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GEOLOGY OF THE SOUTHEASTERN PART OF THE GANDER LAKE MAP AREA (NTS 2D/15) AND THE SOUTHWESTERN PART OF THE GAMBO MAP AREA (NTS 2D/16)

Patrick P. O'Neill
Newfoundland Mapping Section

ABSTRACT

In the study area, the two principal geological divisions are the Gander Group and the Gander Lake Granite. The Gander Group consists of interbedded psammite, semipelite and pelite metamorphosed to greenschist or amphibolite facies. Approximately 60 percent of the map area is underlain by the Siluro-Devonian Gander Lake Granite, a predominantly massive, K-feldspar megacrystic and biotite-rich granite, which posttectonically intrudes the Gander Group. A static thermal aureole characterized by cordierite and andalusite hornfels occurs peripheral to the granite. This hornfels contrasts texturally with andalusite- and fibrolite-bearing schistose rocks associated with a syn- to late tectonic leucocratic granite west of Rodney Pond. Phyllonites near Square Pond contain kyanite, andalusite and sillimanite and are correlated with similar rocks to the north, near Gull Pond. The phyllonites define a regionally developed, high-strain zone termed the Wing Pond Shear Zone. Two small bodies of ultramafic rock occur in the Gander Group near Square Pond and Butts Pond.

INTRODUCTION

During the 1990 field season, the southeast corner of NTS map area 2D/15 (Gander Lake) and the southwest corner of NTS map area 2D/16 (Gambo) were mapped at 1:50,000 scale (Figures 1 and 2). This work represents a continuation of the mapping of the Gander Zone, initiated in 1986 in the Weir's Pond area (O'Neill, 1987).

The northern and eastern parts of the area are accessible from the Trans-Canada Highway and by boat from Gander Lake and Square Pond. The central and southern parts of the area can be accessed by four-wheel-drive and all-terrain vehicles from a system of logging roads, and by boat from Rodney Pond.

The topography of much of the area south of Gander Lake is gently undulating having local elevations rising to between 200 and 250 m. The land bordering Gander Lake, as far east as Joe's Brook on the southern shore and Soulis Brook on the northern shore, is steeply sloping and heavily wooded. Farther east on both sides, the land slopes gently toward the lake; a northeast-trending escarpment immediately west of Benton is responsible for this change in topography. The lineament so defined, controls the direction of flow of Soulis Brook. A major bend also occurs in Gander Lake where the lineament crosses the lake. Although the lineament is quite marked north of Gander Lake, there is no physiographic expression of it south of the lake. The most rugged topography occurs on the east side of Square Pond, where the land rises steeply to approximately 200 m and falls off steeply to Gambo Brook and Freshwater Bay. Peat bogs are extensive, particularly near Rodney Pond and Second Burnt Pond. In areas underlain by the Gander Lake Granite, boulder fields cover broad areas and the boulder type is predominantly megacrystic granite. In the wooded areas, spruce is the dominant tree type along with minor birch, fir and scattered pine.

South of Gander Lake, topographic lineaments are absent. The area is dissected by several small- to medium-sized ponds, the largest being Rodney Pond, by Joe's Brook, which flows to the northwest, and by an unnamed system of brooks that drain eastward from Rodney Pond through Second Burnt, First Burnt and Square ponds. The latter drains northeastward to Butts Pond, which drains into Freshwater Bay through Middle Brook. The gentle undulating topography that characterizes the area reflects the absence of a strong structural grain in the underlying bedrock and the presence of a boulder-rich till.

Although bedrock exposure is generally less than 1 percent throughout the area, the Gander Lake Granite is well exposed on the south shore of Gander Lake and there is also good exposure of the Gander Group on the northeast side of Square Pond.

PREVIOUS WORK

A detailed account of previous geological work in the area has been given in O'Neill (1990). Noranda Exploration Company Limited has carried out work in NTS map area 2D/16 near the Trans-Canada Highway, in metasedimentary rocks of the Gander Group; the report on Noranda's work is proprietary.

REGIONAL RELATIONSHIPS

The study area lies within the Gander Lake Subzone of the Gander Zone (Williams *et al.*, 1988). The Early

Ordovician and/or older Gander Group (Kennedy and McGonigal, 1972) underlies the eastern and western parts of the area, and has also been mapped northeastward to Carmanville (NTS 2E/8) (Currie and Pajari, 1977) and southwestward for approximately 100 km, to the Bay d'Espoir area (Dickson, 1987). Farther north, the Gander Group is interpreted to pass gradationally eastward into amphibolite-facies rocks of the Square Pond and Hare Bay gneisses (Blackwood, 1978). In the study area, the Gander Group is intruded by the megacrystic Gander Lake Granite, which underlies much of the area. Small bodies of a garnetiferous, muscovite granite, which occur in the western part of the map area, may be correlative with the Middle Ridge Granite to the southwest.

GENERAL GEOLOGY

GANDER GROUP–UNITS 1 AND 2

Approximately 40 percent of the map area is underlain by interbedded psammite, semipelite and pelite of the Jonathans Pond Formation (O'Neill and Knight, 1988) (Unit 1) of the Gander Group. The psammite is grey-weathered, thin- to medium-bedded and is generally in sharp contact with more pelitic layers. Quartzitic beds and concordant mafic bodies form a minor component of the formation. Four kilometres southwest of Rodney Pond, pink layers up to 2 cm thick occur in one exposure and appear to be coticules, a garnet- and quartz-bearing rock. A pervasive tectonic foliation and extensive metamorphic recrystallization have destroyed most of the sedimentary structures in the rocks. In the aureole of the Gander Lake Granite, weathered surfaces commonly have a pitted appearance and are typically bleached to a greyish-white, whereas fresh surfaces are dark blue to black and have a purple hue, where cordierite is present.

Several small exposures of dark grey to black pelite interbedded with psammite (Unit 2), occur northeast of the east end of Gander Lake. These rocks are along strike with the Indian Bay Big Pond Formation (see O'Neill, 1990), which includes black pelite, and are therefore, included with them. The contact between the formations was not observed.

ULTRAMAFIC ROCK AND DIABASE–UNIT 3

Two exposures of altered ultramafic rock were identified during mapping. One outcrop (subunit 3a) adjacent to the old railway line, 1 km west of Butts Pond (Figure 2), is weathered to a mottled to streaky, blueish grey and orange. The rock is completely altered to an assemblage of serpentine, talc and minor carbonate. A penetrative foliation developed in the rock is parallel to the regional foliation in the Gander Group. Immediately east of the ultramafic body, interbedded psammite, semipelite and pelite are exposed. However, there is an exposure gap between the metasedimentary and ultramafic rocks and therefore, the nature of the relationship between them is unknown. Distinctive micaceous green layers, several centimetres thick, form a minor component of the metasedimentary rocks. The micaceous rocks consist of alternating chlorite-rich and green hornblende-rich layers.

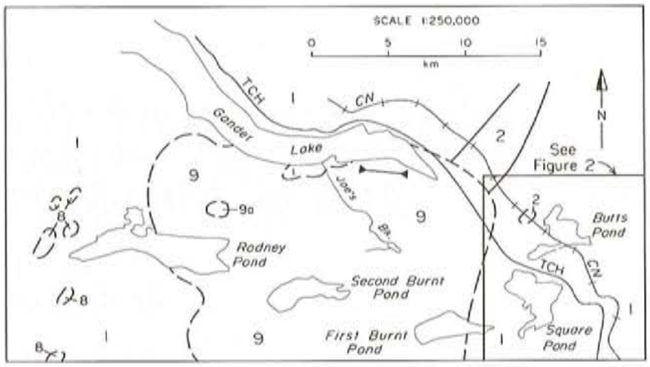

Figure 1. *Geology of the study area. The inset block in the southeast corner is shown in detail in Figure 2.*

LEGEND for Figures 1 and 2

SILURO-DEVONIAN OR OLDER

9 Gander Lake Granite: *Massive, K-feldspar megacrystic biotite granite;* **9a,** *equigranular phase having scattered megacrysts*

8 *Equigranular, leucocratic, garnetiferous muscovite-rich granite*

7 **7a,** *muscovite–biotite granite;* **7b,** *highly strained muscovite granite*

6 *Biotite granite*

5 *Hornblende granite*

4 *Hornblende gabbro*

3 *Ultramafic rock and diabase:* **3a,** *serpentine talc rock;* **3b,** *pyroxenite having minor colourless amphibole (and possible olivine), partly altered to serpentine and carbonate, in tectonic contact with* **3c,** *a fine-grained, banded diabase*

ORDOVICIAN OR OLDER
GANDER GROUP

2 Indian Bay Big Pond Formation: *interbedded, laminated black and greyish-green pelite and dark grey to grey sandstone*

1 Jonathans Pond Formation: *interbedded psammite, semipelite and greyish-green pelite predominantly metamorphosed to greenschist or amphibolite facies*

SYMBOLS

Geological contact, approximate...............

High-strain foliation...................................

Primary flow foliation in granite................

Bedrock exposure....................................... ×

Lineament, inferred from airphoto............

Metamorphic minerals in high-strain zone are Sill = Sillimanite, Ky = Kyanite, And = Andalusite

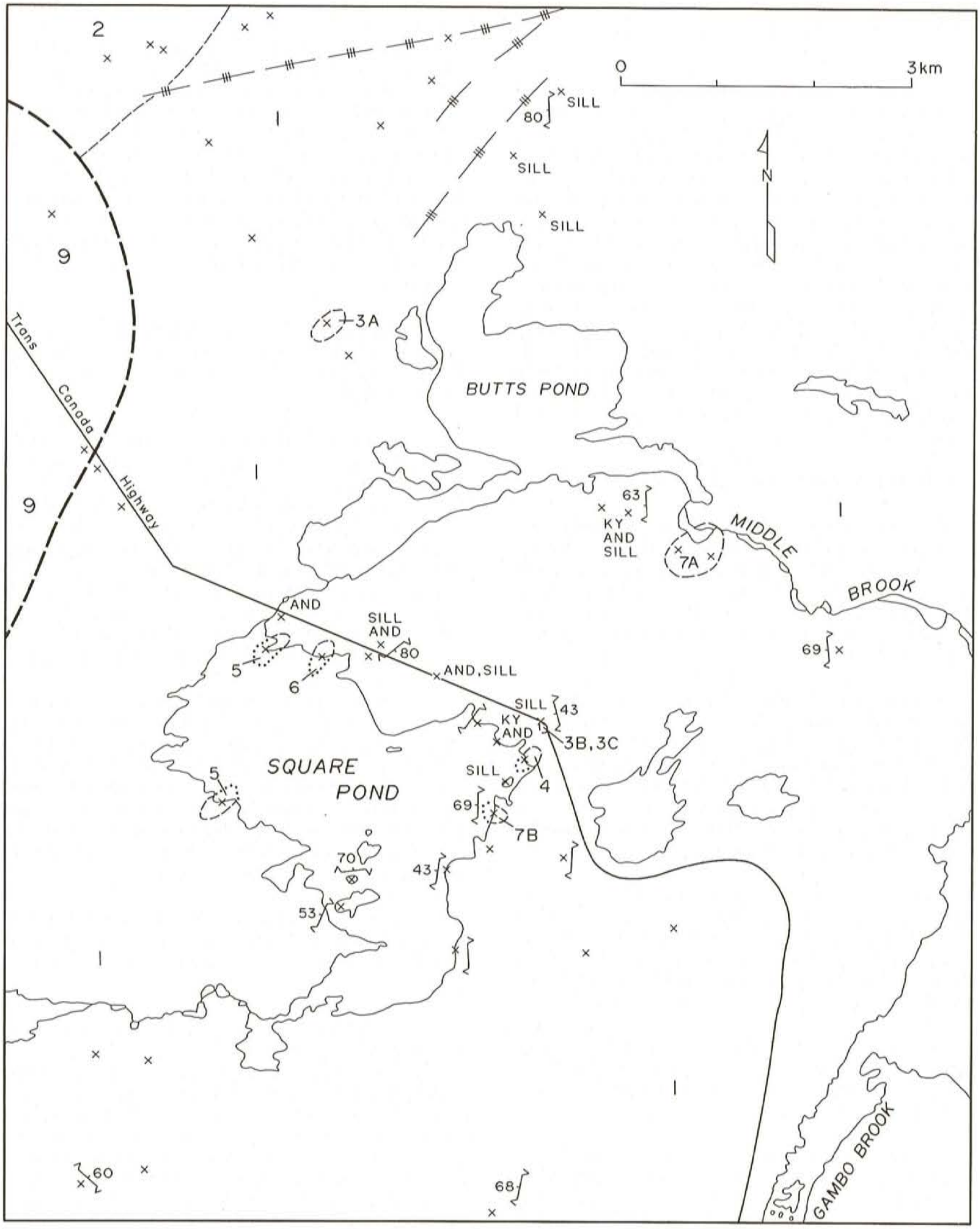

Figure 2. *Geology of the Square Pond and Butts Pond area, showing the location of the felsic, mafic and ultramafic bodies associated with the Wing Pond Shear Zone.*

A concordant biotite granite vein, less than a metre thick and containing disseminated pyrite, is interlayered with the metasedimentary rocks.

A body of ultramafic and mafic rock (subunits 3b and 3c) in tectonic contact with the psammite and semipelite of the Jonathans Pond Formation, is exposed in a roadcut on the Trans-Canada Highway, immediately north of the east side of Square Pond (Figure 2). The contact between the igneous and metasedimentary rocks is a shallowly dipping in the middle of the exposure, but dips steeply on the sides. The ultramafic rock is partly altered to serpentine and carbonate and is talcose in the foliated margins. Locally, fibrous serpentine occurs in the talc-rich zones. Clinopyroxene is locally preserved. Strongly foliated zones (possibly shear zones), also occur within the ultramafic body. On the top side of the exposure, the rock consists of a light-green weathering, fine-grained diabase (subunit 3c), which is cut by a network of quartz, calcite and epidote veins. The diabase has been recrystallized to green and blueish-green hornblende and minor quartz.

INTRUSIVE ROCKS–UNITS 4 TO 9

Several exposures of hornblende gabbro (Unit 4) occur at the north end of Square Pond. Boulders of gabbro are common on the southwest shore of Square Pond and in one locality south of the pond. The gabbro consists of coarse-grained green hornblende, plagioclase and minor opaque material and biotite and contains a heterogeneously developed high-strain foliation.

Two exposures of hornblende granite (Unit 5) occur on the north and southwest shores of Square Pond. In the southern locality, the granite is moderately foliated and consists of sericitized feldspar, quartz, green hornblende, chlorite, epidote and sphene. At the second locality, the granite is coarser grained, more weakly foliated and mineralogically similar to the first, although containing a greater proportion of hornblende.

One exposure of biotite granite (Unit 6) occurs on the north shore of Square Pond. The rock is foliated, medium grained and consists of quartz, plagioclase, microcline and biotite and minor epidote and sphene. The feldspars are moderately sericitized. The rock has been cataclastically deformed as some feldspars are cracked or broken.

Two exposures of muscovite- and biotite-bearing granite (subunit 7a) occur near the southeast corner of Butts Pond. The granite is white weathered, fine to medium grained, equigranular and massive.

Several small exposures of a leucocratic, muscovite-rich granite (subunit 7b) occur on the east shore of Square Pond. The granite locally contains a high-strain foliation and is spatially associated with gabbro (Unit 4).

Small bodies or sheets of a leucocratic, muscovite-rich granite (Unit 8) are exposed west of Rodney Pond (Figure 1). Many other exposures in the area, which contain predominantly metasedimentary rocks, also contain sheets of similar granite and pegmatite. The granite is white weathered, typically fine to medium grained, equigranular (grains range from 3 to 6 mm across) and consists of quartz, feldspar and muscovite and accessory garnet, biotite and pyrite. Quartz and feldspar occur in approximately equal amounts and muscovite forms approximately 20 percent of the rock; associated pegmatites are mineralogically similar. Although the granite is mostly massive, it is locally banded on a centimetre scale; individual bands are defined by alternating quartz- and feldspar-rich layers and micaceous layers; garnet is abundant in some bands and may form as much as 5 percent of the rock.

The granite is similar to that mapped farther north near Gillinghams Pond (O'Neill, 1990) and is mineralogically similar to the Middle Ridge Granite, as described by Blackwood (1981).

The Gander Lake Granite is characterized by abundant K-feldspar megacrysts that range up to 6 cm in length in a biotite, quartz and feldspar matrix, in which the crystals are up to 1 cm across. Feldspars are typically white weathered and form 60 to 70 percent of the rock; some are compositionally zoned. Quartz is greyish blue and averages approximately 20 percent of the matrix; biotite forms approximately 10 to 15 percent of the matrix. The feldspar megacrysts commonly contain small inclusions of biotite. Tourmaline is an accessory mineral but, in places, is concentrated in patches (which are 5 to 10 cm across).

The granite is massive in most exposures and boulders, however, a primary flow foliation is present in the northeastern part of the granite, close to its contact with metasedimentary rocks of the Gander Group (Plate 1). In many of the granite exposures on the shore of Gander Lake, the foliation is defined by feldspars and by elongate metasedimentary xenoliths, most likely derived from the Gander Group. The flow foliation trends approximately eastward and in one locality it is steeply dipping.

The proportion of xenoliths within the granite varies from less than 10 percent to approximately 70 percent. In some outcrops, the metasedimentary xenoliths stand out in positive relief.

The contact between granite and metasedimentary rocks is marked by a zone of sheeting, a metre or less across, in which granitic veins intrude along the tectonic foliation and/or bedding planes in the metasedimentary rocks (Plate 2). On a larger scale, e.g., along the shore of Gander Lake, granite exposures are tens of metres thick, and alternate with metasedimentary rocks; the latter are hornfelses, very hard and locally well-jointed. The granite adjacent to the contact, on the Trans-Canada Highway, is extensively shattered. Thin tourmaline-bearing, pegmatitic dykes commonly cut the metasedimentary rocks close to the contact. There is a noticeable lack of xenoliths in the granite close to the contact. This, along with the observation that the boundary between

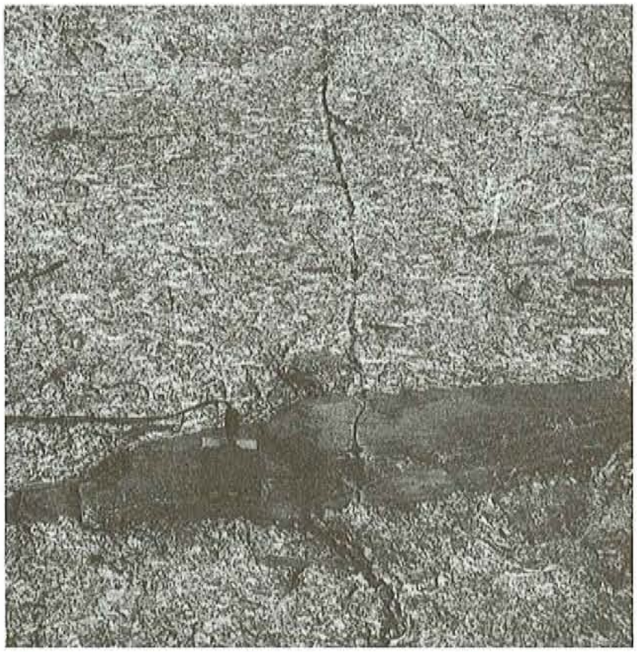

Plate 1. *Elongate metasedimentary xenolith in the Gander Lake Granite, aligned parallel to the magmatic foliation defined by feldspars. Note compass for scale, near bottm left corner.*

Plate 2. *Contact between the Gander Lake Granite and metasedimentary rocks of the Gander Group. Note the pick for scale at bottom of plate.*

xenolith and granite is typically very sharp (Plate 3), i.e., no assimilation of metasedimentary material, implies that the granite intruded relatively cool rocks.

Locally, the granite is cut by numerous, thin, quartz- and epidote-rich veins. Pegmatitic veins, which are generally

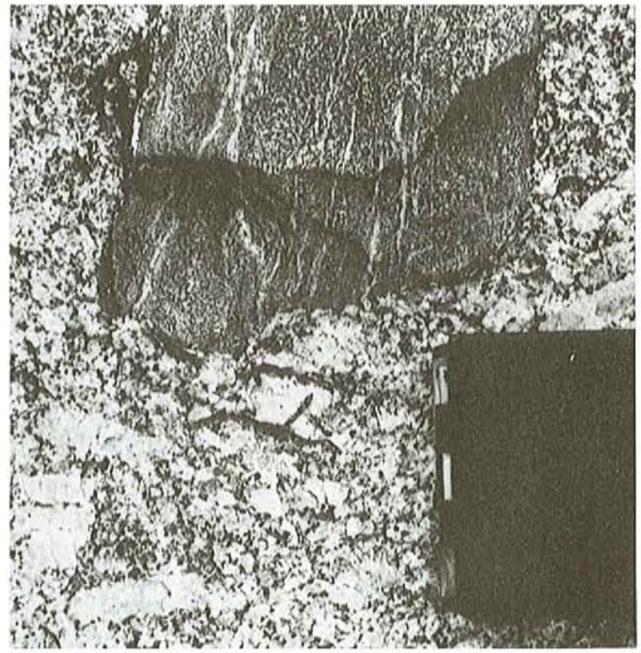

Plate 3. *Angular xenolith in the Gander Lake Granite. Note the sharp contact.*

tourmaline-bearing rarely occur and are less than 2 m thick. In one outcrop, the megacrystic granite is intruded by a leucocratic, equigranular, quartz–feldspar granite in which grain size ranges up to 3 mm. The contact is irregular and there is no obvious chilled margin. Elsewhere, a 10-cm-thick, fine-grained leucocratic granite dyke cuts the Gander Lake Granite and the margins of this dyke are overgrown by small megacrysts. In the boulder fields south of Second Burnt Pond, some megacrystic granite boulders contain fine-grained granite inclusions. The inclusions show rounded margins and contain some megacrysts.

Approximately 2 km north of the eastern end of Rodney Pond, an exposure of a finer grained variety of the Gander Lake Granite (subunit 9a) occurs (Figure 1). The granite contains quartz, feldspar and biotite and the average grain size is 3 mm. Disseminated megacrysts are up to 3 cm long and form less than 10 percent of the rock. Although the exposure is small, approximately 10 m across, this equigranular granite is the predominant rock type in boulders found in the immediate area, and this suggests that subunit 9a underlies a much more extensive area than that implied by the exposure.

METAMORPHISM

All of the sedimentary rocks mapped in the area have been metamorphosed to either greenschist or amphibolite facies and most of this metamorphism is attributable to nearby granitic intrusions. Kyanite schists, which occur near Square Pond, are not directly related to any granitic body and are discussed separately below.

Peripheral to the Gander Lake Granite, rocks of the Gander Group are thermally metamorphosed to hornfelses. Biotite, garnet, andalusite and cordierite are the principal index minerals in the aureole. In the northwest (near the mouth of Fifteen Mile Brook), there may be some overlap between metamorphic effects of the Gander Lake Granite and the leucocratic granite believed to be nearby (O'Neill, 1990).

Schistose rocks west of Rodney Pond contrast texturally with rocks in the aureole of the Gander Lake Granite. The pelitic and semipelitic rocks near the garnetiferous, leucocratic granite that outcrops west of Rodney Pond are typically medium- to coarse-grained schists. Biotite and garnet are developed near Rodney Pond as is andalusite and, locally, fibrolite. Sillimanite schist occurs farther west in the vicinity of the larger body of granite near Gillinghams Pond (O'Neill, 1990).

DEFORMATION

One principal tectonic foliation is defined throughout much of the Gander Group. This fabric is designated S_2 (so as to conform with fabric description established in the Weir's Pond area (O'Neill and Knight, 1988) and immediately north of the present map area; O'Neill, 1990). West of the Gander Lake Granite, S_2 has a shallow to moderate dip to the west and northwest. Locally, the foliation strikes north-northwest and has a shallow dip. The foliation is subhorizontal in places. On the southern shore of Gander Lake, where a small area of the Gander Group is partially enclosed by the Gander Lake Granite, S_2 strikes northeast and dips steeply northwest. This strike contrasts with the general trend of S_2 north of the lake but is parallel to a major lineament, which apparently controls the topography at the south end of Soulis Pond. The strike of S_2 also appears to bend and becomes sub-parallel to this lineament, north of the lake near Soulis Brook.

Several exposures of the Gander Group on the south side of the lake (south of Soulis Brook) are characterized by brecciation (Plate 4). The fragments within the breccia range up to approximately 5 cm across and are generally rounded to subrounded. The breccia has a quartz-rich matrix and occurs in zones approximately parallel to the foliation/bedding. The remainder of the exposure is dominated by psammite, which has a well-developed pressure solution cleavage. A similar breccia has been mapped on the north side of Home Pond. The brecciation is pre- or syn-metamorphism and may be the result of faulting.

East of Gander Lake, the S_2 foliation strikes north-northeast and dips moderately to steeply west-northwest. Locally, the main foliation is folded by mesoscopic scale, open to tight F_3 folds and by a crenulation lineation.

THE WING POND SHEAR ZONE

Schists, which exhibit a high-strain foliation and contain kyanite, sillimanite and andalusite, occur in several exposures northeast of Square Pond. Biotite-, muscovite- and hornblende-bearing granites and gabbro, outcrop as small

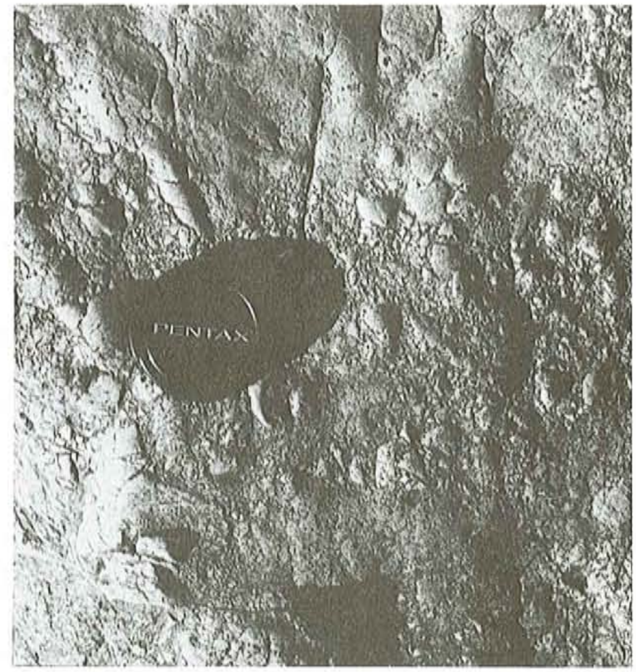

Plate 4. *Subrounded fragments in breccia zone in metasedimentary rocks of the Gander Group, southern shore of Gander Lake.*

bodies within or adjacent to the phyllonites and contain a weak to high-strain foliation. Phyllonites also occur south of Square Pond. The metamorphic assemblages, the high-strain foliation and the particular association of rock types, allows a correlation to be made with rocks exhibiting similar features along strike in the Wing Pond and Gull Pond areas (O'Neill and Knight, 1988; O'Neill, 1990). The correlation is further strengthened by a regional, positive aeromagnetic anomaly, which is coincident with the shear zone throughout its strike length. Exposures of gabbro and biotite or hornblende granite in the Wing Pond, Gull Pond and Square Pond areas and of ultramafic rock near Square Pond and Butts Pond are spatially associated with the shear zone, which suggest that the aeromagnetic anomaly is due to a large mafic-ultramafic body, occurring at depth. This zone of rocks exhibiting a high-strain foliation is termed the Wing Pond Shear Zone, after the area where the most extensive exposures of phyllonites is found. The shear zone is considered to be a regional feature, at least 40 km long and up to 3 km wide, locally. If the interpreted correlation with the aeromagnetic anomaly is correct, then the shear zone continues southward along strike because the anomaly continues at least as far south as the Maccles Lake Granite.

In the vicinity of Square Pond, the high-strain foliation strikes north to north-northeast and predominantly dips steeply northwest. Concordant, pretectonic granitic and gabbroic bodies also locally contain the high-strain foliation. A preliminary examination of the asymmetry of the foliation and syntectonic folds in the area suggest a dextral sense of shear. Near Square Pond, tight, upright folds are developed in psammite and semipelite and their axial planes are sub-parallel to the high-strain foliation of the Wing Pond Shear Zone. These folds fold the regionally developed solution seam or pin-stripe banding (S_2) in the Gander Group and are therefore termed F_3. The sub-parallel nature of the S_3 and high-strain foliations suggests that their development may be related.

The juxtaposition of low- to medium-pressure rocks with metasedimentary rocks at chlorite grade, which is apparently characteristic of the Wing Pond Shear Zone, suggests a significant dip-slip component of motion, in addition to the strike-slip component. The relative timing of the dip-slip and strike-slip components is unknown. At least locally, the high-strain zone coincides with the southeastern margin of the Indian Bay Big Pond Formation. Because of the significant dip-slip component of motion in the zone, the kyanite-, andalusite- and sillimanite-bearing phyllonite may not necessarily represent part of the Gander Group. If the phyllonite is part of the group, it is not clear which of the Jonathan's Pond or Indian Bay Big Pond formations it represents. The presence of the shear zone also implies that the Gander Group is not a continuous sequence.

Farther east toward Gambo, and away from the high-strain zone, the grade of metamorphism decreases. This decrease was also observed east of Wing Pond.

Based on mapping in the eastern Gander Lake Subzone, Blackwood (1977, 1978) defined the Square Pond Gneiss as a paragneiss unit, which he interpreted as equivalent to the Gander Group but at a higher metamorphic grade. He concluded that the Square Pond Gneiss was separated from the Hare Bay Gneiss by a migmatite front. The Square Pond Gneiss encompasses greenschist- and amphibolite-grade rocks in the Ocean Pond, Wing Pond and Square Pond areas and farther south. However, recent mapping (O'Neill and Lux, 1989; O'Neill, 1990 and this paper) has shown that 1) although the protolith (the Gander Group) remains the same throughout, the type of metamorphism is variable in the Square Pond Gneiss, 2) the metasedimentary rocks do not represent part of a prograde (west to east) sequence, and 3) the metasedimentary rocks are not gneisses. In the Ocean Pond area, the regionally metamorphosed rocks define a low pressure—high temperature type of metamorphism associated with the foliated, garnetiferous, leucocratic Ocean Pond Granite (O'Neill and Lux, 1989). North of Four Mile Pond, the metamorphic rocks represent the thermal aureole to the posttectonic Deadmans Bay Granite. Metamorphic rocks in the Wing Pond area are distinct again and have been described in O'Neill and Lux (1989; see above, Wing Pond Shear Zone). Therefore, it is recommended that the term Square Pond Gneiss be dropped and the rocks included under this term revert to their former status as part of the Gander Group.

It is important to emphasize that east of the Wing Pond Shear Zone in the Wing Pond area and near Gambo, the metamorphic grade actually decreases. Thus, metamorphic rocks in the Gander Lake Subzone do not represent the effects of one progressive regional (west to east) metamorphic event. Hence, the Hare Bay Gneiss does not represent a culmination of any such regional metamorphic process, but represents a more localized metamorphism spatially associated with the eastern boundary of the Gander Zone. The timing of the various metamorphic and structural events is uncertain.

ECONOMIC GEOLOGY

Quartz veins are profusely developed in many exposures of the Gander Group, however, no obvious mineralization was noted. A gossan, 1 to 2 m thick, occurs within the eastern part of the ultramafic body (subunit 3b) exposed in a roadcut on the Trans-Canada Highway; much of the gossan is a brown mud.

ACKNOWLEDGMENTS

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