MMQMD, Murray Mountain Quartz Monzodiorite; PPF, Price Point Formation.

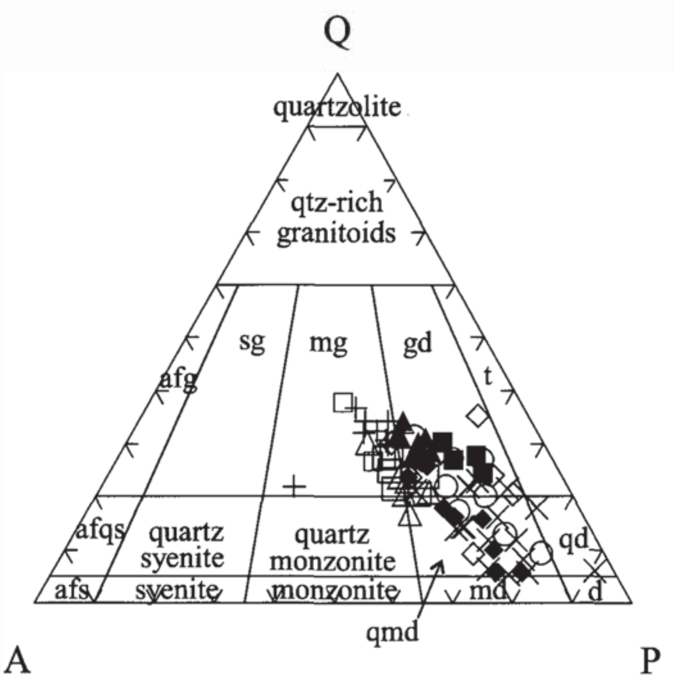


Fig. 3. Ternary plot of CIPW normative quartz (Q), orthoclase (A), and albite + anorthite (P), with fields from Streckeisen (1976). CIPW normative mineralogy was calculated assuming an Fe_2O_3/FeO ratio of 0.15. Symbols are as in Fig. 2. Abbreviations: afg, alkali feldspar granite; afs, alkali feldspar syenite; afqs, alkali feldspar quartz syenite; d, diorite; gd, granodiorite; md, monzodiorite; mg, monzogranite; qd, quartz diorite; qmd, quartz monzodiorite; sg, syenogranite; t, tonalite.

SiO_2 content (67.2 to 70.2%), and a significantly lower average SiO_2 content (68.7%) than the Birch Plain Granite (71.9%). In most chemical features, the Kerrs Brook Granite appears intermediate between the southeastern part of the Indian Brook Granodiorite and the Birch Plain Granite, but shows some distinctive features such as lower K_2O and higher Pb (Fig. 2, 4b).

Murray Brook Granodiorite

Only four samples have been analysed from this small unit, and they have an average SiO_2 content of 66.4%, similar to the samples from the southeastern part of the Indian Brook Granodiorite (Table 2; Fig. 2). However, they are lower in Rb, Ba, Th, K, Nb, Sr, P, Zr, Ti, V, and Y, and higher in Al. Some of these differences may be related to the pervasive alteration in the Murray Brook Granodiorite.

Murray Mountain Quartz Monzodiorite

Eight analysed samples from the Murray Mountain Quartz Monzodiorite have generally lower SiO_2 contents than the other granitoid units, consistent with the more mafic modal mineralogy and lower quartz and K-feldspar contents. The average value is 58.6%, but the samples show a range from 53% to 65.3%. They overlap in SiO_2 content with samples from the northwestern, southwestern, and northeastern parts of the Indian Brook Granodiorite, to which they are chemically similar (Fig. 2, 3, 4). However, they show the most striking chemical similarity to the Price Point Formation, as described below.

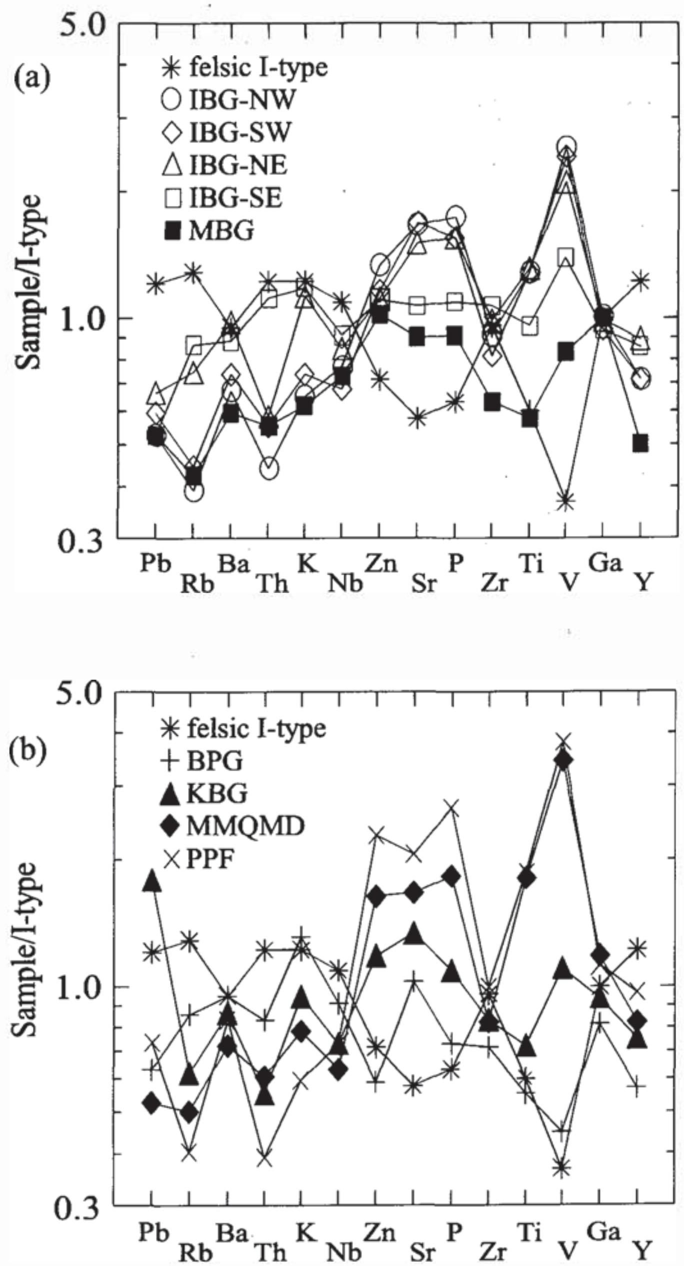


Fig. 4. Multi-element variation diagrams for average analyses of Table 2, normalized against the average I-type granite of Whalen *et al.* (1987). Average felsic I-type of Whalen *et al.* (1987) is shown for comparison. Abbreviations are as in Fig. 2.

Price Point Formation

The chemical data base for the Price Point Formation includes ten samples from the present study, combined with 6 analyses from Dostal *et al.* (1996). Locations and petrography of the latter samples are unknown. Three dyke samples from Dostal *et al.* (1996) are excluded because of the possibility (noted above) that such dykes are unrelated to the formation. The samples show a range in SiO_2 contents similar to that in the spatially associated Murray Mountain Quartz Monzodiorite, and the average value is only 1% lower at 57.18%. The volcanic samples show more chemical variation, particularly in the more mobile elements such as Ca and K, but display the same trends as the plutonic samples (Fig. 2, 3). The multi-element variation diagram shows the similarity between the Price Point Formation and the Murray Mountain Quartz Monzodiorite, notably in Nb, Ti, V, Ga, and Y (Fig. 4b).

Discussion

The ranges in chemical composition correspond well with variations in the proportions of feldspars and mafic minerals in the units, and these variations seem to be gradational. The data are consistent with the interpretation that the samples represent a comagmatic suite. Taken as a group, the samples range more or less continuously from mafic to felsic, but most are intermediate (52 to 66% SiO_2). Most major element oxides display linear trends on silica variation diagrams (Fig. 2); TiO_2, Al_2O_3, Fe_2O_3t, MnO (not shown), MgO, CaO and P_2O_5 display good negative correlations with silica, whereas K_2O displays positive correlation with SiO_2. The Na_2O contents are approximately constant at ca. 3% (Table 2). Overall, the chemical variations within each pluton and among the plutons as a group suggest a major role for crystal fractionation in magma evolution. Plots of Rb versus Sr and Ba versus Sr (Fig. 5a, b) show patterns qualitatively consistent with fractionation dominated by plagioclase and hornblende, with evidence for K-feldspar and biotite removal in the granitic samples. However, the presence of distinct mappable units, each with internal variations and compositional overlaps with other units, suggests that each unit may represent an individual magma, generated from the same or similar source rocks by different amounts partial melting and then subject to fractional crystallization. In this sense, the separate plutonic and volcanic units may be considered cogenetic but not directly comagmatic. The probable exception to this interpretation may be the Price Point volcanic rocks and the spatially associated Murray Mountain Quartz Monzodiorite.

A variety of chemical parameters, as well as the petrographic characteristics of the rocks, indicate that they are calc-alkalic, such as trends on the AFM diagram (Fig. 6), on which the more evolved composition of the Birch Plain Granite compared to the other units is very clear. The tectonic setting is clearly a volcanic arc (Fig. 7), and overall, the compositions are typical of compositionally expanded calc-alkaline I-type suites formed in association with continental-margin subduction zones (e.g., Pitcher 1982, Brown *et al.* 1984), as also concluded by Dostal *et al.* (1996).

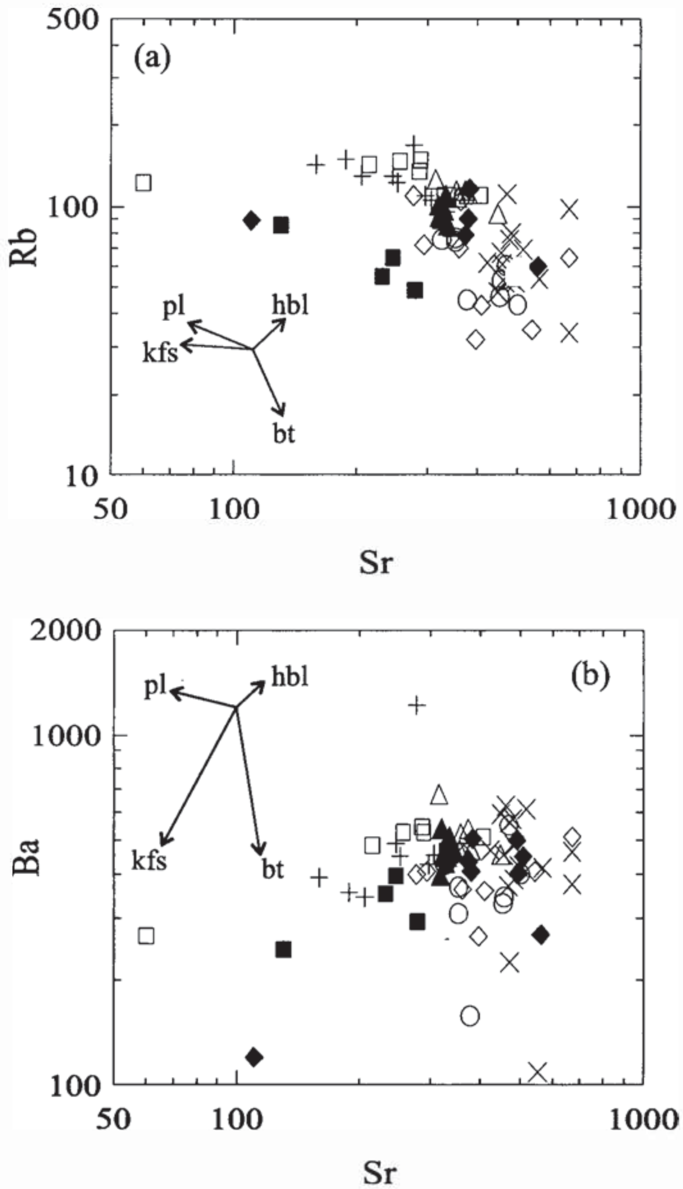


Fig. 5. Plots of (a) Rb against Sr and (b) Ba against Sr. Approximate mineral fractionation vectors for plagioclase (pl), hornblende (hbl), biotite (bt), and potassium feldspar (kfs) are shown, after Farrow and Barr (1992), as a qualitative indication of the effects of removal of these minerals on magma evolution. Symbols are as in Fig. 2.

Rare-Earth Element Data

Dostal *et al.* (1996) published REE data for six volcanic samples from the Price Point Formation, two samples from the Indian Brook Granodiorite, and two samples from the Kerrs Brook Granite. We contribute previously unpublished analyses for two additional samples from the Indian Brook Granodiorite (one each from the southeastern and northwestern areas) and two samples from the Birch Plain Granite (Table 3). The chondrite-normalized patterns for all samples are similar in shape, showing light REE enrichment, a slight negative Eu anomaly, and gently downward-sloping heavy REE (Fig. 8a, b, c). The lower REE contents, especially light REE, in more felsic samples may be due to their lower content of REE-bearing accessory phases such as titanite, which may have been removed by crystal fractionation.

Based on their samples, Dostal *et al.* (1996) suggested that the volcanic rocks of the Price Point Formation may have had a different source than the plutonic rocks because of the

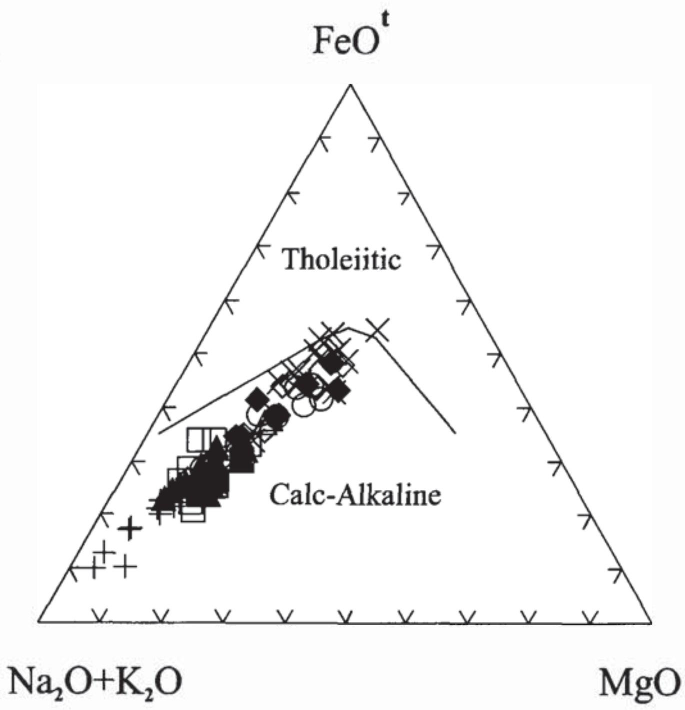


Fig. 6. Ternary AFM diagram, with tholeiitic/calc-alkaline dividing line from Irvine and Baragar (1971). Symbols are as in Fig. 2.

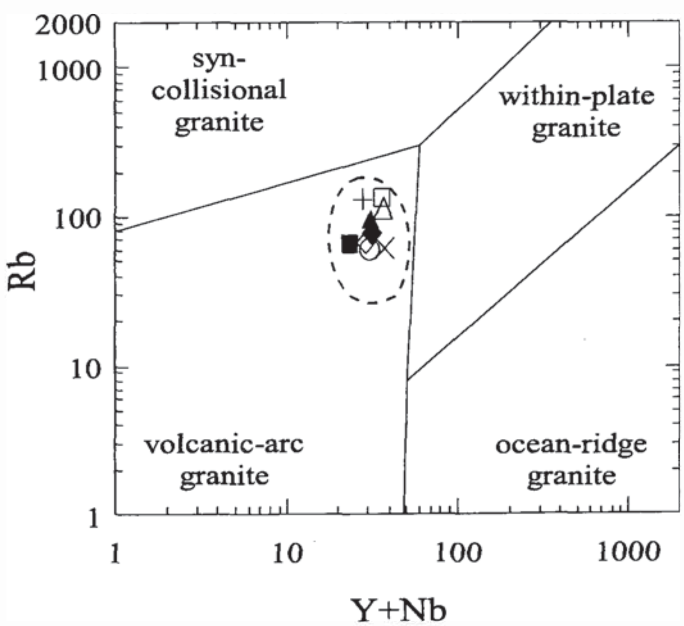


Fig. 7. Rb against Y+Nb, with fields from Pearce *et al.* (1984). Average analyses of units (with symbols as in Fig. 4) are shown; the dashed field encloses most of the samples.

differences, for example, in heavy REE patterns. However, most of the samples analyzed by Dostal *et al.* (1996) are basaltic. The REE pattern for their most felsic sample (P-17; 63.33% SiO_2) has a REE pattern very similar to that of the Indian Brook Granodiorite (Fig. 8b). The data, although admittedly limited, support the overall chemical similarity among volcanic and plutonic units in the area.

Table 3. Rare-earth element data[1] (in ppm) from the Indian Brook Granodiorite (IBG) and Birch Plain Granite (BPG).

SAMPLE	IBG-NW K9-A28	IBG-SE IBG-1	BPG K9-A18	BPG AM84-028
La	27.57	31.26	16.31	27.52
Ce	62.54	69.18	36.18	58.66
Nd	24.85	30.87	11.94	22.00
Sm	4.13	6.15	2.15	4.21
Eu	1.54	1.44	0.65	0.99
Tb	0.47	0.71	0.33	0.50
Yb	1.74	2.49	1.20	1.85
Lu	0.28	0.36	0.19	0.28

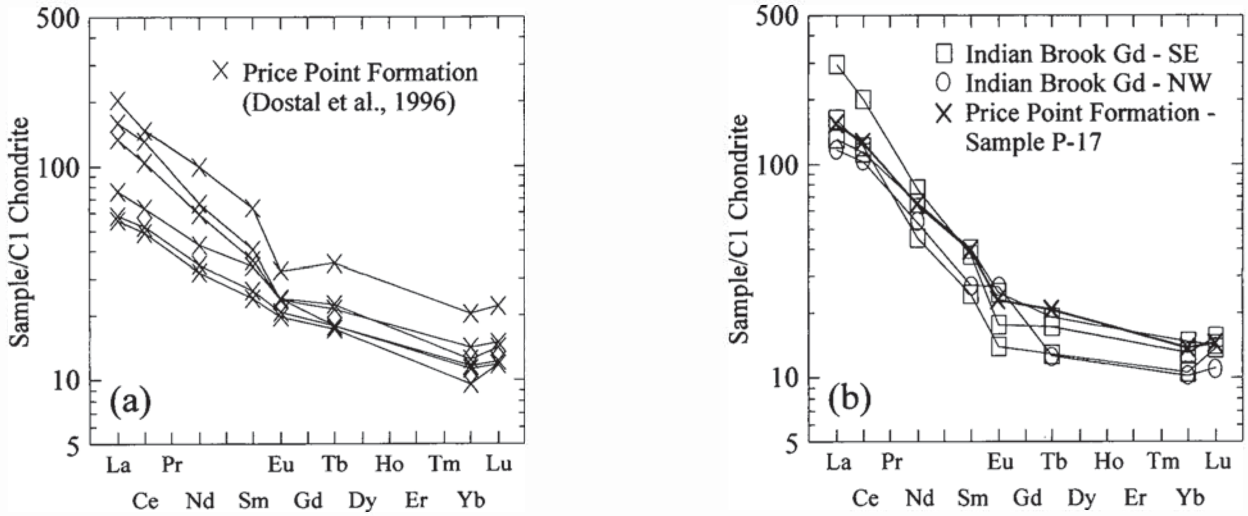
[1]Analyes by Instrumental Neutron Activation at St. Mary's University, Halifax, NS. Whole-rock analyses for samples are in Table 1. Unit abbreviations as in Figure 2.

Amphibole compositions in the Indian Brook Granodiorite

Farrow and Barr (1992) reported that amphibole in samples from the western part of the Indian Brook Granodiorite contains higher Al_2O_3 than amphibole in samples from the eastern part. They interpreted this difference to indicate that the western part represents deeper levels of crystallization, based on the hornblende geobarometer (Hammarstrom and Zen 1986; Hollister *et al.* 1987; Johnson and Rutherford 1989; Schmidt 1992). To further investigate this difference, additional analyses were done on amphibole in some of the samples studied by Farrow and Barr (1992), and analyses were also obtained of amphibole from two additional samples. Representative analyses from the 11 samples are presented in Table 4.

Most of the amphiboles are classified as magnesiohornblende (Fig. 9). Although compositions vary within each sample, hornblende in samples from both the northwestern and southwestern parts of the pluton tends to have lower Mg/Mg+Fe ratio and tetrahedral Si content compared to hornblende in samples from the northeastern and southeastern parts (Fig. 9), as well as higher Al content (Table 4). The differences in hornblende composition are reflected in colour differences in thin section. Hornblende in samples from the western part of the pluton is blue-green to pale yellow whereas in samples from the eastern part, the hornblende lacks blue-green colour and is pleochroic from green to yellow-green.

The Indian Brook Granodiorite contains the appropriate mineral assemblage (quartz + plagioclase + K-feldspar + hornblende + biotite + titanite + an oxide phase) for use of the Al-in-hornblende geobarometer. Although the use of this geobarometer has been controversial (e.g., Anderson 1997), the rationale for its use has also been well documented (e.g., Leake and Said 1994; Ague and Brandon 1997). The higher Al contents in hornblende in samples from the northwestern and



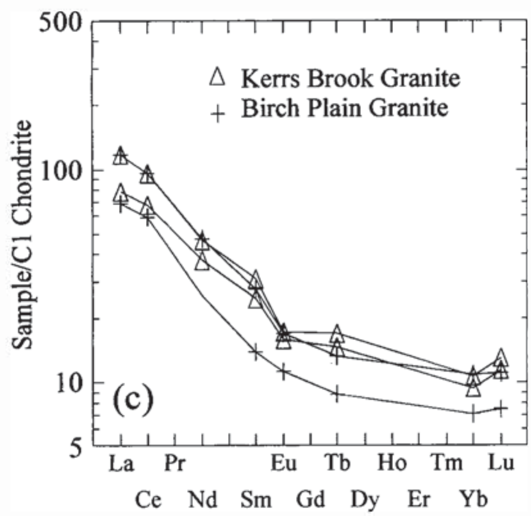


Fig. 8. Chondrite-normalized REE diagrams for (a) volcanic rocks of the Price Point Formation (data from Dostal *et al.* 1996), (b) samples from the Indian Brook Granodiorite, with sample P-17 (66.33% SiO_2) from the Price Point Formation shown for comparison (data from Dostal *et al.* 1996, and Table 3), and (c) samples from the Kerrs Brook Granite (data from Dostal *et al.* 1996) and Birch Plain Granite (data from Table 3). Chondrite-normalizing values are from Sun and McDonough (1989).

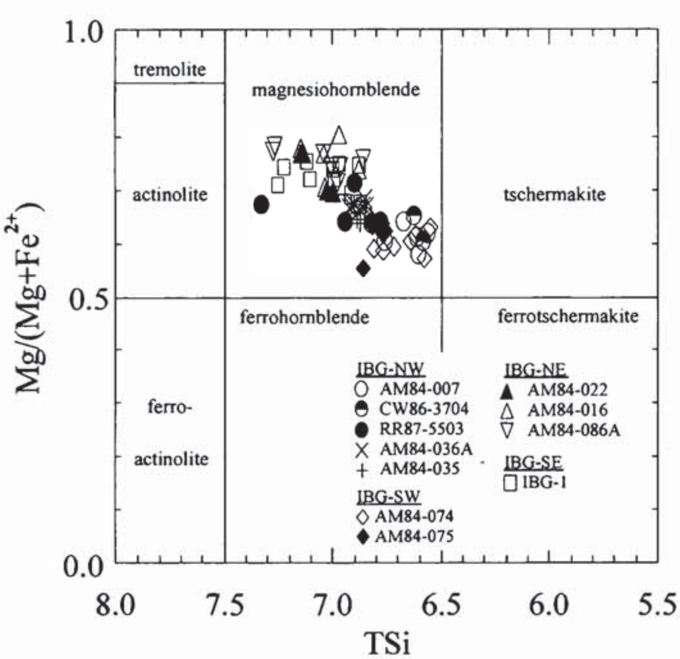


Fig. 9. Classification of calcic amphiboles with Na+K < 0.5 and Ti < 0.5, criteria which apply to most of the analyzed amphiboles in the Indian Brook Granodiorite. Classification diagram is after Leake *et al.* (1997).

southwestern areas suggest higher pressures of crystallization (Table 5). The calculated pressures are consistent with crystallization of the western part of the Indian Brook Granodiorite at mesozonal to catazonal depths, whereas the eastern part crystallized at epizonal depths. This variation in the level of emplacement is compatible with the variation in the metamorphic grade in the area, because the western margin of the Indian Brook Granodiorite contains abundant gneissic xenoliths from the Barachois River Metamorphic Suite, whereas the southeastern part is associated with low-grade metavolcanic rocks of Price Point Formation (Raeside and Barr 1990). The data are also consistent with compositional variations in the Indian Brook Granodiorite, which becomes more felsic toward the southeast.

CONCLUSIONS

The continental margin-volcanic arc setting for magmatism in the Indian Brook area is consistent with the abundance of Late Neoproterozoic arc-related plutons elsewhere in the Bras d'Or terrane (Raeside and Barr 1990; Farrow and Barr 1992; Justino and Barr 1994; Keppie *et al.* 1998). Units of similar age also occur in the Coastal belt of the Mira terrane (Barr *et al.* 1996), and Dostal *et al.* (1996) linked

Table 4. Representative amphibole analyses[1] from the Indian Brook Granodiorite

SAMPLE	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Total	TSi	TAl	CAl	CFe^3	CTi	CMg	CFe^2	CMn	BCa	BNa	ANa	AK
Indian Brook Granodiorite (northwestern part)																						
AM84-007	43.89	1.28	9.05	16.86	0.46	10.93	12.47	1.07	0.96	96.97	6.61	1.39	0.22	0.36	0.15	2.46	1.77	0.06	2.00	0.00	0.31	0.19
AM84-007	44.84	1.29	8.27	16.13	0.47	11.98	12.13	1.25	0.84	97.20	6.68	1.32	0.13	0.51	0.14	2.66	1.49	0.06	1.94	0.07	0.30	0.16
RR87-5503	47.24	0.98	7.54	15.12	0.62	12.32	12.34	0.88	0.45	97.49	6.95	1.05	0.25	0.36	0.11	2.70	1.50	0.08	1.94	0.06	0.20	0.08
RR87-5503	45.93	1.12	8.49	15.79	0.64	11.73	12.12	0.86	0.58	97.26	6.79	1.22	0.26	0.51	0.12	2.58	1.44	0.08	1.92	0.08	0.17	0.11
AM84-36A	46.39	1.14	7.51	14.98	0.65	12.45	11.96	1.05	0.71	96.84	6.87	1.13	0.19	0.45	0.13	2.75	1.40	0.08	1.90	0.10	0.20	0.13
AM84-36A	47.15	0.94	7.35	15.29	0.68	12.52	12.04	0.93	0.63	97.53	6.92	1.08	0.19	0.51	0.10	2.74	1.37	0.09	1.89	0.11	0.16	0.12
CW86-3704	46.08	1.38	7.44	15.90	0.47	12.21	12.22	0.98	0.83	97.52	6.82	1.18	0.12	0.43	0.15	2.70	1.54	0.06	1.94	0.06	0.22	0.16
CW86-3704	44.37	1.61	8.67	17.09	0.54	11.37	12.23	1.29	0.98	98.15	6.59	1.41	0.11	0.49	0.18	2.52	1.63	0.07	1.95	0.05	0.32	0.19
Indian Brook Granodiorite (southwestern part)																						
AM84-74	44.60	0.91	9.38	17.03	0.43	10.95	12.22	0.93	0.85	97.30	6.64	1.36	0.29	0.53	0.10	2.43	1.59	0.05	1.95	0.05	0.22	0.16
AM84-74	43.83	0.74	9.58	17.70	0.48	10.54	12.55	1.04	0.86	97.32	6.58	1.42	0.27	0.47	0.08	2.36	1.75	0.06	2.00	0.00	0.30	0.17
AM84-75	45.51	0.90	7.40	16.12	0.89	11.79	12.27	0.80	0.71	96.39	6.82	1.18	0.13	0.54	0.10	2.64	1.49	0.11	1.97	0.03	0.20	0.14
AM84-75	45.76	1.03	7.99	16.81	0.89	11.37	11.74	1.02	0.69	97.30	6.78	1.22	0.18	0.66	0.12	2.51	1.43	0.11	1.86	0.14	0.16	0.13
Indian Brook Granodiorite (northeastern part)																						
AM84-22	49.20	0.77	4.69	13.56	0.86	14.93	11.83	1.24	0.41	97.48	7.14	0.80	0.00	0.60	0.08	3.23	0.99	0.11	1.84	0.16	0.19	0.08
AM84-22	47.38	1.21	5.87	13.91	0.66	13.79	12.04	1.35	0.60	96.79	7.00	1.00	0.03	0.39	0.13	3.04	1.33	0.08	1.91	0.09	0.30	0.11
AM84-16	47.90	0.86	5.37	14.39	0.59	14.67	11.78	0.80	0.36	96.72	6.98	0.92	0.00	0.87	0.09	3.19	0.78	0.07	1.84	0.16	0.06	0.07
AM84-16	48.31	0.83	5.28	13.42	0.68	14.87	12.25	0.91	0.40	96.95	7.05	0.91	0.00	0.61	0.09	3.23	0.98	0.08	1.92	0.09	0.17	0.07
AM84-35	46.51	1.12	7.61	15.05	0.62	12.59	11.98	1.09	0.76	97.33	6.86	1.14	0.18	0.48	0.12	2.77	1.37	0.08	1.89	0.11	0.20	0.14
AM84-35	46.26	1.16	7.70	15.65	0.63	12.24	12.09	1.05	0.79	97.57	6.83	1.17	0.17	0.47	0.13	2.69	1.46	0.08	1.91	0.09	0.21	0.15
AM84-86A	47.75	1.02	6.71	13.98	0.61	13.63	12.00	0.97	0.58	97.25	6.98	1.02	0.13	0.52	0.11	2.97	1.19	0.08	1.88	0.12	0.15	0.11
AM84-86A	46.19	1.12	6.42	13.46	0.59	14.19	11.98	1.12	0.58	95.65	6.86	1.12	0.00	0.64	0.13	3.14	1.02	0.07	1.91	0.09	0.23	0.11
Indian Brook Granodiorite (southeastern part)																						
IBG-1	49.45	1.06	5.82	13.73	0.73	14.26	11.87	1.30	0.51	98.73	7.11	0.89	0.09	0.46	0.12	3.06	1.19	0.09	1.83	0.17	0.19	0.09
IBG-1	47.24	1.26	6.29	14.00	0.68	14.29	11.98	1.38	0.52	97.64	6.89	1.08	0.00	0.61	0.14	3.11	1.06	0.08	1.87	0.13	0.26	0.10

[1] Analyses by electron microprobe at Dalhousie University, Halifax, Nova Scotia. Recalculations were done on the basis of 23 oxygen and total cations = 13, excluding Ca, Na, and K, using the computer program MINPET. T, C, B, and A refer to the tetrahedal and C, B, and A cation sites in the standard amphibole formula. Fe^2 and Fe^3 refer to ferrous and ferric iron, respectively. Sample locations are shown on Figure 1.

Table 5. Average amphibole data in samples from the Indian Brook Granodiorite*.

	n[1]	Alt[2]	TSi[3]	P[4] (kbar)
Northwest				
AM-84-7	5	1.52	6.57	4.22
CW-3704	3	1.43	6.68	3.80
RR-5503	4	1.24	6.99	2.89
AM-84-36A	7	1.29	6.88	3.13
AM-84-35	7	1.30	6.88	3.18
Southwest				
AM-84-74	7	1.60	6.67	4.61
AM-84-75	4	1.39	6.81	3.61
Northeast				
AM-84-22	4	1.17	6.92	2.56
AM-84-16	6	0.96	7.04	1.56
AM-84-86A	7	1.01	7.06	1.80
Southeast				
IBG-1	11	1.05	6.98	1.99

[*] grouped by area as described in the text.
[1] number of analyses used in the calculation.
[2] average total aluminum content
[3] average total silicon content
[4] pressure calculated using formula of Schmidt (1992)

these rocks in the same subduction zone. One problem with this interpretation is that the Coastal belt is separated from the Bras d'Or terrane by older belts of volcanic and plutonic rocks (Stirling, East Bay Hills, and Coxheath Hills belts), which do not show evidence for thermal or tectonic overprinting by ca. 575 - 555 Ma subduction (Barr *et al.* 1990). Furthermore, isotopic data suggest that the Mira terrane does not have the same type of crust as that under the Bras d'Or terrane (Ayuso *et al.* 1997; Barr *et al.* 1998). Hence, we suggest that linking the volcanic and plutonic rocks of the Indian Brook area (and other parts of the Bras d'Or terrane) with compositionally different volcanic and plutonic rocks of the Coastal belt in the Mira terrane on the basis of similar age is not a viable model.

No evidence has been documented to separate the units of this study from those to the northwest by a major structural break, as proposed by Lynch and Lafrance (1996) and Lynch (1996). The previous interpretation (Farrow and Barr 1992) that progressively higher crustal levels are exposed from northwest to southeast across the southeastern Cape Breton Highlands is supported by the present study but the change appears gradual across the Indian Brook Granodiorite, and does not take place at an inferred major thrust along its western margin. The presence of xenoliths of diorite, tonalite, and gneiss in the western part of the Indian Brook Granodiorite further suggests that the contacts with adjacent units to the northwest are intrusive. However, the western margin of the Indian Brook Granodiorite is difficult to access and not yet well mapped, and the nature of the Barachois River Metamorphic Suite is not yet known. This area should clearly be the target of future study.

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