NORTHEASTERN GANDER ZONE, NEWFOUNDLAND

by R.F. Blackwood

INTRODUCTION

The Gander Zone (Williams *et al.*, 1974) forms a linear crystalline belt along the southeastern side of the Appalachian Orogenic Belt in Newfoundland. It is underlain by polydeformed and metamorphosed sedimentary rocks, paragneisses and migmatites. A variety of plutonic rocks are intrusive into the metamorphic units. The Gander Zone is bounded to the west by the Davidsville Group (Kennedy and McGonigal, 1972) of the Botwood Zone (Williams *et al.*, 1974); to the east the Dover fault (Blackwood and Kennedy, 1975) separates it from the Avalon Zone (Williams *et al.*, 1974).

Twenhofel (1947) named interbedded sedimentary and volcanic rocks along Gander Lake the "Gander Lake Series" and believed them to be of Silurian age. These rocks were raised to group status by Jenness (1958) and he later subdivided the Gander Lake Group into three units (lower, middle and upper) to include rocks from Glenwood in the west to Hare Bay in the east (Jenness, 1963). He interpretted these rocks to be part of a conformable sequence which underwent eastward prograde metamorphism. Jenness assigned a Middle Ordovician age to the group based upon brachiopods and graptolites in the middle and upper units.

Kennedy and McGonigal (1972) redefined the Gander Lake Group to include only those rocks in the lower unit of Jenness but excluding most of the gneissic rocks of a presumed basement complex to the east. They renamed the fossiliferous middle and upper units of Jenness, the Davidsville Group of Middle Ordovician age. The Davidsville Group was described as overlying the Gander Lake Group by an inferred major angular unconformity. Thus, a pre-Middle Ordovician age was assigned to the Gander Lake Group.

The gneissic rocks in the east were named the Bonavista Bay Gneiss Complex by Blackwood and Kennedy (1975) and were interpreted as part of a basement terrain. Blackwood (1976, 1977) subdivided the gneiss complex into a paragneiss unit (Square Pond Gneiss), and a migmatite unit (Hare Bay Gneiss), separated by a migmatite front; a presumed tectonic break, interpreted as a basement/cover contact, was indicated as the boundary between the Square Pond Gneiss and the Gander Group.

During the 1977 field season the major elements of the Gander Zone, namely the Square Pond Gneiss, the Hare Bay Gneiss and the Gander Group, were investigated to determine continuity and consistency of relationships along strike, including the Dover Fault, the migmatite front, and the basement/cover contact. The Dover fault was located south of Terra Nova Lake and Davidsville/ Gander Group relationships were examined briefly in the Weir's Pond area.

GENERAL GEOLOGY

The following is a brief description of the major rock units and structures of the northeast Gander Zone.

The Square Pond Gneiss

The Square Pond Gneiss (Unit 1) consists of psammitic and semipelitic paragneisses with zones of schist and migmatite (Blackwood, 1976, 1977). A good cross-section is exposed along the Trans Canada Highway in the vicinity of Square Pond. In the northeastern Gander Zone, these rocks form a narrow belt approximately 150 km long by 12 km wide, extending from Lake St. John in the southwest to Musgrave Harbour in the northeast. The belt is bounded by the Gander Group to the west and the Hare Bay Gneiss to the east. Large areas of posttectonic megacrystic granite intrude the paragneisses as well as lesser amounts of foliated granite.

Psammitic paragneiss with a "pinstripe" banding is characteristic of the Square Pond Gneiss north of Gambo Pond. Semipelitic to pelitic zones are common and, locally, small areas of migmatite are developed. Bedding and a clastic texture are preserved in some localities, generally in the more siliceous horizons. The main fabric is a composite gneissosity/schistosity which transposes an earlier banding. This fabric locally parallels a lithological variation presumed to be primary.

South of Gambo Pond, the paragneisses are more pelitic and biotite/muscovite schists are common. Psammitic horizons show the composite gneissosity, which is generally less well defined than in the north. Zones of migmatite and strongly feldspathized semipelitic gneiss occur locally.

The metamorphic grade of the Square Pond Gneiss varies from greenschist to upper amphibolite facies. Generally, this increase occurs from west to east towards the migmatites of the Hare Bay Gneiss.

Hare Bay Gneiss

The Hare Bay Gneiss (Unit 2) consists of migmatite and tonalite gneiss containing xenoliths and rafts of paragneiss (Blackwood, 1976, 1977). Representative exposures occur at Hare Bay and vicinity in Bonavista Bay. In the northeastern Gander Zone, the Hare Bay Gneiss outcrops in a linear zone approximately 140 km long by 10 km wide, extending from Ocean Pond in the southwest to the Wesleyville area in the northeast. It is bounded by the Square Pond Gneiss to the west; the Dover Fault separates it from the Avalon Zone to the east. A variety of foliated granitoid rocks intrude the migmatites and are largely concentrated in the northwestern part of Bonavista Bay.

The Hare Bay Gneiss in the Bonavista Bay region consists mainly of crudely banded, biotite migmatites. Individual bands are discontinuous and marked by diffuse margins. Locally, zones of regularly gneissose, tonalitic orthogneiss occur. Paragneiss inclusions are common and represent a variety of lithologies; etc., semipelitic, psammitic, and amphibolitic rocks. The gneissosity of the tonalitic host forms augen around these xenoliths which contain earlier tectonic fabrics. Complex interference patterns are common throughout the gneiss terrain; the metamorphic grade is upper amphibolite facies.

South of Terra Nova Lake the migmatites form a narrow belt approximately 5 km wide. Relationships similar to those in the north exist; however, less remobilization appears to have occurred since a greater proportion of the paragneiss protolith is preserved. This area is also marked by fewer foliated granitoid rocks although small bodies are present.

A migmatite front, defined by the formation of granitic sweats, feldspathization and lit-par-lit granitic veining in the paragneiss protolith, separates the Square Pond and Hare Bay Gneisses. It represents an abrupt change in the north but appears to be more gradational in the south.

Gander Group

The name Gander Lake Group as defined by Kennedy and McGonigal (1972) was shortened to Gander Group (Unit 3) by McGonigal (1973) and Blackwood and Kennedy (1975). It comprises dominantly polydeformed metasedimentary rocks that are well exposed along Gander Lake and the Trans Canada Highway east of Gander. The Gander Group appears to be a linear belt some 30 km wide in its central portion but forms a narrowing tongue east and northeast of Weir's Pond. It outcrops south of Gander Lake and is presumed continuous with metasedimentary rocks east of Middle Ridge.

The Gander Group is bounded by the Davidsville Group of the Botwood Zone to the west and by the Square Pond Gneiss to the east. It is intruded by synkinematic, two mica, leucocratic granites with garnetiferous phases and by posttectonic megacrystic granites.

Monotonous psammites and semipelites are characteristic of the Gander Group. However, minor conglomerate, quartz wacke, quartzite, black pelite, and basic volcanic rocks also occur (Indian Bay Big Pond area). West of Lake St. John, black pyritiferous slate horizons are interbedded with the psammites. Where recognizable, beds vary from 8 cm to 1 m thick.

The Gander Group is polydeformed with a fine first fabric developed parallel to bedding (indistinguishable in highly siliceous beds). A second schistosity transposes the first fabric and is axial planar, locally, to large scale recumbent folds. Third phase folds are upright to shallowly plunging and may have a widely spaced, axial planar foliation. The metamorphic grade ranges from greenschist to lower amphibolite facies and is apparently highest around the synkinematic granites; garnet-staurolite schists in the Middle Ridge area are interpreted to represent a local increase in metamorphic grade around the margins of a large foliated leucocratic granite.

Gander Group/Square Pond Gneiss relationships

Gander Group metasedimentary rocks have been interpreted as a cover sequence to gneissic rocks in the east (Kennedy and McGonigal, 1972; Blackwood and Kennedy, 1975; Kennedy, 1975; Blackwood, 1976). Blackwood (1977) defined a tectonic break between the Square Pond Gneiss and the Gander Group in the Gull Pond area and interpreted it as a basement/cover contact. In that region the contact separates low grade psammites, quartz wackes, and semipelites of the Gander Group from paragneisses and migmatites of the Square Pond Gneiss. A strong aeromagnetic signature coincides exactly with the boundary. The contact between the two terrains, when projected along strike, is nearly everywhere marked by contrasting aeromagnetic patterns. Thus, the belt of rocks east of the projected contact consisting of paragneisses, migmatite and schists but including minor low grade metasedimentary rocks were thought to be basement gneisses; rocks west of the contact consisting of largely low grade metasedimentary rocks were interpreted as a cover sequence. However, field relationships in the Indian Bay Big Pond, Gambo Pond, and Lake St. John areas suggest a conformable contact approximately coinciding with a metamorphic isograd.

The Gander Group comprises psammites, quartz wackes and semipelites along the west half of Indian Bay Big Pond. Bedding is locally well developed and there is a composite phyllitic fabric parallel to it. This foliation is represented by a fine banding on weathered surfaces. Rocks included in the Square Pond Gneiss consist of psammites and semipelites close to the Gander Group; they are thinly laminated and contrast sharply with the Gander Group in this regard. A regular banding parallels this lithological variation, which is similar to and appears to merge with the composite fabric of the Gander Group. A clastic texture is recognizable in both units but more commonly in the Gander Group. The metamorphic grade is low greenschist in the contact area but increases rapidly eastwards with the appearance of medium size muscovite and biotite grains on the main foliation planes in the eastern part of the pond. These rocks grade into upper greenschist and amphibolite facies rocks in the extreme east where the regular banding becomes the "pinstripe" gneissosity typical of the Square Pond Gneiss. (It should be noted that greenschists identical in lithology to those of the Gander Group outcrop within the paragneiss terrain and are demonstrably conformable with the latter [subdivision la of Blackwood, 1977]).

Similar relationships exist between the Square Pond Gneiss and the Gander Group at the southwest end of Gambo Pond. A composite schistosity in laminated semipelites of the Gander Group produces a regularly banded rock identical on weathered surfaces to Square Pond Gneiss. The phyllitic fabric becomes finely schistose close to the contact and is replaced by a fine metamorphic banding in easterly exposures of the paragneisses.

In the Lake St. John area, the contact is marked by the development of small feldspar porphyroblasts in semipelitic schists. They disappear over a short distance westward but become more profuse towards the east.

The Gander Group/Square Pond Gneiss contact approximates a biotite isograd in this region.

Gander Group/Davidsville Group relationships

Kennedy and McGonigal (1972) interpreted the Davidsville Group as overlying the Gander Group with "inferred major angular unconformity". This was based on (a) the presence of metamorphic detritus in Davidsville Group graywackes; (b) the presence of metamorphic fragments in melange, locally developed at the base of the Davidsville Group in the north; and (c) the contact between the two groups was one of structural discontinuity. Kennedy (1975) described an unconformity between the Davidsville Group and ultramafic rocks deformed with the Gander Group on the north shore of Gander Lake. However, Currie and Pajari (1977), working north of Weir's Pond, indicated a conformable contact between the two groups and described the mélange in that region as cutting "downward across the stratigraphy of the Davidsville rocks, terminating in the upper part of the Gander sequence". Thus, the exact nature of the contact in the area between Gander Lake and north of Weir's Pond is problematical.

The Gander River ultrabasic belt (Unit 4) of Jenness (1958a) is represented by gabbro, serpentinite, and talc-carbonate schist in the vicinity of Weirs Pond. Ultramafic rocks are not exposed in contact with the Gander Group and rarely with the Davidsville Group; fine grained gabbro commonly intrudes basaltic horizons within the latter.

The Davidsville Group directly west of Weir's Pond, comprises narrow (0.5 to 1.5 km wide), northeast trending, lithological units. These units consist of foliated, poorly sorted conglomerates, graywackes, and gray-black slates. In one horizon, near Weir's Pond, the conglomerate is reworked agglomerate containing a variety of volcanic detritus. In other exposures the conglomerates include basaltic, gabbroic and ultramafic pebbles. Trondhjemite clasts are common in the conglomerates and graywackes and locally form the highest proportion of clasts. A lenticular zone of fine grained basalt pervaded by gabbro and intruded by trondhjemite is apparently intercalated with the sedimentary rocks.

Two limestone (and associated dolostone) localities outcrop on the west side of Weir's Pond. The northern occurrence is east of a small serpentinite body with unexposed contacts; the southern occurrence is west of a small serpentinite body and appears to be in depositional contact with it. At the southern locality, the limestone grades into calcareous graywacke through to black and gray slates. Jenness (1958) collected brachiopod fragments from both limestone sites and suggested an Ordovician age. Reasonably well preserved brachiopods and gastropods were collected during the 1977 field season for further identification. From the southern locality, a coarse ribbed species of *Orthambonites* suggests an Early Ordovician to early Middle Ordovician age (R.G. Newman, written communication, 1978); gastropods representative of *Paraphistoma* and *Maclurea Speciosa* Billings indicate a late Early Ordovician to early Middle Ordovician age (E.L. Yochelson, written commenication, 1978). Also some samples from the northern locality were examined by Mr. Svend Stouge of Memorial University of Newfoundland for conodonts. His preliminary fauna list is of the North Atlantic province affinity and indicates an Upper Llanvirn-Lower Llandeilo age.

The Davidsville Group is overprinted by a northeast trending, steeply dipping foliation in the Weirs Pond area that is subparallel to bedding and axial planar to isoclinal folds; it appears to be a single fabric in the field.

No outcrops occur along the east side of Weir's Pond but a small island near the southeast shore is underlain by strongly foliated, gray psammites typical of the Gander Group. East of Weir's Pond (approximately 1.5 km) psammites, semipelites and quartz wackes of the Gander Group are exposed. These rocks are identical in lithology and structural style to the rest of the Gander Group. A composite schistosity axial planar to small scale F_2 folds is common. The metamorphic grade increases eastward and the rocks appear to grade into paragneisses northwest of Indian Bay Big Pond (rocks in this area were only briefly examined using a helicopter).

From the above, the following points regarding the Davidsville Group/Gander Group contact may be made. First, and most importantly, it represents an abrupt change in lithofacies from the monotonous, mainly psammitic sequences of the Gander Group to the volcanogenic and flyschoid sequences of the Davidsville Group. Secondly, the nearest outcrops of Gander Group rocks east of Weir's Pond are polydeformed whereas similar structures are not readily observable in Davidsville Group rocks west of the pond. Thus, the contact may be one of structural discontinuity. Finally, if the limestone on Weir's Pond is in depositional contact with serpentinite, it may have the same significance as the unconformity on Gander Lake.

Intrusive Rocks

Plutonic rocks intrusive into the Gander Zone may be subdivided into three broad categories based upon composition and (where possible) relative age. (This is a simplified classification and is not meant to imply a rigid designation of age). The first group consists of coarse grained, megacrystic granites (Unit 5) which form linear bodies that are restricted to the migmatites of the Hare Bay Gneiss. A strong, northeast trending fabric, commonly with a cataclastic component, overprints these granites and the country rocks. Locally, however, areas of weakly deformed to undeformed granite occur.

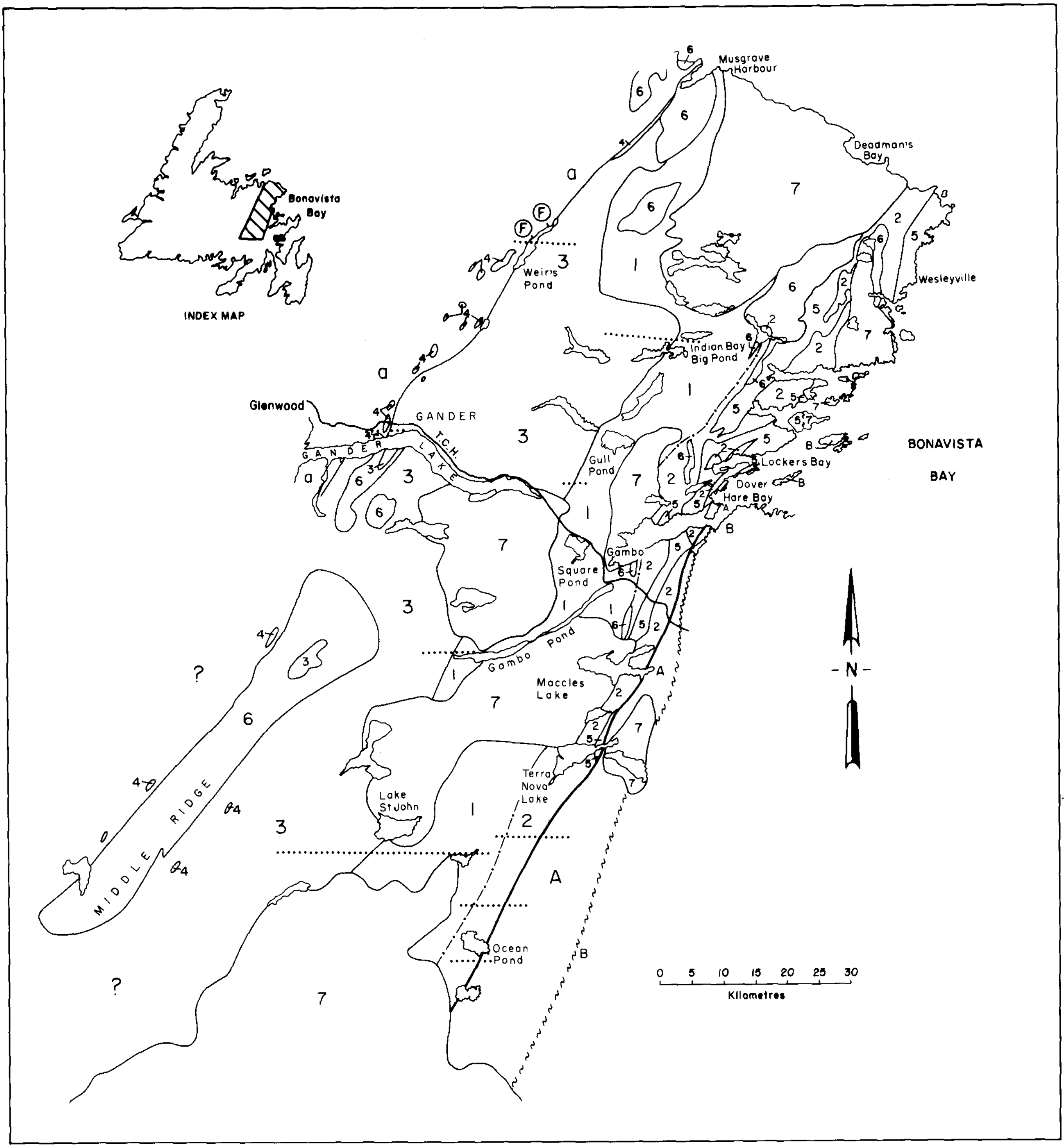
A second group comprises medium to coarse grained, locally porphyritic, two-mica leucocratic granites (Unit 6). Locally, richly to sparsely garnetiferous phases are associated with these rocks. The leucocratic granites form linear to elongate bodies which intrude the major subdivisions of the Gander Zone including the foliated megacrystic granites. (Similar granites intrude rocks that have been defined as the Davidsville Group by Currie and Pajari (1977), east of Musgrave Harbour). The granites range from massive to strongly schistose; in the east they intrude the foliated megacrystic granites pretectonically (Blackwood, 1976; Jayasinghe, this volume). Elsewhere, they show the polyphase structures of the Gander Group (Kennedy and McGonigal, 1972; Currie and Pajari, 1975).

A third group of plutonic rocks consists of undeformed (except marginally) coarse grained megacrystic granites (Unit 7). These large, massive plutons have crudely globular outlines which truncate the major structural and lithologic units of the country rocks.

GANDER/AVALON ZONE BOUNDARY

The Dover Fault, a 300-500 m wide mylonite zone, forms the boundary between the Gander and Avalon Zones in northwestern Bonavista Bay (Blackwood and Kennedy, 1975). It continues southward to Maccles Lake and on to Terra Nova Lake (Blackwood, 1976). The fault separates the gneisses and granites of the Gander Zone from Love Cove Group (Unit A) volcanic rocks of the Avalon Zone. The mylonites which underlie the fault zone developed during the regional deformation of the Love Cove Group and the formation of the cataclastic foliation overprinting some of the granites and gneisses of the Gander Zone.

Relationships which occur along the Dover Fault north of Terra Nova Lake continue south of the lake. The



Geological sketch map of the northeast Gander Zone (in part after Jenness, 1963; Kennedy and McGonigal, 1972; Blackwood, 1976, 1977; Currie and Pajari, 1977; Jayasinghe, this volume).

LEGEND

BOTWOOD ZONE

MIDDLE ORDOVICIAN AND YOUNGER

a	**DAVIDSVILLE GROUP:** *Slates, graywackes, conglomerates, and volcanic rocks.*

GANDER ZONE

DEVONIAN AND OLDER

7	*Undeformed megacrystic granites.*
6	*Foliated two-mica granites (locally garnetiferous).*
5	*Foliated megacrystic granites.*
4	**GANDER RIVER ULTRABASIC BELT:** *Gabbro, pyroxenite, and serpentinite.*

LOWER ORDOVICIAN OR OLDER

3	**GANDER GROUP:** *Psammites, semipelites, and minor volcanic rocks.*
2	**HARE BAY GNEISS:** *Migmatites with paragneiss inclusions.*
1	**SQUARE POND GNEISS:** *Paragneisses with migmatite zones.*

AVALON ZONE

HADRYNIAN

B	**MUSGRAVETOWN GROUP:** *Shale, sandstone, conglomerate and volcanic rocks.*
A	**LOVE COVE GROUP:** *Metavolcanic and metasedimentary rocks.*

SYMBOLS

Gradational contact ....

Fault (defined, assumed) ....

Dover Fault ....

Study areas during 1977 field season ....

gneisses are overprinted by a strong cataclastic fabric close to the fault zone and granite protoliths range from protomylonites to ultramylonites. The Love Cove Group acid volcanic rocks and associated quartz-feldspar porphyries are similarly overprinted by a strong cataclastic foliation. Exposure is poor southwest of Ocean Pond but the Dover Fault appears to be terminated by a megacrystic granite (Ackley Batholith of White, 1939) which is completely undeformed in this area.

MINERALIZATION

Few mineral showings have been found by previous workers or this writer in the northeast Gander Zone. Jenness (1958a and 1963) reported showings of chromite, asbestos, and talc in association with the Gander River ultrabasic belt and minor lead, zinc and pyrrhotite showings along the margins of granites intruding his Gander Lake Group. Leucocratic pegmatites and aplites which intrude the gneisses and granites of northwestern Bonavista Bay contain minor beryl, chrysoberyl, and molybdenite (Gale, 1967; Jayasinghe, this volume). Disseminated magnetite occurs locally in the migmatites. Minor volcanic and pelitic horizons in the Gander Group are pyritiferous.

DISCUSSION

In this report, rocks now defined as the Gander Group, Square Pond Gneiss, and Hare Bay Gneiss are interpreted as a conformable sequence which underwent prograde metamorphism from west to east. This is essentially the same conclusion reached by Jenness (1963). The older foliated megacrystic granites are restricted to the migmatite terrain and are regionally concordant with the country rocks. This spatial relationship might suggest that the granites are the cause of, and/or the result of, the formation of migmatites, especially since migma in the Hare Bay Gneiss is most extensive in northwestern Bonavista Bay where the greatest profusion of these granites occur. The discordant relationships, seen in detail, between the granites and structures in the country rocks could reflect an allocthonous magma, which at deeper structural levels would be gradational into migmatite; e.g. similar to granite/migmatite relationships in the Coast Ranges plutonic complex of British Columbia (Hutchison, 1969).

The deformed granites and migmatites are overprinted by a pervasive foliation which is interpreted to have formed during the deformation of the Love Cove Group. This implies that some, migmatization occurred before the late Precambrian since the deformation of the Love Cove Group is presently interpreted to predate the Late Hadrynian Musgravetown Group (Jenness, 1963; Blackwood, 1976; O'Driscoll and Hussey, 1977). However, diachronous deformation westward is a possibility, which would eliminate the restriction of all rocks of the northeast Gander Zone to the Precambrian.

The contact between the Davidsville and Gander Groups is apparently of a fundamental nature. It could represent a change from a relatively stable shelf area (Gander Group) to deeper water turbidites and volcanogenic deposits (Davidsville Group). The significance of the Gander River ultrabasic belt to this abrupt change in lithofacies is an intriguing problem yet to be resolved.

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