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PLATINUM-GROUP ELEMENTS IN THE ARCHEAN FLORENCE LAKE GROUP, CENTRAL LABRADOR

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ABSTRACT

Elevated concentrations of the platinum-group elements (*PGE*) are associated with Fe–Ni–Cu sulfides at the Baikie showing within the Archean Florence Lake Group, in central Labrador. The mineralization consists of disseminated and locally massive pentlandite, pyrrhotite, pyrite, minor chalcopyrite and magnetite within a small (4 × 6 m) metaultramafic raft in trondhjemite. A xenolith (0.5 m in diameter) of actinolite schist on the northeastern side of the same outcrop contains pentlandite, pyrite and minor chalcopyrite, but no pyrrhotite or magnetite. The chondrite-normalized *PGE* patterns of the sulfide phases are relatively flat, with pronounced negative Pt and Au anomalies, and are somewhat similar to those of Archean komatiite-related deposits. The economic potential of the Baikie showing is limited because the mineralization is contained within xenoliths; however, a continuous belt of ultramafic rocks south of Florence Lake may represent a favorable exploration target for *PGE* deposits. Several rock samples from this belt also were analyzed for *PGE* and Au, and generally have very low concentrations. However, two samples contain slightly elevated Pt and Pd concentrations, which may be related to above-background Cu concentrates.

Keywords: platinum-group elements, sulfides, ultramafic rocks, Archean greenstone, Nain Province, Labrador.

SOMMAIRE

Des concentrations élevées des éléments du groupe du platine (*EGP*) ont été découvertes dans une association de sulfures de Fe–Ni–Cu de l'indice de Baikie, dans le Groupe de Florence Lake, d'âge archéen, dans la partie centrale du Labrador. La minéralisation contient, en disséminations et en accumulations localement massives, pentlandite, pyrrhotite et pyrite, ainsi que chalcopyrite et magnétite accessoires dans une petite (4 × 6 m) enclave métaultramafique dans une trondhjémite. Un xénolithe de 0.5 m de diamètre de schiste à actinote au nord-est du même affleurement contient pentlandite, pyrite et chalcopyrite accessoire; pyrrhotite et magnétite y sont absentes. Les teneurs en *EGP* des sulfures, normalisés par rapport à une chondrite, montrent un profil relativement plat et une forte anomalie négative en Pt et Au, et ressemblent ainsi aux profils des zones minéralisées liées aux komatiites archéennes. Le potentiel économique de l'indice de Baikie est limité, parce que la minéralisation se trouve uniquement dans les xénolithes. Par contre, la ceinture continue de roches ultramafiques au sud du lac Florence pourrait très bien être une cible favorable pour une minéralisation plus importante. Plusieurs échantillons de cette ceinture possèdent des teneurs très faibles en *EGP*, mais deux échantillons marquent un faible enrichissement en Pt et Pd, qui pourrait bien être lié à des concentrations anomales de Cu.

(Traduit par la Rédaction)

Mots-clés: éléments du groupe du platine, sulfures, roches ultramafiques, roches vertes archéennes, province de Nain, Labrador.

INTRODUCTION

This paper contains a preliminary description of rocks enriched in the platinum-group elements (*PGE*) recently discovered in the Florence Lake Group of central Labrador (Reusch 1987), and as such constitutes the first such report from Labrador. The Florence Lake Group (Ermanovics & Raudsepp 1979a) forms a 65-km-long northeast-trending greenstone belt (Fig. 1) within the southernmost portion of the Archean Nain Province, Labrador (Taylor 1971). It consists (Brace & Wilton 1989) dominantly of dark to medium green mafic flows and pillow lavas, and minor synvolcanic sills. White, pale pink and green siliceous metasedimentary and metavolcanic rocks are less extensive. Strongly serpentinized peridotites, which have undergone various degrees of talc--carbonate alteration, form elongate, regionally concordant intrusive bodies within the Florence Lake Group (Fig. 1).

The Florence Lake Group is enveloped and intruded by the Archean Kanairiktok Intrusive Suite (Ermanovics & Raudsepp 1979a), which consists of white and pink, massive to gneissic trondhjemite–tonalite. Both units are folded and have undergone metamorphism in the middle greenschist facies (Ermanovics & Raudsepp 1979a).

To the southeast and east, trondhjemites of the Kanairiktok Intrusive Suite are unconformably overlain by Proterozoic Aphebian volcanosedimentary rocks of the Moran Lake Group (Ryan 1984, Wilton *et al.* 1988), which forms the foreland zone of the Makkovik Province (Wardle *et al.* 1986).

EXPLORATION HISTORY

Following an airborne magnetometer and electromagnetic survey over the Florence Lake 'green-

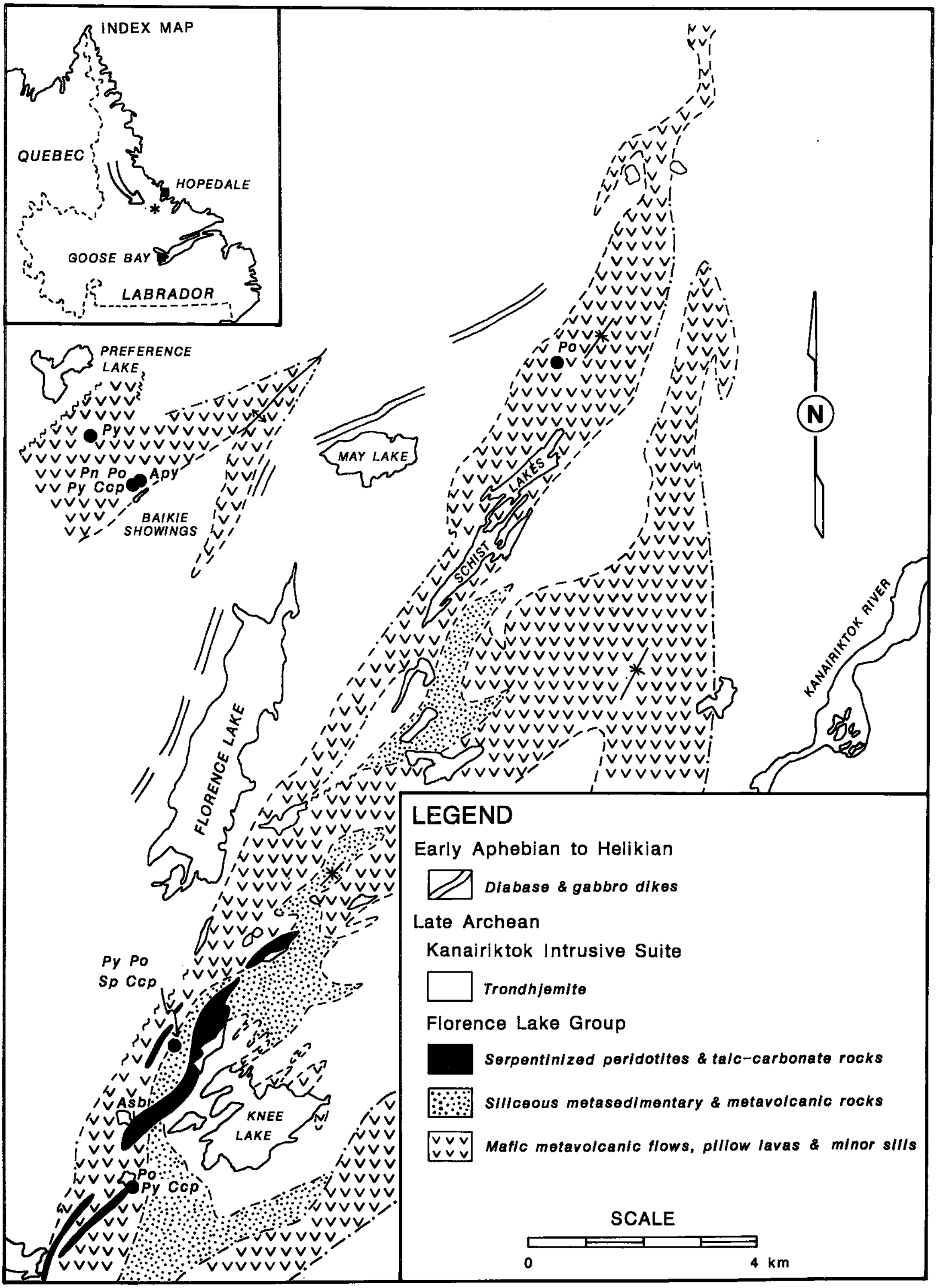

FIG. 1. Generalized geological map of the southernmost portion of the Florence Lake Group, central Labrador (modified after Ermanovics & Raudsepp 1979b). Mineral occurrence abbreviations are: pyrite (Py), pyrrhotite (Po), pentlandite (Pn), chalcopyrite (Ccp), arsenopyrite (Apy), sphalerite (Sp), asbestos (Asb).

stone belt' (Wilson 1959), British Newfoundland Exploration Limited (BRINEX), in joint venture with Asbestos Corporation, carried out an extensive program of exploration throughout the area (*e.g.*, Piloski 1962). Numerous thin pyritic horizons generally less than 1 meter thick were discovered within the metavolcanic rocks, but these commonly contain negligible base-metal or gold concentrations. Several small asbestos occurrences also were discovered within the ultramafic rocks south of Florence Lake.

The Baikie showing was discovered in 1960 by BRINEX personnel; however, it was not detected on the airborne survey, and the mineralization showed only moderate to weak magnetic contrast on the ground (Piloski 1962). Subsequent work involved stripping and sampling, and the drilling of six packsack diamond drill-holes totalling 42 m. The area surrounding the showings was mapped in detail, and a ground magnetometer survey was conducted (Piloski 1962). Sutton (1970) remapped the area northwest of Florence Lake at a scale of 1:24000, primarily to determine the relationship of the granite–greenstone contact in the context of the Baikie showings.

In 1982–1983, BP Minerals and Billiton Canada Ltd. carried out a joint venture exploration program, including an airborne magnetic–VLF–EM survey by Geophysical Surveys Inc. and geological investigations to determine the potential for base-metal and gold deposits within the Florence Lake Group. Stewart (1983) found a paucity of felsic volcanic rocks within the area, and a lack of spatial association between geophysical anomalies and felsic volcanic rocks. Guthrie (1983) and Stewart (1983) also described zones of intense carbonatization associated with major strike-parallel faults, with near-complete replacement of ultramafic rocks and adjacent lithologies. Stewart (1983) reported negligible sulfide mineralization and gold associated with either the carbonatized rocks or the thin pyritic horizons.

In 1986, the *PGE* potential of the Baikie showing was assessed by Platinum Exploration Canada Ltd., and analysis of grab samples revealed anomalous *PGE* concentrations of up to 497 ppb Pt and 1020 ppb Pd (Reusch 1987). Detailed chip sampling across the occurrence (Wilton 1987) showed as much as 120 ppb Pt over 0.6 m and 269 ppb Pd over 2 m (one grab sample contained 284 ppb Pd). The potential for *PGE* deposits in Labrador has been reviewed by Wardle (1987)

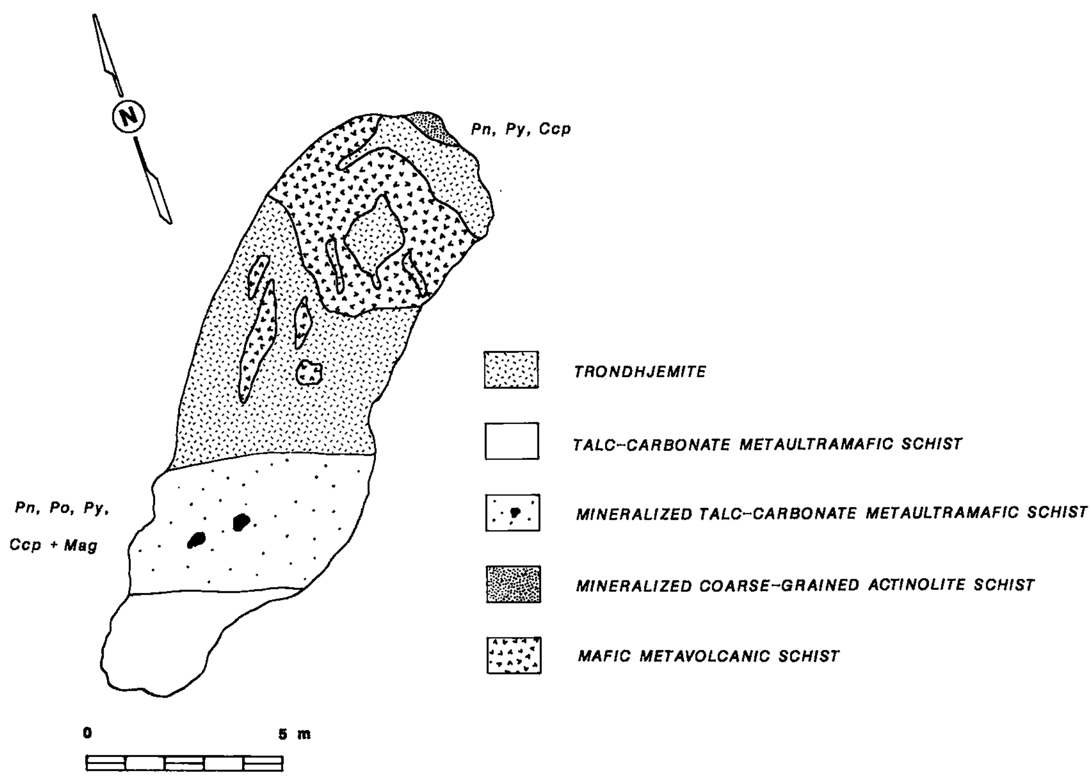

FIG. 2. Plan view of the Main Baikie showing, which consists of massive disseminated and locally nickeliferous sulfide patches within a talc–carbonate metaultramafic xenolith in trondhjemite of the Kanairiktok Intrusive Suite.

MINERALIZATION

The Baikie showing is located approximately 2.8 km northwest of Florence Lake (Fig. 1) along a northeast-trending linear defined by a low-lying boggy area where the showings are located, and a small northeast-trending rise (2–3 m in relief) to the east. Sutton (1970) described the Baikie showing as occurring within a 500-m-wide contact zone of mixing between greenstone and granodiorite gneiss, and noted that the rocks are intensely modified by post-intrusion, synfoliation deformation and shearing. Sutton (1970) also suggested that this zone marks the site of an 'early' tectonic granite–greenstone contact, and that similar contacts elsewhere may warrant detailed geological mapping. However, recent investigations indicate that the contact is intrusive in nature, with numerous mafic metavolcanic and minor metaultramafic xenoliths within the trondhjemite (Brace & Wilton 1989). In the vicinity of the Baikie showings, the trondhjemite is relatively massive, and small angular xenoliths are so numerous in places, that the trondhjemite is more properly termed an agmatite. A series of outcrops extending to approximately 25 m south of the Main Baikie showing provide evidence of remobilization and several periods of intrusion of the trondhjemite. A number of different phases, each with variable proportions of mafic minerals, are present. One small outcrop contains a xenolith of garnet (almandine) amphibolite.

The Fe–Ni–Cu sulfide mineralization at the Main Baikie showing is contained within a 4 x 6 m metaultramafic xenolith in the Kanairiktok Intrusive Suite trondhjemite (Fig. 2). The ultramafic rock has been completely replaced by an assemblage of talc + carbonate (ferroan magnesite: 39.91 wt.% MgO, 7.67% FeO, 0.20% CaO, 0.47% MnO) + chlorite. Opaque oxides consist of relict chromite cores rimmed by magnetite, and discrete anhedral magne-

TABLE 1. Ni, Cu, S, PGE AND Au CONCENTRATIONS IN SAMPLES

Sample #	Ni (ppm)	Cu (ppm)	S (ppm)	Pt (ppb)	Pd (ppb)	Rh (ppb)	Ru (ppb)	Ir (ppb)	Os (ppb)	Au (ppb)	Cu/(Cu+Ni)	Pt/(Pt+Pd)	(Pt+Pd)/(Ru+Ir+Os)
MINERALIZED SAMPLES, BAIKIE SHOWING													
MBS-MS	140634	314	365548	36.3	1208.5	110.7	315.5	126.8	64.1	28.7	0.002	0.029	2.458
				*37.4	*1244.8	*114	*324.9	*130.6	*66.0	*29.6			
MBS-DS	11359	356	34684	24.6	181.2	15.3	61.4	24.8	19.5	6.6	0.030	0.120	1.947
				*270.6	*1992.8	*168.1	*675.0	*273.1	*214.4	*72.7			
TB-87-276	8408	374	32367	93.0	180.1	40.8	151.1	53.2	59.8	3.6	0.043	0.341	1.034
				*1328.0	*2571.8	*582.6	*2157.7	*759.7	*853.9	*51.4			
UNMINERALIZED METAULTRAMAFIC ROCKS AT AND NEAR BAIKIE SHOWING													
MBS-CTUM	2020	26	2507	5.1	11.8	1.2	5.0	2.3	2.1	0.9	0.013	0.301	1.802
TB-87-256D	2027	nd	415	8.8	11.0	1.8	8.5	2.9	4.1	167.9		0.444	1.274
TB-87-277	2052	nd	566	2.3	3.0	0.6	4.9	4.2	4.1	2.9		0.438	0.405
ULTRAMAFIC ROCKS FROM SOUTH OF FLORENCE LAKE WITH SLIGHTLY ELEVATED Pt AND Pd													
TB-87-135	866	63	581	26.9	55.8	2.7	4.5	0.7	0.4	4.0	0.068	0.326	14.960
TB-87-157A	919	63	240	7.0	10.4	0.9	3.8	1.3	1.2	1.7	0.064	0.402	2.748
'TYPICAL' ULTRAMAFIC ROCKS FROM SOUTH OF FLORENCE LAKE													
TB-87-180C	3311	nd	295	1.0	2.0	0.3	2.5	3.4	2.1	2.0		0.338	0.385
TB-87-181	2649	nd	737	0.8	1.1	0.2	3.4	2.2	2.7	0.7		0.444	0.226
TB-87-184A	2148	nd	637	1.6	1.7	0.5	4.6	0.9	0.4	4.8		0.497	0.557
TB-87-185A	2276	nd	279	0.6	0.6	0.3	4.2	1.8	2.1	1.9		0.496	0.153
TB-87-185B	2397	nd	159	0.8	1.0	0.4	5.2	2.4	2.9	2.0		0.451	0.174
TB-87-185C	2767	nd	321	0.6	0.6	0.3	4.6	2.0	2.4	0.6		0.491	0.126
TB-87-271	1934	nd	451	1.5	1.5	0.5	6.8	1.0	1.4	1.9		0.510	0.332
BASE-METALS IN METASEDIMENTARY/METAVOLCANIC ROCKS													
TB-87-021	1035	611	84966	2.7	5.8	0.2	2.5	0.3	0.4	89.9	0.371	0.315	2.684
TB-87-123A	140	1580	42459	0.6	1.5	nd	13.6	0.1	nd	11.7	0.919	0.282	0.148
TB-87-270	34	22	31490	0.2	0.4	0.1	5.4	nd	nd	8.6	0.393	0.267	0.111
MEAN MEASURED DETECTION LIMITS													
				0.20	0.34	0.10	0.17	0.05	0.52	1.92			

* PGE concentrations recalculated to values expected in 100% sulfide.

nd = not detected

tite grains up to 0.5 mm in diameter. No primary igneous textures have been observed.

Pentlandite, pyrrhotite, pyrite and minor chalcopyrite are disseminated and locally form massive sulfide patches (with magnetite) up to 50 cm in diameter. The massive sulfides consist of pyrrhotite- and pentlandite-rich segregations with intergrown pyrite and minor chalcopyrite. Pentlandite occurs as irregular blocky segregations with a pronounced octahedral cleavage, and pyrrhotite, as anhedral granular segregations. Pyrite, in places, forms bands within the pyrrhotite and pentlandite. Some of the massive sulfides show a green stain, characteristic of nickel. Disseminated sulfides occur as individual grains less than 0.1 mm and sulfide intergrowths up to 2 mm in diameter. A limited amount of SEM examination has not revealed any platinum-group minerals in the sulfide aggregates; they appear to be in solid solution within the sulfides.

A small xenolith (0.5 m in diameter) of actinolite schist, approximately 3 m from the talc–carbonate xenolith, also contains Fe–Ni–Cu sulfides and minor chromite, but in contrast to the main showing, it does not contain pyrrhotite or magnetite (Fig. 2). Pyrite is by far the most abundant phase, and occurs as intergrowths with pentlandite and as segregations along grain boundaries between actinolite crystals. Minor chalcopyrite is invariably intergrown with pyrite.

An arsenopyrite showing occurs approximately 125 m northeast of the Main Baikie showing along the same linear. Euhedral prismatic arsenopyrite crystals up to 4–5 mm in length occur throughout a very fine-grained carbonatized quartz–sericite schist. Late-stage clear quartz and calcite veins crosscut the lithology but do not control the mineralization. Some arsenopyrite crystals contain small (<0.1 mm) inclusions of chalcopyrite. Pyrite locally forms small crystals up to 0.5 mm in diameter that also contain small inclusions of chalcopyrite. Pyrite is found, as well, along fractures within the arsenopyrite crystals.

No significant sulfide mineralization has been observed within the ultramafic rocks south of Florence Lake (Fig. 1). Trace amounts of pentlandite, pyrrhotite and millerite, however, have been observed in several samples on a microscopic scale. These are minute (<0.15 mm) monomineralic grains, and are possibly of metamorphic origin.

A pyrite–pyrrhotite–sphalerite–chalcopyrite occurrence (TB–87–021; Appendix 1) located approximately 2.75 km south of Florence Lake is contained within a fine-grained siliceous metasedimentary or metavolcanic (?) rock with quartz fragments up to 3–4 mm in diameter. Pyrite is by far the most abundant sulfide and forms segregations up to 5 mm in diameter. Pyrrhotite and pyrite are locally intergrown, and each mineral has been seen to rim the other. Minor sphalerite occurs as disseminations and is concentrated along fractures with chalcopyrite, which also is finely disseminated.

A pyrrhotite–pyrite–chalcopyrite showing (TB–87–123A) located 5.5 km south of Florence Lake is contained within a fine-grained quartz–sericite schist. The mineralization is both disseminated and concentrated along small fractures. Locally, massive sulfide consists of 'early' pyrrhotite rimmed and replaced by pyrite, and overprinted by 'later' pyrite cubes intergrown with chalcopyrite. Numerous fragments up to 7 mm in diameter consisting of quartz,

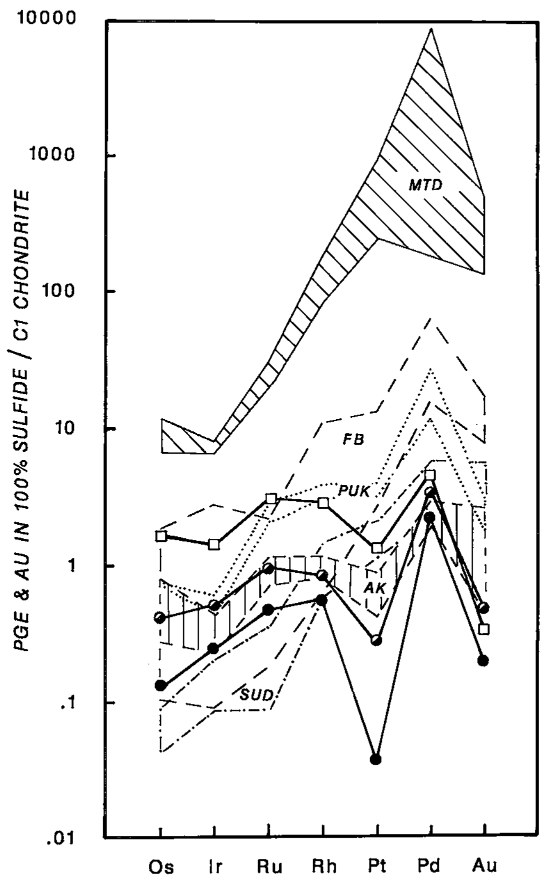

FIG. 3. Chondrite-normalized plots of *PGE* and Au for samples from the Baikie showing. MBS–MS is massive sulfide (solid circle), MBS–DS is disseminated sulfide (half-filled circle); and TB–87–276 is the mineralized actinolite schist (open square). Chondrite-normalized patterns for several types of magmatic sulfide deposits (Naldrett & Duke 1980, Naldrett 1981) are plotted for comparison. Fields are Merensky-type deposits (MTD), flood-basalt-related deposits (FB), Sudbury deposits (SUD), Proterozoic Ungava komatiite-related deposits (PUK) and Archean komatiite-related deposits (AK).

chlorite, and the host lithology are contained within the massive sulfide.

Analytical Techniques

Samples were analyzed for *PGE* and Au using inductively coupled plasma – mass spectrometry (ICP–MS), and sulfur and base-metal contents were determined by X-ray-fluorescence spectrometry (XRF), at the Department of Earth Sciences, Memorial University of Newfoundland.

The procedure used for collecting the *PGE* and Au combines the standard NiS fire-assay technique (Robert *et al.* 1971) accompanied by Te precipitation (Fryer & Kerrich 1978), which significantly improves recovery of the *PGE* and Au. A NiS button is prepared by fusing 15.0 g of powdered rock with a mixture of Ni, S, sodium carbonate, borax and silica. The button is then dissolved in concentrated HCl, and a Te solution is added to form a precipitate that collects the *PGE* and Au. Concentrated HNO_3 is then added, which dissolves the precipitate, and the solution is analyzed by ICP–MS using two internal standards to correct for instrument drift and matrix effects; Cd for the light metals (Ru, Rh and Pd), and Tl for the heavy metals (Os, Ir, Pt and Au) (Jackson *et al.* 1990). Minor modifications to the standard preparation procedure are required for samples containing significant concentrations of one or more of chromite, Ni, S, Cu, or Zn. The measured instrumental detection limits for the four production runs containing samples of this study ranged from 0.12–0.27 ppb (Ru), 0.02–0.28 ppb (Rh), 0.21–0.59 ppb (Pd), 0.05–0.11 ppb (Re), 0.31–0.83 ppb (Os), 0.04–0.07 ppb (Ir), 0.12–0.27 ppb (Pt) and 0.26–5.68 ppb (Au).

Jackson *et al.* (1990) have determined that measured concentrations on reference standard SARM–7 are lower than certified values, ranging from 4% (Ir) to 12% (Rh), with poorer recovery for Os (15%) and Au (18%). They also report relative standard deviations for Ru (2.1% for 407 ppb), Rh (1.9% for 218 ppb), Pd (1.3% for 1382 ppb), Os (11.4% for 30 ppb), Ir (1.6% for 75 ppb), Pt (2.0% for 3782 ppb), and Au (1.9% for 238 ppb).

PGE and Au concentrations in mineralized samples were recalculated to values expected in 100% sulfide and normalized to average C1-chondrite (values from Naldrett & Duke 1980). The recalculation procedure used here follows that of Wilson (1988), where the modal proportion of pyrrhotite to pyrite in the massive (MBS–MS) and disseminated (MBS–DS) sulfide samples at the Baikie showing was estimated to be 9:1 from examination of polished thin sections. The mineralized actinolite schist sample contains pyrite, but no pyrrhotite. All other samples contain negligible sulfide contents; hence only whole-rock *PGE* concentrations are presented.

Results

Baikie showing

In evaluating the whole-rock *PGE* data, the mas-

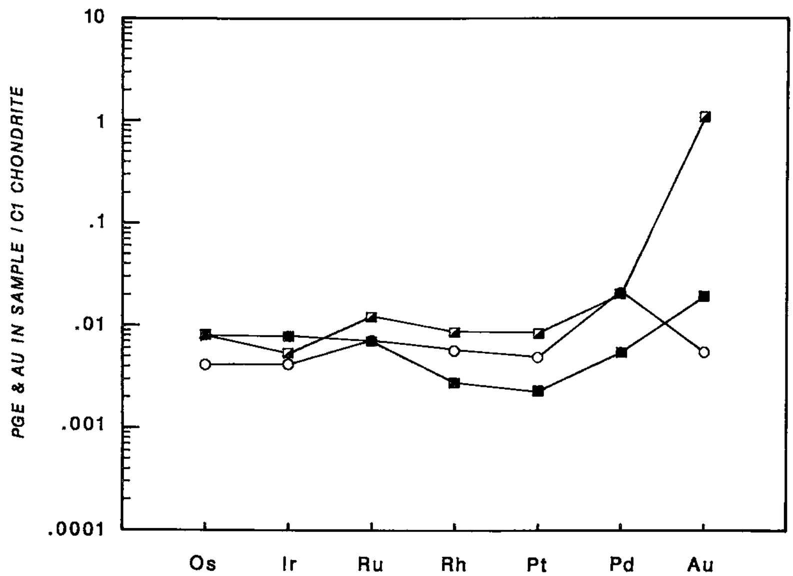

FIG. 4. Chondrite-normalized *PGE* and Au patterns for unmineralized ultramafic rocks near the Baikie showing: MBS–CTUM, the unmineralized host rock at the main showing (open circle), TB–87–256D (half-filled square), and TB–87–277 (solid square).

sive sulfide (MBS–MS) contains the highest concentrations of total *PGE* (Table 1). The actinolite schist (TB-87-276), however, has the highest concentration of Pt (93 ppb), whereas the massive sulfide has only slightly higher Pt (36 ppb) relative to the disseminated sulfide (MBS–DS) (25 ppb). The Pd concentration in the massive sulfide (1209 ppb) is considerably higher than for the other two samples, which are essentially identical (181 ppb in the disseminated sulfide and 180 ppb in the actinolite schist).

The chondrite-normalized *PGE* patterns for 100%

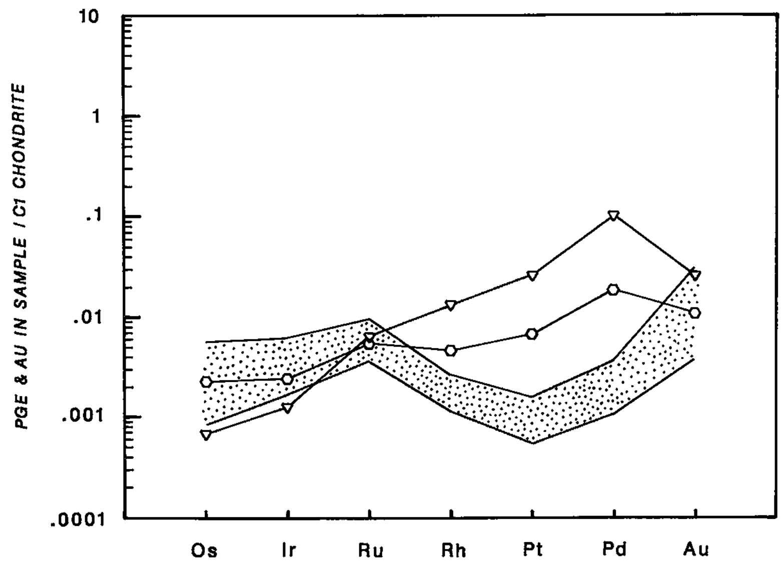

FIG. 5. Chondrite-normalized *PGE* and Au patterns for 'typical' unmineralized ultramafic rocks south of Florence Lake (field), and two samples with slightly elevated Rh, Pt and Pd, TB-87-135 (upside down triangle) and TB-87-157A (hexagon).

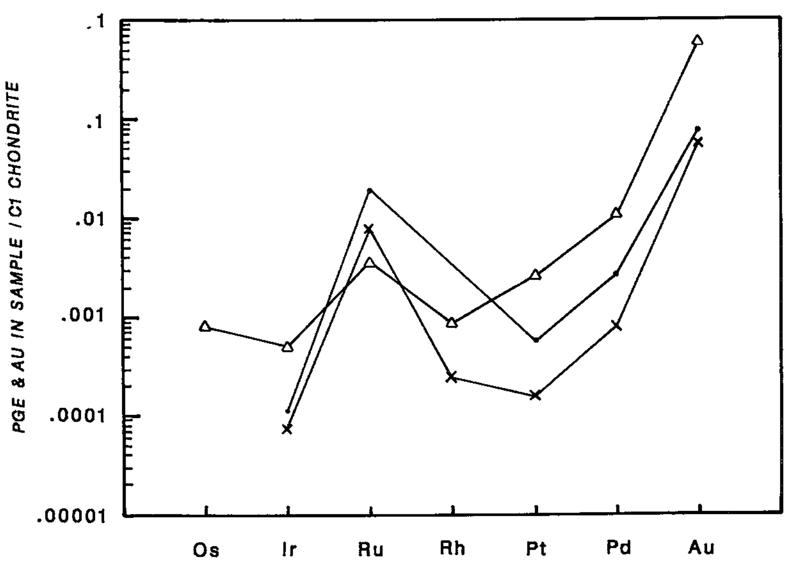

FIG. 6. Chondrite-normalized *PGE* and Au patterns for two samples containing base-metal sulfides, TB-87-021 (triangle) and TB-87-123A (dot) and TB-87-270 (x) from a pyrite horizon within siliceous metasedimentary rocks of the Florence Lake Group.

sulfide from the Baikie showing are plotted and compared with those of several types of magmatic sulfide deposits (Naldrett & Duke 1980, Naldrett 1981) in Figure 3. The low (Pt + Pd)/(Ru + Ir + Os) values of the Balkie samples (Table 1) are reflected in the relatively flat *PGE* patterns, which are most similar to those of Archean komatite-related deposits. The profiles maintain an overall gentle positive slope from Os to Pd, but with pronounced negative Pt and Au anomalies (Fig. 3). The *PGE* and Au concentrations range between 0.1 and 5 times C1-chondrite, except for Pt in the massive sulfide, which shows an extreme depletion. More fractionated *PGE* patterns with steeper positive slopes are commonly typical of deposits related to gabbroic magmas (Naldrett 1981).

Examination of Ni and Cu contents in Table 1 reveals that the samples have very low concentrations of Cu. The massive sulfide contains approximately the same amount of Cu, yet much more Ni than the disseminated sulfide. The actinolite schist has the highest Cu and lowest Ni contents of the mineralized Baikie samples.

Unmineralized ultramafic rocks at and near the Baikie showing

Data for unmineralized ultramafic rocks in the vicinity of the Baikie showing are plotted in Figure 4. MBS–CTUM, a sample of the talc-carbonate-chlorite schist xenolith hosting the Baikie showing, contains only trace amounts of sulfide. TB–87–256D is a grab sample of talc-carbonate schist from the North Baikie showing, located approximately 60 m northeast of the Main Baikie showing, and TB–87–277 is a serpentinized ultramafic rock with minor talc–carbonate alteration that contains trace sulfides, located 90 m southwest of the Main Baikie showing. The *PGE* concentrations are low, and the profiles, quite flat. Sample MBS–CTUM shows a depletion in Au relative to Pd, in contrast to the other unmineralized ultramafic rocks, and sample TB–87–256D shows an elevated Au content (168 ppb). A 1.5-m-long chip sample across the same outcrop, however, has returned < 2 ppb Au (Wilton 1987).

Utramafic rocks south of Florence Lake

The *PGE* and Au concentrations of ultramafic rocks south of Florence Lake are shown in Figure 5. The concentrations of the 'typical' ultramafic rocks are quite low, with (Pt + Pd)/(Ru + Ir + Os) values < 1. These flat *PGE* patterns may reflect the presence of cumulate olivine and chromite in the peridotites.

Two samples (TB–87–135, –157A) show slightly elevated Rh, Pt, and Pd relative to the typical ultramafic rocks, and have a slight Au depletion relative to Pd, which is characteristic of the mineralized samples at the Baikie showing. Sample TB–87–135 is the only ultramafic rock collected south of Florence Lake that contains a primary igneous phase, that being clinopyroxene. This sample also contains trace (<< 1%) amounts of pentlandite. The very low con-

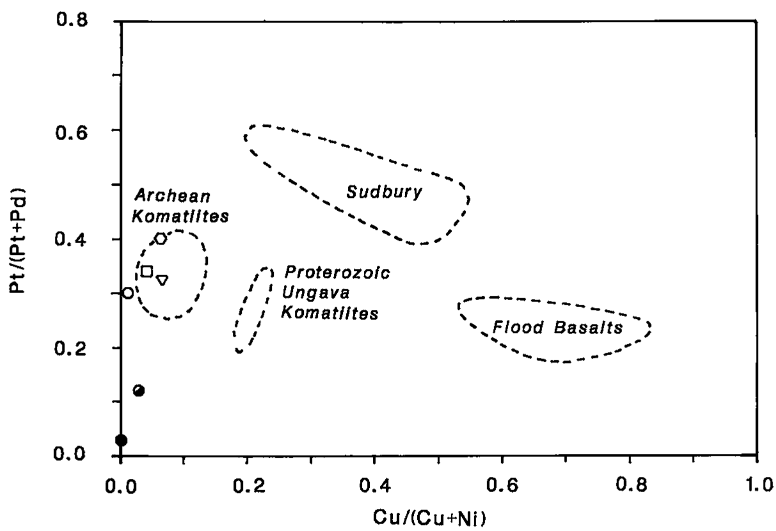

FIG. 7. Pt/(Pt+Pd) *versus* Cu/(Cu+Ni) diagram for Baikie showing samples (MBS–MS, –DS, TB–87–276), the unmineralized host ultramafic rock (MBS–CTUM) and two samples from ultramafic rocks south of Florence Lake (TB–87–135, –157A). Symbols as for Figures 3, 4 and 6. The fields are from Naldrett (1981).

centrations of Os and Ir, and elevated Rh, Pt and Pd contents, result in a relatively high (Pt + Pd)/(Ru + Ir + Os) value (14.96). Sample TB–87–157A is a sheared carbonate–chlorite schist with secondary euhedral chromite and magnetite, and traces (<< 1%) of sulfides, and has slightly elevated Pt, Pd and Rh relative to the typical unmineralized ultramafic rocks. Only these two samples contain detectable Cu concentrations among the ultramafic rocks analyzed from south of Florence Lake (Table 1). As this may indicate a positive correlation between elevated Pt and Pd concentrations and trace sulfides, Cu is potentially a useful pathfinder trace element in the exploration for *PGE* deposits within these ultramafic rocks. Ni has limited potential because of the naturally high and variable background concentrations in ultramafic rocks.

Base metals in metasedimentary/metavolcanic rocks

PGE and Au concentrations in fine-grained siliceous metasedimentary and metavolcanic rocks containing pyrite and base-metal sulfides are presented in Figure 6. The concentrations are extremely low, and only sample TB–87–021 from a pyrite-pyrrhotite-sphalerite-chalcopyrite occurrence (Fig. 1) has an elevated Au content (94 ppb).

DISCUSSION

The ultramafic rocks located south of Florence Lake are interpreted to be intrusive into metavolcanic and metasedimentary rocks of the Florence Lake Group (Ermanovics & Raudsepp 1979a), and they consist dominantly of serpentinized peridotites, commonly with a relict cumulate texture. However, the ultramafic rocks northwest of Florence Lake, in the vicinity of the Baikie showing, are totally replaced, and primary textures are not preserved. Furthermore, the rocks are present only as xenoliths, so that original stratigraphic and structural relationships with other supracrustal rocks are unknown. Hence, it is impossible to determine if these rocks are intrusive or extrusive.

The chondrite-normalized *PGE* and Au patterns of Baikie sulfides are relatively flat, and are similar to Archean komatiite-related deposits. The similarity of the Baikie mineralization to komatiite-type occurrences is further supported by Figure 7 (Naldrett 1981), wherein the talc–carbonate host rock and the mineralized actinolite schist plot in the Archean komatiite field. The massive and disseminated sulfide samples from the Baikie mineralization, however, plot well below the komatiite field, owing to their much lower Pt/Pd values. These samples may have suffered Pt loss, as indicated in the large negative Pt anomalies on the chondrite-normalized plot (Fig. 3). The Cu/(Cu + Ni) values also are generally komatiitic, although the massive sulfide has anomalously low Cu and may also have suffered Cu loss. The two ultramafic samples with detectable Cu concentrations from south of Florence Lake are similarly classified as having an Archean 'komatiitic' affinity (Fig. 7).

Evidence for hydrothermal mobilization of the *PGE* would be fractionation of Pd and Pt from Os, Ir, Ru and Rh (McCallum *et al.* 1976, Rowell & Edgar 1986). The unfractionated chondrite-normalized *PGE* patterns and the similar Pd concentrations among the samples (Fig. 3) indicate that the *PGE* have not been remobilized by hydrothermal processes. One striking feature, however, is the

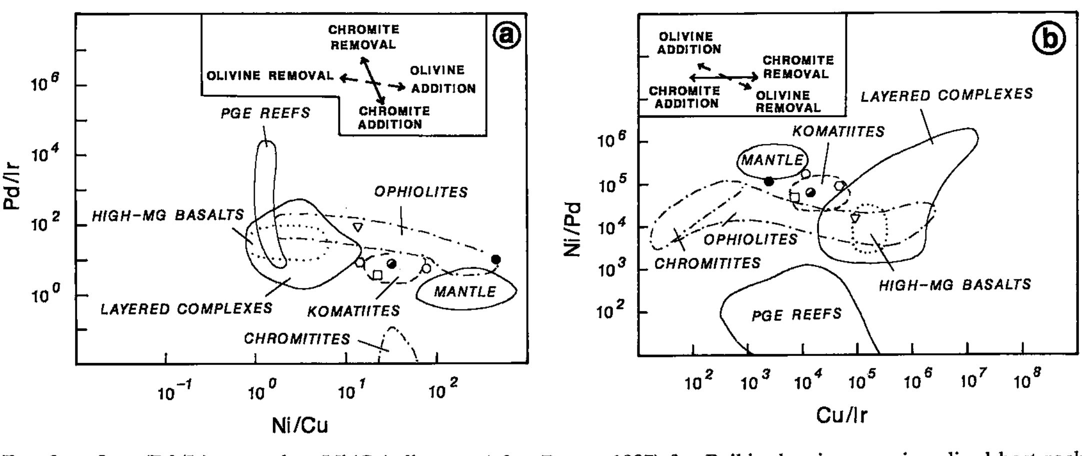

FIG. 8. a. Log (Pd/Ir) *versus* log (Ni/Cu) diagram (after Barnes 1987) for Baikie showing, unmineralized host-rock and Florence Lake ultramafic rocks southeast of Florence Lake. Symbols as for Figures 3, 4 and 6. In general these samples have a komatiitic affinity. b. Log (Ni/Pd) *versus* log (Cu/Ir) diagram (after Barnes 1987), further indicating the general komatiitic affinity of ultramafic and sulfide samples from the Baikie area. Symbols as for Figures 3, 4 and 6.

very Pt-depleted nature of the massive sulfide and, to a lesser extent, the disseminated sulfide (Fig. 3), which is reflected in their extremely low Pt/(Pt + Pd) values of 0.029 and 0.12, respectively (Table 1). Barnes *et al.* (1985) have pointed out that Pt and Au appear to be mobilized and significantly depleted in komatiites that have undergone talc–carbonate alteration. The elevated Au content (93 ppb) in sample TB–87–256D from the North Baikie showing, and the strong Pt and Au depletion of sulfides from the main showing, indicate that they have been remobilized. The extremely low Cu content of the massive sulfide indicates that Cu may also have been mobilized and lost.

As illustrated in Figures 8a and 8b (Barnes 1987), the Florence Lake and Baikie samples are generally komatiitic, although the extremely high Ni/Cu ratio in the massive sulfide is evident in Figure 8a. The Baikie showing and the Florence Lake Group ultramafic rocks are, therefore, chemically similar to komatiites with respect to their *PGE* and Cu–Ni concentrations, and their general geological features are consistent with a komatiitic affinity. Widespread deformation and metamorphism of the Florence Lake Group preclude the recognition of komatiites (*sensu stricto*) by typical chemical or petrographic methods; hence, the distributions of the supposedly relatively immobile *PGE* may offer the best means of classifying this rock suite as komatiitic.

Such a determination has regional significance, as it represents the first suggestion of komatiitic magmatism in the Archean Nain Structural Province, and thus raises the possibility of more metallogenic models than previously presented. Collerson *et al.* (1976) reported high-Mg mafic rocks with bladed olivine crystals (not spinifex) that intruded into the Hunt River Greenstone Belt, 50 km north of Florence Lake; these authors did not definitively identify those rocks as komatiitic, and in fact suggested that they were chemically distinct from the typical Barberton Mountainland and Munro Township ultramafic rocks.

Conclusions

Ultramafic xenoliths within the Kanairiktok Intrusive Suite contain *PGE*-enriched nickeliferous sulfides at the Baikie showing, central Labrador. The *PGE* and Cu–Ni concentrations lead to the conclusion that the intrusive ultramafic rocks south of Florence Lake and the ultramafic xenoliths at the Baikie showing are komatiitic, and hence represent the first evidence of komatiitic magmatism in Labrador.

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APPENDIX 1.

BRIEF DESCRIPTION OF SAMPLES USED IN THIS STUDY

[MBS–MS]: Massive sulfide comprising pentlandite, pyrrhotite, pyrite, chalcopyrite and magnetite, Main Baikie showing; [MBS–DS]: Disseminated sulfide containing pentlandite, pyrrhotite, pyrite, chalcopyrite and magnetite, Main Baikie showing; [TB–87–276]: Actinolite schist comprising pentlandite, pyrite and chalcopyrite, located at the northeastern side of the outcrop hosting the Main Baikie showing; [MBS–CTUM]: Talc–carbonate–chlorite schist host rock to the Main Baikie showing containing trace sulfides; [TB–87–256D]: Talc–carbonate–chlorite schist from the North Baikie showing; [TB–87–277]: Serpentinized peridotite containing trace (<<1%) sulfides located approximately 90 m southwest of the Main Baikie showing; [TB–87–135]: Serpentinized peridotite containing unaltered clinopyroxene and trace (< 1%) pentlandite; [TB–87–157A]: Sheared chlorite schist containing euhedral secondary chromite and trace sulfides (<<1%); [TB–87–180C, –181, –184A, –185A, –185B]: Serpentinized peridotites; [TB–87–185C, –271]: Carbonatized peridotites; [TB–87–021, –123A]: Pyrite, pyrrhotite, sphalerite and chalcopyrite mineralization within siliceous metasedimentary and metavolcanic rocks; [TB–87–270]: Conformable pyritic band in quartz–sericite schist.