GEOLOGY AND ECONOMIC POTENTIAL OF THE GREAT BURNT LAKE AREA, NEWFOUNDLAND

by

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INTRODUCTION

The Great Burnt Lake area is defined for the purposes of this report as including the eastern half of the Great Burnt Lake (12A/8) map area and the northeastern quarter of the Cold Spring Pond (12A/1) map area. Geologic mapping at a scale of 1:20,000 was carried out in this area during the 1981 field season as the final part of a three year project to assess the metallogeny and economic potential of the Hermitage Flexure region (see also Swinden, 1980, 1981a).

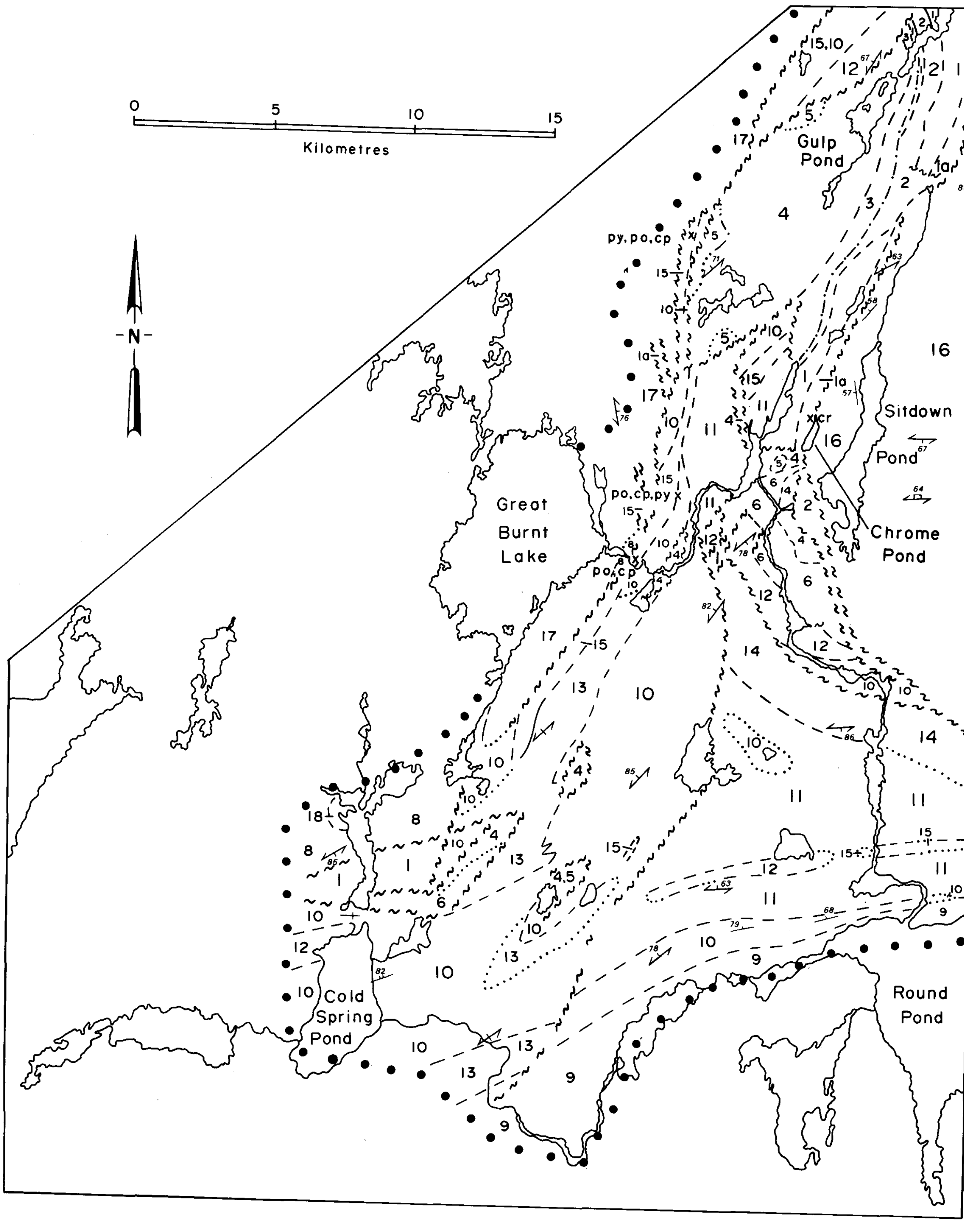
The primary incentive for extending this program to the Great Burnt Lake area was the presence of two massive pyrite-pyrrhotite-chalcopyrite deposits associated with basaltic rocks of the "Great Burnt Lake volcanic belt" (Colman-Sadd and Swinden, 1981). The principal objectives of the mapping were to identify the geologic environment of these deposits, trace the favourable stratigraphy as far as possible and to classify the deposits in the context of similar mineralization throughout central and southern Newfoundland.

In addition, other rock units of possible economic interest were known to be present. Felsic volcanic rocks of the "Huxters Pond volcanics" were known, from mapping to the east by Colman-Sadd (1981), to strike into the area; also, the Pipestone Pond mafic-ultramafic complex was known from previous work to contain chromite showings and possibly to host environments with potential for massive-sulfide deposition. A second objective of the present mapping was therefore to evaluate the geologic and tectonic setting of these rock units in terms of their regional geologic setting and to identify environments of possible economic significance.

Access to the southwestern part of the area between the North Salmon and West Salmon Rivers is provided by all weather gravel roads recently constructed to service the Upper Salmon Hydro Development. This road system connects with public routes in St. Alban's approximately 50 km to the southeast of the map area. The area north and west of the North Salmon River is accessible by float plane via several of the larger ponds or by helicopter; the area north of Godaleich and western Round Ponds is accessible by road and canoe. The North Salmon River provides a convenient canoe route to south-central parts of the area during periods of low water; however, the water level fluctuates considerably depending on the rate of outflow from the Meelpaeg Reservoir and when outflow is high, this can be a difficult and dangerous route. Completion of the North Salmon Dam sometime in 1983 will drastically lower the water levels in this river and perhaps reduce its usefulness as a canoe route.

A comprehensive review of previous work in this area with complete reference to published data and unpublished assessment files can be found in Colman-Sadd and Swinden (1981). The following summary briefly reviews the work which was previously carried out in the area.

The earliest systematic geological work in the Great Burnt Lake area was carried out, not surprisingly, by Alexander Murray, who ascended the Bay East (now known as the Salmon) River in 1870 (Murray and Howley, 1881). He surveyed this river system as far north as Pipestone Pond and Great Burnt Lake and recognized the four principal geologic terrains which underlie the area (see General Geology). He reported


0
5
10
15
Kilometres
N
Gulp Pond
Sitdown Pond
Chrome Pond
Great Burnt Lake
Cold Spring Pond
Round Pond
py, po, cp
po, cp, py
po, cp
x cr

LEGEND

DEVONIAN AND YOUNGER

18 Pink equigranular biotite granite.

DEVONIAN AND OLDER

17 Granite and granodiorite; moderately to strongly foliated biotite granite and porphyroblastic granite.

LOWER AND MIDDLE ORDOVICIAN

16 Thick bedded quartzite and mature graywacke, lesser semipelitic schist often containing andalusite porphyroblasts.

Baie d'Espoir Group (no stratigraphic order implied by sequence)

15 Mafic pillow lavas, massive basalt, pillow breccia. Includes considerable fine grained chloritic tuff, lesser fine grained sediments.

14 Silicic volcanic rocks; dominantly rhyolitic to dacitic, massive to porphyritic flows and ash flows; local volcanic breccia and agglomerate; minor fine grained sediments.

13 Silicic pyroclastic rocks; dark green to black, siliceous tuff with abundant quartz phenocrysts and/or crystal fragments; local concentrations of feldspar and/or lithic fragments.

12 Conglomerate; polymictic unstratified to poorly stratified boulder and pebble conglomerate; commonly matrix supported, poorly sorted.

11 Silicic tuff and reworked tuff; quartz and feldspar crystal tuff and crystal-lithic tuff; commonly unstratified but locally shows evidence of reworking.

10 Sedimentary rocks; includes green, thick to thin bedded graded psammites, siltstones; finely bedded green to black argillites, locally graphitic.

9 Salmon River Dam Formation: Thin to medium bedded black to purplish sandstone and siltstone.

ORDOVICIAN AND OLDER

8 Psammitic to semipelitic schist and paragneiss.

CAMBRIAN-LOWER ORDOVICIAN

Pipestone Pond Complex

7	Black, fine grained sedimentary rocks.
6	Basalt; pillowed to massive flows, commonly variolitic, pillow breccia, minor tuff.
5	Trondhjemite; coarse to medium grained, equigranular.
4	Dominantly coarse to medium grained gabbro; includes fine grained diabase and trondhjemite dikes in higher levels and interlayered pyroxenite in lower levels.
3	Coarse to medium grained pyroxenite, locally with interbanded gabbro.
2	Banded coarse to medium grained pyroxenite and fine grained peridotite, commonly serpentinized.
1	Peridotite; fine grained, commonly with pyroxene phenocrysts and disseminated chromite; 1a, sheared, brecciated and serpentinized peridotite.

the presence of chromite and asbestos in the ultramafic rocks west of Pipestone Pond and this was the first account of concentrations of economic minerals in the area.

The chromite concentrations first reported by Murray have received sporadic attention in subsequent years. Good descriptions of the deposits and an assessment of their potential can be found in Snelgrove (1934) and Fogwill (1964).

Early exploration for base metal sulfides in the Great Burnt Lake area was carried out by the Buchans Mining Company in the 1950's. They produced the first comprehensive regional geological maps of the area (Swanson, 1952-1960) and in addition, sponsored detailed mapping of the areas around Sitdown and Pipestone Ponds (Wolofsky, 1951; Slipp, 1952). This exploration was spurred by the discovery of the South Pond copper deposit in 1951 and culminated in the discovery of the Great Burnt Lake copper deposit in 1966. During the years 1967-1970, the area around Cold Spring Pond was explored by the Hansa Syndicate (Sander and Owen, 1968; Sander, 1969; Sander and Heshka, 1970). They carried out airborne and ground geophysical surveys, geochemistry, geologic mapping and diamond drilling but did not locate any significant sulfide concentrations. At about the same time, McIntyre Porcupine Mines were carrying out regional exploration on NALCO concession land in the area around and north of Gulp Pond.

The first published map to include the whole map area was that of Williams (1970) at a scale of 1:250,000. Kean (1974) examined the ultramafic parts of the Pipestone Pond Complex during his assessment of the economic potential of ultramafic rocks in eastern Newfoundland. Geologic maps at a scale of 1:20,000 resulting from the present mapping have previously been released on open file by the Newfoundland Department of Mines and Energy (Swinden, 1981b).

Exploration in the area in recent years has been relatively active. Abitibi-Price continue to carry out sporadic exploration on the mining lease which includes the South Pond and Great Burnt Lake deposits. Other companies which have acquired ground and/or filed recent assessment reports in this area include Riocanex, Consolidated Morrison, Shell Canada and Minorex.

GENERAL GEOLOGY

Four geologic terrains are represented in the Great Burnt Lake area. From west to east, these are: (1) an igneous/metamorphic terrain comprising equigranular to porphyritic granite, deformed, commonly porphyroblastic granite and psammitic to semipelitic paragneiss and schist; (2) volcanic and sedimentary rocks provisionally assigned to the Baie d'Espoir Group; (3) ultramafic and mafic rocks, assigned to the Pipestone Pond complex, which display ophiolitic stratigraphy; and (4) unnamed quartzites and semipelitic schists which show a steady increase in regional metamorphic grade towards the east. These four geologic terrains are fault bounded at their mutual contacts and, in addition, all are disrupted internally by faulting. Stratigraphic correlations between terrains (and often within them as well) may therefore be somewhat tenuous. The geologic units are described below in order of decreasing age.

OPHIOLITIC ROCKS (UNITS 1-7)

A sequence of mafic and ultramafic rocks, termed the Pipestone Pond complex, underlies a crescent-shaped area between the Jamieson Hills to the south and the northeast boundary of the map area. Similar rocks are known to extend into the Burnt Hill area to the east (Colman-Sadd, 1981) and into the Noel Paul's Brook (Kean and Jayasinghe, 1980) and Miguel's Lake (Colman-Sadd and Russell, 1982) map areas to the northeast. The sequence displays a complete ophiolitic stratigraphy but is considerably disrupted by internal faulting such that no single section through the sequence traverses the complete stratigraphic section. The ophiolite faces west and a reconstructed stratigraphic section would consist of, from east to west: peridotite; banded peridotite/pyroxenite; pyroxenite and banded pyroxenite/gabbro; gabbro grading into diabase and cut in the upper levels by dikes of diabase, pegmatitic gabbro and trondhjemite; mafic pillow lava and isolated pods of fine grained clastic sedimentary rocks. Where ultramafic rocks occur adjacent to the boundary faults, they are commonly highly sheared and serpentinized.

Unit 1 consists of massive, brown weathering peridotite which forms a prominent outcrop band east of Gulp Pond and a less well exposed belt east and northeast of Pipestone Pond. Chromite is ubiquitous in this rock, generally as finely disseminated grains, less commonly as blebs up to 2 cm in diameter and rarely as pods and lenses up to 3 m long. Phenocrysts of pyroxene are commonly present in amounts ranging from less than 0.5% to 4%. The peridotite exhibits no obvious tectonic fabric although most outcrops carry widely spaced fractures that are commonly serpentinized. A subtle banding composed of chromite enriched horizons is rarely developed.

Peridotite forms the eastern boundary of the ophiolite north of Chrome Pond and, adjacent to the boundary fault, it is commonly highly sheared and serpentinized (Unit 1a). The serpentinized peridotite weathers a distinctive red and is characterized by a well developed fracture cleavage, intense shear and breccia zones and local development of talc-carbonate schist. Minor amounts of asbestos are rarely developed on shear surfaces and some exposures are injected by myriads of quartz veins and stringers. Similar features are developed near the narrows on Pipestone Pond where the west boundary fault cuts peridotite as well.

The peridotite grades westward into a unit of banded peridotite and pyroxenite (Unit 2). The pyroxenite is generally coarse grained, with individual crystals up to 2 cm, and weathers a pale green, whereas the peridotite is commonly serpentinized, fine grained and weathers a bright red-brown. In the Jamieson Hills, this unit is the lowest stratigraphic unit exposed and is faulted to the east against sediments of Unit 16. West of Gulp Pond, it is gradational with peridotites of Unit 1 and passes westward into dominantly finer grained pyroxenite/gabbro of Unit 3. A sliver of unaltered peridotite outcrops in a narrow band east and northeast of Gulp Pond on the west side of Unit 2; it is not clear whether this is a conformable pod occurring slightly higher in the stratigraphy than usual or whether it is a faulted-in slice from lower levels in the ophiolite.

The banding in Unit 2 occurs at scales ranging from centimetres to tens of metres. On outcrop scale, peridotite and pyroxenite commonly form bands of 5 to 50 cm wide. Locally the coarse pyroxenite appears to intrude the serpentinized peridotite; in other cases, this relationship is not clear. Mega-banding is best developed in the Jamieson Hills where individual bands up to 100 m wide can be mapped. West of Gulp Pond, the banding is generally on a finer scale of 1 to 100 cm. As a general rule, the ratio of pyroxenite to peridotite in Unit 2 increases to the west until the latter lithology disappears. The last westward exposure of peridotite is taken as the boundary between Units 2 and 3.

Unit 3 consists of pyroxenite and banded pyroxenite/gabbro. It is principally a transitional unit between the ultramafic rocks of Units 1 and 2 and the mafic sequences (Units 4-6) to the west. Pyroxenite without gabbro forms a relatively narrow band along the eastern boundary of Unit 3 east of the last exposures of serpentinized peridotite. Gabbro first appears as a minor component in the eastern part of Unit 3 and gradually increases in abundance towards the west. Gabbro and pyroxenite are generally interbanded on outcrop scale in the western part of Unit 3, and dikes of fine grained gabbro cut the pyroxenite as well. The western contact with Unit 4 is very gradational and is drawn to reflect the point at which gabbro becomes more abundant than pyroxenite; as such, it is a fairly subjective boundary.

Gabbro and associated rocks which make up Unit 4 outcrop in two areas within the Pipestone Pond complex. Northeast of Pipestone Pond, they form an elongate body which can be traced northeastwards to the vicinity of Gulp Pond whereas southeast of Pipestone Pond in the Jamieson Hills, they form a relatively thin unit directly underlying the pillow lavas of Unit 6. In the northern lens, the principal lithology is medium to coarse grained gabbro. In the eastern (lower) parts of this lens, the gabbro is interbanded with medium to coarse grained pyroxenite on both outcrop and larger scales; the incidence of pyroxenite gradually decreases westward until it dies out. The western (upper) part of the gabbro body is cut by dikes of diabase, pegmatitic gabbro and trondhjemite. The diabase dikes are commonly multiply injected along parallel tracks and may comprise up to 50% of some outcrops. They are generally not sheeted in the sense that dike-within-dike features can be recognized; however, parallel dikes are locally seen to share a mutual contact along which screens of gabbro may be preserved. Pegmatitic gabbro is a common constituent of Unit 4 southwest of South Pond. It consists principally of very coarse plagioclase and pyroxene crystals (up to 10 cm) and locally contains coarse blebs of magnetite as well. It occurs as dikes cutting gabbro and diabase and locally comprises entire outcrops. A third common intrusive phase cutting the gabbros is trondhjemite which generally forms dikes and pods within the gabbro and appears to cut most other mafic phases as well. Locally, it forms large pods which can be separated as distinct map units (Unit 5).

In the Jamieson Hills, Unit 4 is commonly fine to medium grained and would generally be more properly termed diabase. Many of the outcrops, particularly close to the contact with pillow lava, are very fine grained, green outcrops with little or no recognizable texture or structure. Surfaces are deeply weathered and lichen covered and it is possible that sheeted dikes in this area could pass unrecognized. However, an unfaulted contact between gabbro and pillow lava is exposed on a hill southwest of Chrome Pond and at this locality, medium grained gabbro forms the intrusive phase. Here, at least, sheeted dikes are not developed between gabbro and volcanic members of the ophiolite.

Trondhjemite locally forms large pods in the upper levels of the gabbro which can be separated as distinct map units (Unit 5). The trondhjemite is commonly medium to coarse grained, composed of plagioclase, mafic minerals (up to 20% but commonly less) and quartz phenocrysts (up to 10%). Three pods have been outlined in the northern gabbro lens northwest of Pipestone Pond and a fourth in the area on the north flank of the Jamieson Hills.

Pillowed and massive basalt (Unit 6) overlies the fine grained gabbro and diabase southeast of Pipestone Pond and is particularly well exposed along the shore of the North Salmon River. It is generally composed of large, well formed pillows up to 1.6 m long, which are commonly vesicular and display spectacular variolitic texture at some localities. Pillow breccia is a common constituent of Unit 5 as well. Little or no chert or hyaloclastic material is developed in the pillow interstices.

A few exposures of black, fine grained sediments (Unit 7) are present in the pillow lavas along the North Salmon River. These rocks are generally highly sheared and of limited aerial extent; they may represent the highest exposed level of the ophiolitic stratigraphy or, alternatively, may be younger sediments introduced along faults.

Ophiolitic rocks which are not strictly part of the Pipestone Pond complex occur throughout the map area as small, fault bounded pods. The largest of these, which underlies the area north of Cold Spring Pond, contains several elements of ophiolitic stratigraphy; most, however, are very local in extent and contain only one or two rock types of ophiolitic derivation.

The Cold Spring Pond fragment is poorly exposed but appears to consist of at least three fault bounded slices. Peridotite and sheared, serpentinized peridotite occupy the northwest part of the fragment, the dominant lithology being massive, brown weathering peridotite very similar to that east of Gulp Pond. The western part of this fragment is underlain by medium to coarse grained gabbro and trondhjemite which is lithologically similar to rocks exposed in the upper parts of the gabbro lens northwest of Pipestone Pond. The gabbro and ultramafic lithologies are bounded to the south and southeast by sheared and deformed pillow lavas which are interpreted, on the basis of their association with gabbro and peridotite, to be ophiolitic; however, it is possible that they comprise part of Unit 15 basalts within the Baie d'Espoir Group and are unrelated to the ophiolite. Whole rock geochemical studies directed towards a better definition of this relationship are in progress.

Ophiolitic rocks outcrop in two small pods northeast of Cold Spring Pond and east of the North Salmon Dam access road. Both consist dominantly of medium grained gabbro, diabase and trondhjemite, although the more northerly of the two also contains some sheared, serpentinized peridotite. A third large pod of mainly gabbroic rocks outcrops along the North Salmon River immediately east of the North Salmon Dam. The structural setting of these three gabbroic pods and of the Cold Spring Pond fragment is not clear. It may be that the faults which bound these fragments continue to the northeast and southwest beyond the limits of the ophiolitic lithologies. In this case, the trace of the faults will be extremely difficult to recognize, as the faults would be separating similar lithologies, and exposure is not good enough to expect the actual faults traces to outcrop. Alternatively, the ophiolitic rocks may be exposed in windows formed either through upward doming or folding of underlying strata; in this case, the bounding fault traces would not extend beyond the margins of the windows. If this latter interpretation is true, it would imply that ophiolitic rocks structurally underlie all rocks west of the Pipestone Pond complex to the limits of present mapping. There is, at present, insufficient evidence to resolve this problem.

Very small pods of ophiolitic, dominantly ultramafic, rocks appear along fault traces in the northern part of the map area, particularly in the area near and north of the North Salmon River. Single outcrops of sheared peridotite within the younger volcano-sedimentary sequences commonly mark the traces of major faults and it appears that this lithology has been particularly amenable to being mobilized along these faults. It should be noted that whereas ophiolitic fragments are very common in sequences to the west of the Pipestone Pond Complex, no such fragments are found in the quartzite/semipelite sequence east of the ophiolite (Unit 16).

METASEDIMENTARY AND METAVOLCANIC ROCKS (UNIT 8)

Metasedimentary and metavolcanic rocks of Unit 8 are irregularly distributed throughout the igneous/ metamorphic terrain at the western edge of the map area. The most northerly exposures of this unit form a thin band northeast of Great Burnt Lake and comprise medium bedded quartzite and mature graywacke interbedded with garnet- and andalusite-bearing semipelitic schists. Quartzite forms the dominant lithology with beds up to 30 cm thick separated by thin semipelitic units. The original lithology would probably have been very similar to quartzites of Unit 16 which outcrop in the Sitdown Pond area.

Near the North Salmon Dam, a thin band of semipelitic schists are faulted against pillow lavas of the Baie d'Espoir Group. These are well exposed in road cuts along the North Salmon Dam access road and in shoreline outcrops along the North Salmon River. The latter outcrops show some migmatization with development of feldspar porphyroblasts and incipient gneissic banding.

South of Great Burnt Lake, migmatized metasediments and meta-volcanics are widespread. Micaceous, garnetiferous psammitic rocks are the dominant lithology and are intercalated with lesser semipelitic rocks. All exhibit tight polyphase folding and extensive injection of quartz. Recognizable volcanic rocks are rare but northwest of Cold Spring Pond, sericitic schists with quartz phenocrysts and massive, white to buff, siliceous rocks may signal a felsic volcanic protolith.

The age of the rocks which comprise Unit 8 is not known with certainty. They are similar lithologically and probably equivalent to schists, gneisses and migmatites which outcrop extensively throughout the south central part of the Central Mobile Belt (*e.g.* Unit 3b of Kean and Jayasinghe, 1980; Units 3c and 3d of Kean and Jayasinghe, 1981; Unit 1 of Dickson and MacLellan, 1981). These are generally considered to be highly metamorphosed equivalents of the Ordovician sedimentary/volcanic packages which are extensively developed throughout the Central Mobile Belt.

BAIE D'ESPOIR GROUP (UNITS 9-15)

Volcanic and sedimentary rocks which lie immediately west and south of the Pipestone Pond complex are assigned to the Baie d'Espoir Group. These include rocks which are on strike with sequences previously mapped as Baie d'Espoir Group in the Burnt Hill area to the east by Colman-Sadd (1981) as well as a northeast-trending belt in the western part of the area previously referred to as the "Great Burnt Lake volcanic belt" (Colman-Sadd and Swinden, 1981). A considerable variety of rock types are represented in the Baie d'Espoir Group in this area, ranging from felsic and mafic volcanic rocks to medium and coarse grained clastic sediments. Because of tight folding and paucity of facing criteria within these sequences, relative stratigraphic positions of the various stratigraphic units are not entirely certain; no stratigraphic order is implied by the position of these units in the legend of the accompanying map, nor by their order in the following discussion, except where specifically stated.

The Salmon River Dam Formation (Unit 9), which underlies the southeastern corner of the map area, is continuous with exposures previously mapped in the Twillick Brook and St. Alban's map areas to the southeast by Colman-Sadd (1976, 1980). It is well exposed in the bed of the West Salmon River southwest of Godaleich Pond and in the tailrace below the Godaleich Pond power house. It consists of dense, fine grained, black to dark gray, finely laminated sandstone. Crosslaminations, ripples and scour and fill are all common. Coarse beds up to 30 cm thick are characteristic of this unit whereas fine laminations on the scale of 10 to 30 mm can be seen in good exposures. Little or no pelitic material is present. The contact with green turbidites of Unit 10 (North Steady Pond Formation) to the north is exposed in the tailrace immediately northwest of Godaleich Pond; it appears to be a conformable sedimentary contact modified by later shearing. Colman-Sadd (1980) has argued on regional stratigraphic grounds that the Salmon River Dam Formation is the basal unit of the Baie d'Espoir Group and therefore should underlie the North Steady Pond Formation. Facing directions are ambiguous in the present area and this was not confirmed or denied.

Units 10 to 15 are probably equivalent to the North Steady Pond Formation as defined by Colman-Sadd (1980). A formal proposal regarding the nomenclature will be made in a forthcoming publication.

Unit 10 consists principally of clastic sedimentary rocks. The main lithologic type is dark green phyllite and psammite displaying crossbedding, scour and fill and ripples. The psammites are generally finely laminated and have beds from 1 to 30 cm thick. This rock forms the bulk of the succession in the northeast trending belt extending from east of Great Burnt Lake to the limits of mapping west of Cold Spring Pond. Gray to black slate and graphitic slate are interbedded with the sandstones and are locally somewhat pyritic. Partial Bouma sequences (Bouma, 1962) are preserved locally, especially near Cold Spring Pond where fine grained turbidites are more prevalent.

An east/west band of fine grained sedimentary rocks which crosses the southern part of the map area north of Godaleich and Round Ponds is also assigned to Unit 10. These rocks comprise relatively fine grained, green sandstones and phyllites displaying well developed partial Bouma sequences with lower graded psammitic beds up to 4 cm thick overlain by thin silty and slaty beds. These rocks are similar to North Steady Pond Formation turbidites described by Colman-Sadd (1980) in the Twillick Brook area. As previously noted, this unit is in conformable contact with the Salmon River Dam Formation to the south. It grades northward into tuffs and arkoses of Unit 11 and appears as lenses in this latter unit.

Along the North Salmon River south of Sitdown Pond, turbidites of Unit 10 gradationally overlie coarse conglomerates of Unit 12 and appear to form the cap of a very large debris flow deposit. In this area, coarse sandstones displaying classic Bouma sequences directly overlie the thick conglomerate unit and grade southwards into finer grained, more distal turbidites consisting of graded sandstones and siltstones with interbedded shales.

Colman-Sadd (1980) has previously noted that sediments of the North Steady Pond Formation contain mainly volcaniclastic debris and appear to have been derived from erosion of the central Newfoundland island arc. This interpretation would appear to be valid for sediments of Unit 10 in the present area as well.

Unit 11 consists of massive, generally structureless, crystal and crystal-lithic tuff, reworked tuff and volcaniclastic lithic arkose. It outcrops in a wide, east/west trending belt north of Round and Godaleich Ponds where it is on strike with similar rocks of the North Steady Pond Formation mapped in the adjacent Burnt Hill map area (Colman-Sadd, 1981), but unseparated from turbidites in the Twillick Brook map area (Colman-Sadd, 1980). It also occupies a northwest-southwest trending belt immediately west of Pipestone Pond where it is in fault contact with the Pipestone Pond complex. Unit 11 lithologies are commonly massive, hard, siliceous rocks which are relatively resistant and form good exposures through most of their mapped extent. The dominant lithology comprises 5-30% quartz and feldspar crystal fragments set in a pale green, very siliceous groundmass. Lithic fragments are less commonly present, but are locally the dominant clast lithology; where present, they are generally volcanic in origin. Fragments range from less than 1 mm to pebble size. Stratification is generally not recognized in outcrop although rare exposures may exhibit a faint layering on the scale of metres which reflects slight differences in grain size distribution. This, and the rounding of crystal fragments, suggests that some resedimentation has taken place.

Tuffs and arkoses of Unit 11 are closely associated with pebble to boulder conglomerates which make up Unit 12; these conglomerates form lenses which are sometimes of mappable scale within the finer grained rocks. There appears to be a continuum between coarse grained, pebbly arkosic rocks of Unit 11 and the finer grained varieties of Unit 12 conglomerates.

North of Godaleich Pond, Unit 11 lithologies are intercalated with green turbidites of Unit 10. To the north, their contact with silicic volcanics of Unit 14 is not exposed but appears to be conformable, marked by a thin band of dark gray to black pelitic sediments. West of Pipestone Pond, Unit 11 appears to pass conformably to the west into mafic volcanics and volcaniclastic sediments.

The origin of the rocks which make up Unit 11 is not clear. Although some evidence of reworking is present locally, they generally show little evidence of deposition by sedimentary processes. The abundance of quartz and feldspar and volcanic lithic clasts suggests that these rocks are derived from a volcanic terrain and it is suggested that they may be tuffs which were rapidly deposited and slightly reworked in the vicinity of contemporaneous volcanism.

Unit 12 consists of poorly sorted, pebble to boulder conglomerates. They form two thick, continuous units, one along the North Salmon River south of Pipestone Pond and the other in a series of prominent ridges west of Gulp Pond. As well, the conglomerate forms lenses within the tuffs and arkoses of Unit 11. Most of these conglomerates consist of 30 to 75% poorly sorted clasts which include, in decreasing order of abundance, quartz, felsic volcanics, mafic volcanics, sedimentary rocks, granite and gabbro and black chert. The clasts are set in a green, fine to medium grained, volcaniclastic matrix. The conglomerates are generally matrix supported and do not normally display stratification, imbrication or other sedimentary structures. However, locally, a crude stratification consisting of broad scale clast size grading or the presence of isolated boulder beds is evident; this is best developed in exposures along the North Salmon River near the gradational contact of the conglomerate with the overlying turbidites. The conglomerates are generally quartzose with subrounded quartz grains occurring as pebble sized clasts. Volcanic and sedimentary clasts are generally angular to subrounded; granitoid and gabbroic clasts (where present) tend to be both larger and more rounded than the accompanying clast assemblage.

The conglomerates in this area appear to have formed as debris flows; the clast assemblage suggests that these flows were sampling both the early stages of the central Newfoundland island arc as well as the older ophiolite. The origin of the granitoid clasts is not certain, although they may be trondhjemite related either to ophiolite or island arc processes. Further petrographic and geochemical studies will be directed at this problem.

Unit 13 consists of crystal and crystal-lithic tuff which outcrops as a series of northeast trending lenses southeast of Great Burnt Lake. It is best exposed in road cuts along the North Salmon Dam access road. Felsic tuffs of Unit 13 are quite different from those of Unit 11; they consist generally of a dense, dark gray to black, aphanitic, very siliceous matrix with 1 to 15% quartz eyes varying in size from 1 mm to 10 mm. Locally, lithic fragments are present and some phases contain feldspar phenocrysts as well.

The felsic tuffs of Unit 13 display little variability along strike. However, in the area immediately south of the North Salmon River, they pass northwards into dense, white, massive rhyolitic rocks which appear to be flows rather than pyroclastic rocks. This may signal the proximity of a volcanic center in this area. The band of Unit 13 lithologies which outcrops in the southwest part of the map area tends to be less siliceous than the lenses to the north and consists of 1-5% quartz eyes set in a black, chloritic matrix. These tuffs are interbedded with conglomerates in the bed of the West Salmon River.

Felsic volcanic rocks of Unit 14 outcrop in a 1 1/2 km wide, east/west trending belt across the southeastern part of the map area. They are correlative with rocks in the Burnt Hill area referred to by Colman-Sadd and Swinden (1981) as the "Huxters Pond volcanics". Two lithologies predominate in this unit; the first is massive pale green rhyolitic flows and ash flows which are commonly aphanitic and exhibit flow banding and flattened pumice fragments in well washed exposures. The second lithology comprises a more mafic-looking rock, dacitic to intermediate in composition, consisting of a pale gray, siliceous groundmass with 20-30% feldspar and quartz phenocrysts. Coarse rhyolitic agglomerate and/or volcanic breccia is present locally, consisting of angular to subround rhyolitic fragments set in a fine grained silicic tuff matrix and suggesting proximity to a center of explosive volcanism.

The felsic volcanics are interbedded with and bounded to the south by fine grained gray to black, water-lain clastic sedimentary rocks. The volcanic rocks themselves contain flow banding and pumice fragments suggestive of deposition in a subaerial environment and it seems likely that during this volcanic episode, both subaerial and submarine deposition were taking place in close proximity, perhaps in a volcanic island environment. The environment would therefore seem to have been favourable for volcanogenic sulfide deposition. In this regard, some horizons in the volcanic sequence are locally highly sericitized and silicified and contain patches up to 3 m in diameter which carry 0.5 to 3% disseminated pyrite. No base metals were noted in these occurrences. Similar occurrences have been reported by Colman-Sadd (1981) in felsic volcanics in the Burnt Hill area.

Unit 15 comprises mafic volcanic rocks, including massive basalt, pillow lava and fine to medium grained mafic tuffs. These rocks are most extensively developed immediately east and northeast of Great Burnt Lake where they can be traced along strike for more than 18 km. Mafic flows which make up the bulk of Unit 15 are well exposed in new quarry and working sites near the North Salmon Dam, where they comprise both massive basalt and pillow lava which is made up of large (0.75 to 1.5 m) pillows which show little evidence of flattening. Hyaloclastic material and chert are generally absent from the sequence. The basalts are interbedded with varying amounts of green to gray, fine grained clastic sediments and tuffs, and these appear in drill core to make up the bulk of the succession in some areas.

The mafic volcanic sequence in this area is host to two volcanogenic Cu (±Zn) deposits, the Great Burnt Lake and South Pond deposits, which are further discussed in a subsequent section.

Minor amounts of mafic volcanic rocks are interbedded with tuffs and arkoses of Unit 11 near the North Salmon River north of Round Pond. These consist of very sheared, green, tuffaceous-looking rocks which outcrop sporadically along the river banks. They are correlated with similar small lenses mapped by Colman-Sadd (1980) in the North Steady Pond Formation to the east.

Basalts of Unit 15 cannot, on outcrop inspection, be distinguished from the mafic volcanic rocks which cap the Pipestone Pond complex. The distinction is presently made on the basis of associated lithologies and position in the stratigraphic succession which suggests that Unit 15 basalts formed during a period of island arc volcanism. It seems likely, based on these criteria, that the extensive mafic volcanic belt in the Baie d'Espoir Group is different from and younger than the ophiolitic rocks exposed along the North Salmon River and Jamieson Hills. This correlation is not as certain for small lenses of mafic volcanic rocks within the Baie d'Espoir Group sequence such as those east of the North Salmon Dam and northwest of Godaleich Pond, which could as easily represent fragments of ophiolitic rocks introduced along faults. Whole rock geochemical studies are in progress which will be directed towards resolving the differences between and distribution of the two episodes of basaltic volcanism.

The Baie d'Espoir Group in the Great Burnt Lake area has been regionally metamorphosed in the greenschist facies and carries evidence of at least two deformations. The first and main deformation formed upright, isoclinal folds and an associated penetrative axial planar cleavage which is uniformly present throughout the sequence. This cleavage commonly trends northeasterly to easterly with steep dips and is subparallel to bedding in most exposures. F_1 folds are rarely observed in the field but where seen, commonly have an amplitude of 0.5 to 1 m and are sheared out along the limbs. A second deformation of variable intensity is occasionally recognized. In the area north of the North Salmon River and west of Pipestone Pond, the first cleavage is folded around moderately open, assymetric folds with steep eastern limbs, the axes of which are approximately parallel to those of the F_1 folds. In the southern and eastern parts of the area, however, the second deformation is represented by a steep crenulation cleavage developed in the fine grained sedimentary rocks which trends north to northwest. No folds associated with this cleavage were recognized.

QUARTZITE, MATURE GRAYWACKE AND SHALE (UNIT 16)

Unit 16 underlies the eastern part of the map area. It consists dominantly of cream to white weathering quartzite and mature graywacke which forms blocky beds from 2 to 10 cm thick. The sandstones are commonly, although not always, interbedded with gray, fine grained clastic sediments. Fine laminations, scouring and channel fill are seen locally in well washed stream exposures south of Sitdown Pond.

This unit is the westward equivalent of rocks mapped in the adjacent map area by Colman-Sadd (1981). He noted a progressive low pressure metamorphism in these rocks towards two centers which culminated in the formation of banded gneiss and migmatite. The rocks of Unit 16 form the westward edge of the metamorphic aureole related to the Through Hill metamorphic center (Colman-Sadd, 1981). Exposures in the west near the Pipestone Pond Complex are metamorphosed in the greenschist facies but towards the east, show the progressive development of porphyroblasts of staurolite and andalusite in the more pelitic members. Some of these exposures are quite spectacular with up to 40% large andalusite porphyroblasts ranging up to 2 cm in size.

The age of Unit 16 is considered to be Lower-Middle Ordovician (uppermost Arenig to Lower Caradoc) on the basis of shelly fossils yielded by equivalent strata in the Miguels Lake map area (Colman-Sadd and Russell, 1982). It is lithologically similar to rocks of the Gander Group which is generally considered to be Middle Ordovician or earlier (*e.g.* Blackwood, 1981).

The principal deformation in Unit 16 is represented by a steep, penetrative cleavage which strikes generally north to northeast in the area of Sitdown Pond and east/southeast south and east of Sitdown Pond. This cleavage appears to be related to tight folds whose axes are steep and plunging to the south in the area west of Sitdown Pond. A later deformation is suggested by local changes in attitudes of the cleavage but it does not appear to have formed a penetrative fabric.

DEFORMED BIOTITE (±HORNBLENDE) GRANODIORITE (UNIT 17)

Deformed granitoid rocks of Unit 17 underlie most of the igneous/metamorphic terrain west of the Baie d'Espoir Group to the limits of the present mapping. The dominant lithology is strongly deformed, medium to very coarse grained, biotite (±hornblende) granodiorite which is usually quartz-poor but locally contains up to 10% bluish quartz eyes. The deformed granitoid rocks are locally gneissic and show a variable development of feldspar porphyroblasts ranging in size from 5 mm to 4 cm. Intensely flattened inclusions of schist and paragneiss, probably from Unit 8, are present in some exposures but there is no evidence that the granitoids have intruded the greenschist facies Baie d'Espoir Group in this area. The eastern contact with the Baie d'Espoir Group is marked by intense shearing and the local presence of sheared serpentinite, characteristic of most major faults in the area.

EQUIGRANULAR BIOTITE (±MUSCOVITE) GRANITE

Undeformed equigranular granite outcrops at a few localities in the present map area. One outcrop on the southeastern shore of Great Burnt Lake consists of medium grained biotite granite or granodiorite; however, this lithology makes up more than 50% of boulders along the lake shore and it seems likely that it is widely developed to the west of the present mapping. Many boulders of this rock type also contain minor muscovite and the rocks appear very similar to those which comprise the southeastern margin of the North Bay Granite in Bay d'Espoir (Colman-Sadd, 1976).

Along the western shore of the unnamed lake immediately north of Cold Spring Pond, there are several outcrops of equigranular, pink biotite ±(muscovite) granite (Unit 18) which appears to be a very late phase. It consists mainly of pink feldspar (70%) with 20% gray cloudy quartz and 10% platy biotite. No contact relations were observed and the full extent of this body is not known as it lies at the extreme western limit of mapping.

Isolated outcrops of muscovite and garnet bearing pegmatite are present in sediments of Unit 16 in the northeastern part of the map area. These are similar to and probably related to pegmatitic phases of the Through Hill Granite on the adjacent Burnt Hill map area (Colman-Sadd, 1981).

MINERALIZATION AND MINERAL EXPLORATION POTENTIAL

(1) Pipestone Pond Complex:

The first reported concentrations of economic minerals in the Great Burnt Lake area are hosted by the Pipestone Pond complex, these being the chromite occurrences east of Pipestone Pond. These prospects have previously been examined and described in some detail by Snelgrove (1934), Fogwill (1964) and Kean (1974). Chromite is a ubiquitous constituent of the peridotites of Unit 1 throughout the Pipestone Pond complex where it is commonly widely disseminated, forming less than 0.5% of the rocks. However, in rare instances such as the Chrome Pond area, it is concentrated in pods which are generally less than 2 m but which may reach up to 6 m in length. The largest concentration noted during the present mapping is the Chrome Pond Prospect, a single pod approximately 6 m long and averaging 0.5 to 1 m wide hosted by sheared and serpentinized peridotite of Unit 1a. The showing occurs at the north end of a 100 m long outcrop ridge which displays unusual chromite concentration along its complete length. Several smaller pods up to 1 m in length are to be found in the immediate vicinity of the main showing. As well, blebs of massive chromite and zones of heavily disseminated chromite are common. Analyses of chromite from this area by Fogwill (1964) suggest that the material has a ratio Cr:Fe in the range 2.5 to 3.5; thus, if a deposit of mineable size could be outlined, there is every likelihood that the ore would produce a very high quality product.

Mapping throughout the ultramafic members of the ophiolite suggests that several other areas of slightly elevated chromite concentrations are present; none are known to be of economic proportions at the present time.

The sheared serpentinite of Unit 1a and Unit 2 is also host to minor occurrences of asbestos and magnesite. Asbestos generally occurs as very local concentrations of cross and slip fibre on widely spaced fracture surfaces. Exploration for magnesite has not been pursued in the Pipestone Pond complex with the same intensity as elsewhere in the eastern Newfoundland ultrabasic rocks (see review in Colman-Sadd and Swinden, 1981). The present mapping suggests that development of magnesite is not as widespread in this area as, for example, in the Coy Pond and Great Bend areas. However, local concentrations are present, especially in Unit 1a in the vicinity of Chrome Pond, and further exploration would seem to be warranted.

The recognition of the Pipestone Pond complex as an ophiolite raises the possibility that depositional environments of ophiolitic massive sulfide deposits (Cyprus-type) may have been extant. The only pillow lavas considered on field evidence to be ophiolitic are those which underlie the western Jamieson Hills and the contact between the underlying gabbro/diabase and the volcanics appears to be exposed in this area. This environment, near the stratigraphic base of the pillow lavas is regarded as the most likely site of massive sulfide deposition, if such deposition did take place. No evidence of exhalative processes such as extensive alteration, exhalative iron or manganese rich horizons or sulfide concentrations were recognized during the present mapping. However, the basal part of the pillow lava unit would appear to be a good exploration target which, to the author's knowledge, is relatively untested.

(2) <u>Baie d'Espoir Group</u>

The Baie d'Espoir Group is considered to have the highest economic potential in the Great Burnt Lake area, both by virtue of the massive sulfide deposits known to be present in this unit and by virtue of apparently favourable environments developed elsewhere in the sequence.

Mafic volcanic rocks of the Baie d'Espoir Group (Unit 15) are host to two sulfide deposits east and northeast of Great Burnt Lake. The larger of these, the Great Burnt Lake deposit, is located on the southeast side of a prominent hill approximately 2 km northeast of the North Salmon Dam; the smaller deposit, the South Pond deposit, is located approximately 10 km to the north of the former deposit and approximately 3 km southwest of South Pond. Both prospects are presently within the boundaries of a mining lease held by Abitibi-Price Inc. and Asarco Ltd. The sulfide zones are exposed; however, both have been extensively drilled and the following descriptions are based on examination of drill core from several holes which cut the deposits.

The Great Burnt Lake deposit is a roughly tabular, conformable body of massive pyrrhotite-chalcopyrite mineralization. The geologic sequence in the vicinity of the deposit consists of mafic flows and tuffs with interbedded siltstone and graywacke and fine grained clastic sediments which are locally graphitic. The deposit ranges up to 14 m in thickness, strikes approximately 030°, with steep dips to the southeast, and plunges gently to the southwest. The main mineralized zone carries sulfide concentrations ranging from less than 40% to 90%. Pyrrhotite is the dominant sulfide mineral present and occurs generally as massive beds. Chalcopyrite is distributed throughout the mineralized zone, forming large blebs within the massive pyrrhotite as well as discrete strata of massive mineralization up to 6 cm thick. To the west, the sulfide zone is in sharp contact with quartzose graywacke and siltstone; the sequence west of the mineralized zone shows little evidence of alteration and/or mineralization. To the east, the deposit is in contact with pillow lavas, although a mafic volcanic breccia up to 1.5 m thick is locally developed between the volcanics and the massive mineralization. The volcanic sequence to the east of the massive mineralization exhibits widespread although not particularly intense, alteration within 30 to 40 m of the massive zone. Black chloritization with associated stringers of pyrite, pyrrhotite and chalcopyrite and local silicification is the principal alteration effect. Similar alteration and sparse, erratic mineralization is prevalent in an apparently separate diffuse zone up to 335 m long and up to 75 m thick immediately north and east of the massive zone. The geologic situation is suggestive of syngenetic sulfide mineralization on the sea floor at the top of a pillow lava succession and followed by a period of clastic sedimentation. The extensive alteration and sparse mineralization in rocks on the eastern side of the massive sulfide body may record the passage of hydrothermal fluids related to the mineralizing event and therefore suggest that the deposit is slightly overturned and facing to the northwest.

The Great Burnt Lake deposit is subeconomic at present. Recent estimates suggest that it contains on the order of 750,000 tonnes of 2-3% copper.

The South Pond deposit lies approximately 10 km north of the Great Burnt Lake deposit and occupies approximately the same stratigraphic interval. The geologic succession in this area is similar to that in the south, comprising pillow lava, mafic tuff and fine to medium grained clastic sediments. Sulfides are more widespread stratigraphically in this area and are present virtually throughout some drill cores. Pyrrhotite commonly comprises 0.5 to 1% in tuffaceous rocks and up to 20% over short sections. Chalcopyrite disseminations and blebs locally accompany the pyrrhotite and a particularly chalcopyrite-rich zone has been outlined which constitutes the South Pond deposit. This zone consists of up to 15 m of mafic tuff which contains up to 30% sulfides, consisting of pyrrhotite which forms anastomosing layers and semi-massive zones and disseminations and blebs up to 1 cm in diameter of chalcopyrite. The boundaries of the zone are gradational and reflect both a decrease in total sulfide content and an attendant disappearance of chalcopyrite.

The South Pond deposit is considerably smaller than the Great Burnt Lake prospect. It is estimated to contain in the order of 300,000 tonnes grading approximately 1% copper.

Although neither of these deposits is of economic size or grade, they are important indicators that exhalative processes accompanied this volcanism. Furthermore, mineralization is not restricted to the two known deposits in the volcanic belt; minor amounts of pyrrhotite and chalcopyrite have been noted in drill core between the two deposits and as well, new exposures recently uncovered near the North Salmon Dam are intensely chloritized and contain minor disseminated chalcopyrite. This new occurrence appears to be at the same stratigraphic level as the Great Burnt Lake prospect 2 km to the north. It appears from the present mapping that sulfide mineralization may have been widespread at this stratigraphic interval and the whole strike extension of the volcanic belt can be considered as favourable prospecting territory. It may be further noted that mafic volcanic rocks of the Baie d'Espoir Group outcrop in small belts northwest of Pipestone Pond and north of Round Pond. It is not known whether these basalts are strict stratigraphic equivalents of the mineralized sequence to the west; however, if they are so, they should also present favourable prospecting targets.

In addition to the potential for basalt-hosted cupriferous massive sulfides, there would also appear to be a good potential in the Baie d'Espoir Group for the discovery of volcanogenic sulfides associated with felsic volcanism. The principal target area is in and around Unit 14, the felsic volcanic unit which forms an east/west trending belt across the southeastern part of the area (the "Huxters Pond volcanics"). The felsic sequence consists primarily of rhyolitic to dacitic flows and ash flows which locally contain coarse breccias and agglomerates suggestive of nearby explosive volcanism. Although some exposures of the volcanic rocks show evidence of being deposited in subaerial conditions, the volcanics are interbedded with fine grained clastic sediments suggestive of marine conditions and are part of a succession that includes turbidites and pillowed basalts. It seems likely, therefore, that they may have formed as, for example, volcanic islands. As such they present a highly favourable environment for massive sulfide deposits resulting from submarine fumarolic activity.

Massive sulfide deposition is known from similar environments elsewhere in southern Newfoundland. The Strickland Prospect and several associated occurrences in the La Poile Bay area of southwestern Newfoundland (Cooper, 1954; Stackhouse, 1976; Swinden, 1981a) occur in a volcano-sedimentary succession, the volcanic component of which is dominated by felsic rocks. Likewise, the Barasway de Cerf Prospect in southern Bay d'Espoir (Jewell, 1939; Swinden, 1980), although in a relatively basinal environment, is closely associated with pulses of felsic volcanism (Swinden, 1980). Massive sulfide mineralization associated with felsic volcanism in southern Newfoundland is dominantly Pb-Zn-Ag rich, with lesser pyrite and copper. By analogy, it might be expected that mineralization associated with the Huxters Pond volcanics would have a similar mineralogical composition; this could have implications for the exploration methods most likely to be successful in this terrain. Recognition of the felsic volcanic sequence in this part of Newfoundland is relatively recent (Colman-Sadd, 1981) and as a result, comparatively little exploration has been carried out. These felsic volcanics are accordingly considered to have a high potential for the discovery of volcanogenic mineralization.

The economic potential of the rest of the Baie d'Espoir Group is relatively unknown. Felsic volcanic rocks appear to be more widespread than was previously known; there is a distinct possibility that they host as yet undiscovered sulfide depositional environments. This is particularly true for the felsic pyroclastic rocks of Unit 13. Further exploration is needed to better define the potential of these rocks.

(3) Western Igneous/Metamorphic Terrain

The economic potential of the igneous/metamorphic terrain to the west of the Baie d'Espoir Group is not well known. This terrain was not investigated in detail during the present program and a detailed economic assessment is therefore beyond the scope of this report. However, a few brief comments are justified.

The metamorphic rocks in this area appear to be dominantly metasediments and bear no obvious economic potential. However, northwest of Cold Spring Pond, they include some buff to white, very silicic rocks which appear to be metamorphosed felsic volcanics similar to those which form part of the Isle Galet Formation to the east (*e.g.* Colman-Sadd and Swinden, 1981). These were only seen in a few outcrops and their distribution is not known; however, they may present a favourable target for massive sulfide exploration.

Most of the granitoid rocks which outcrop within the present map area are highly deformed biotite (±hornblende) varieties which do not display any obvious potential. However, a late, undeformed pink biotite granite outcrops along the northwest shore of the unnamed lake immediately north of Cold Spring Pond. This may suggest that, as one progresses westward, perhaps more late granite plugs associated with the south-central Newfoundland granitoid complex will be encountered. This possibility is supported by the abundance of undeformed biotite and biotite-muscovite boulders along the eastern shore of Great Burnt Lake. It seems possible that a granitoid terrain which may be favourable for tin, tungsten, uranium and/or other lithophile elements similar to that at Granite Lake 30 km to the west (Dickson and MacLellan, 1981) may be present immediately west of the present map area. Further mapping in this area is needed to evaluate this possibility.

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