PLATFORMAL ROCKS AND GEOLOGY OF THE RODDICKTON MAP AREA, GREAT NORTHERN PENINSULA

by

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INTRODUCTION

1:50,000 geological mapping of the Cambro-Ordovician platformal rocks of the Roddickton map area commenced in the summer of 1979. The platformal rocks form a southward narrowing terrain of low elevation between the high mountains of the Long Range Mountains on the west and a slightly lower range of hills on the east. Narrow arms of the sea penetrate the area from south to north. The area overlying the platformal rocks is heavily forested with a few lakes and small marshes. Large areas of forest have been cut-over in the north; some of these cut-overs were later burned by a major bush fire in the late sixties. Access to the area by seas, highway and woods roads is good. Outcrop is present in many parts of the forest although not easily located.

Geological Setting

Three geological terrains occur in the Roddickton map area (fig. 2).

1. Precambrian crystalline basement (map unit 1, fig. 4) underlies the Long Range Mountains in the western part of the map area. Grenvillian gneisses and a variety of granites with associated pegmatite dikes cut by a northeast trending diabase dike swarm (Williams *et al.*, 1974a) occur in this terrain.

2. Cambro-Ordovician platformal strata (map units 2 to 7) unconformably overlying the Precambrian basement, occur in the central part of the area. The sequence includes both siliciclastic and carbonate rocks of Lower Cambrian to Middle Ordovician age. Minor volcanics also occur near the base of the sequence.

3. Allochthonous sedimentary and volcanic rocks of the Hare Bay Allochthon (map unit 8) structurally overlie the platformal terrain in the eastern part of the area (Smyth, 1973).

Mapping of the platformal terrain attempted to apply previously established lithostratigraphic subdivisions for the Cambro-Ordovician platformal rocks of the Great Northern Peninsula (see Knight 1978). This was partly successful in the northwest but is complicated for the rest of the area by a number of factors. These include:

A. Distinct lithological changes occur within the platformal sequence in the map area. These changes occur across north to northeast trending normal faults, called the Saltwater Cloud Pond, Shoal Pond and Hatters Pond Faults (see fig. 2) and reflect changes of depositional environment.

B. The platformal sequence is deformed to varying degrees. The intensity of deformation increases eastward and southward as the platformal rocks are pinched between the Hare Bay Allochthon in the east and the buttress of Long Range gneissic basement in the west. Metamorphism and recrystallization has affected the carbonates changing their character and appearance.

C. Thrust faulting has produced major repetitions of the succession in the area. This is further complicated by later northeast trending faults that offset both the stratigraphy and the thrust faults.

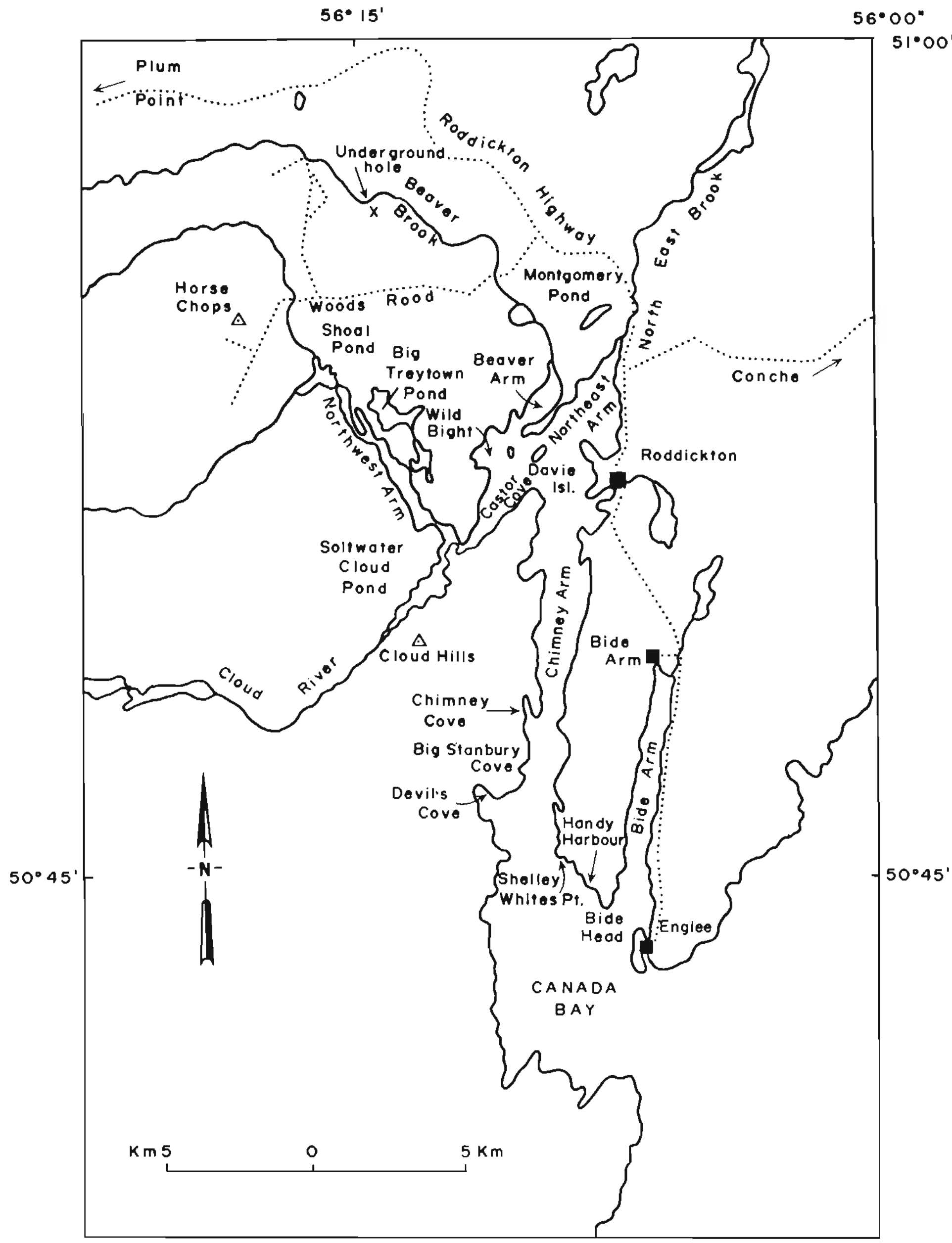


Figure I. Location Map of Roddickton Area

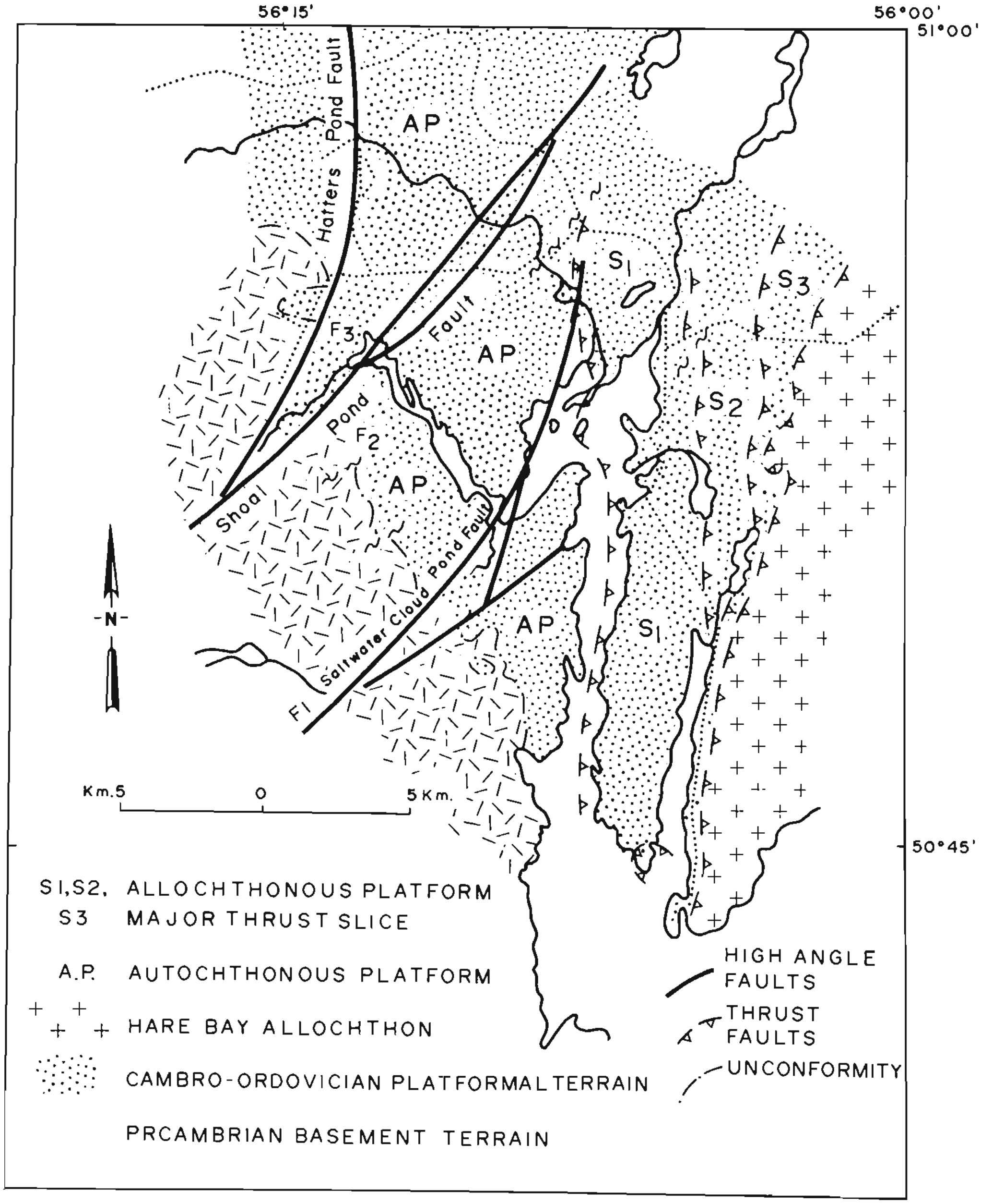


Figure 2

Generalised Map Showing Major Geological Elements of Roddickton Area includes Faults (F1, F2, F3) believed to have influenced sedimentation in the area

STRATIGRAPHY

The platformal sequence can be conveniently divided into four sequences.

1. A Lower Cambrian mixed siliciclastic and carbonate sequence referred to as the Labrador Group.

2. A Middle to Upper Cambrian carbonate sequence.

3. A Lower Ordovician carbonate sequence, the St. George Group.

4. A Middle Ordovician limestone and shale sequence, the Table Head and Goose Tickle Formations.

Labrador Group (map unit 2)

The Labrador Group consists of a mixed siliciclastic and carbonate succession with some localized mafic volcanics. The basal strata of the group which may be either pebbly arkosic sandstones or mafic volcanics unconformably overlie Precambrian basement along the west side of the area.

Oxidation, reduction and destruction of the textures of the gneisses below the unconformity occur locally and suggest that a regolith is locally preserved.

Four lithological units occur in the group in the map area.

A) Volcanic Rocks

These are tholeiitic, predominantly subaerial mafic volcanics (Strong and Williams, 1972; Strong, 1976). They occur in a number of isolated outliers upon Precambrian basement or may overlie a few metres of arkosic sediment (Smyth, 1973). A narrow fine grained diabase dike probably related to the volcanism cuts through to the top of the basal arkose unit where it becomes concordant to bedding.

B) Basal arkosic unit (Bradore Formation)

This unit sits unconformably upon Precambrian basement and consists of about 62 m of red to purplish-red pebbly arkose, arkosic sandstone, minor conglomerate and black to purple haematitic sandstones and a yellow weathering, dolomitic limestone. The arkoses are generally poorly sorted, coarse grained, crossbedded, with some planar stratification. Minor thin siltstone and mud partings occur and are usually mudcracked. The hematitic sandstones, however, are mostly very fine grained, micaceous with numerous shaly partings. Thin planar stratification, lamination, flaser bedding and some crossbedding are the main sedimentary structures.

The succession is divided into a lower arkosic sequence with a thin basal conglomerate, overlain by the hematitic sandstones which is capped by the dolomitic limestone and overlain by an upper arkosic sequence. The limestone is eroded and enclosed as clasts in a conglomerate at the base of the upper arkose. Other pebbles in the conglomerate include pisolitic ferruginous intraclasts mixed with quartz pebbles.

The formation was probably deposited by braided streams on alluvial fans. These sediments were derived from the northwest and southwest marginal to a Precambrian highland under semiarid conditions. The finer grained hematitic sandstones were, however, probably a more distal alluvial plain or perhaps a shallow marginal marine facies.

C) Siltstone-shale-limestone unit (Forteau Formation)

Green-gray, pyritiferous calcareous siltstones, black to gray shales, black, gray and mottled pink and cream colored limestones and some thin sandstones comprise the second formation of the Labrador Group. The base is placed at a cleaved, pink and cream colored limestone, the Devils Cove Limestone (Betz, 1939). Above the limestone, the formation is well bedded consisting of beds of laminated calcareous siltstone separated by thin shales and enclosing nodular limestone or limestone beds. The limestones are generally finely crystalline and some are highly fossiliferous, containing abundant *Salterella*. Thinly laminated and crosslaminated sandstones occur in the upper part of the formation. Slumping and channels are recognized locally in the formation.

A black shale sequence with thin black limestones and some black laminated siltstones occurs in the middle of the formation. The unit is highly deformed and rich in folded quartz and calcite veins and tension gashes. A single trilobite fragment of *Olenellus (Paedumias) Transitans* (Walcott) (Boyce, personal communication, 1979) was recovered from the unit. A coarsening upward black, limestone unit occurs a few metres above the black shales. It consists of micrite, fine calcarenite, oolitic calcarenite and is capped by an oncolitic, oolitic calcarenite.

The lithologies of the formation are characteristic of outer shelf muddy siltstones, deposited under generally low energy conditions. The black shale probably marks a platform wide period of tectonic stability and possible climatic change and reflects generally stagnant basin conditions that existed at this time throughout the Northern Peninsula area.

D) Oolitic limestone-mudstone-quartzite formation

The upper formation of the Labrador Group is a mixed assemblage of oolitic limestones, mudstones, shales, sedimentary quartzites, dolomites and dolomitic sandstones. The unit is approximately 90 m thick and is probably laterally equivalent of the quite different Hawke Bay Formation (Knight, 1977) of the western side of the Northern Peninsula. The change occurs across the Hatters Pond and Shoal Pond Faults and further variations occur across the Saltwater Cloud Pond Fault. The lithologies are arranged in three cycles consisting of oolitic with some stromatolitic and oncolitic limestones and dolomites at the base overlain by dark brown weathering mudstones with some units of sedimentary quartzite.

The oolitic limestones are well stratified, lenticular wavy bedded or crossbedded. They include layers and lenses of oncolites, and also intraclasts derived from erosion of cemented oolitic limestones. Large and small sinuous ripple marks also occur. Stromatolites form layers of discrete club-shaped heads or broad, flat topped mounds within or at the top of the oolites. The dolomites occur mostly in the upper cycle and are also crossbedded.

The overlying mudstones enclose thin sandstone and quartzite beds. The mudstones are generally poorly bedded, lenticular bedded and in places exhibit crosslamination. Sedimentary deformation features such as sandstone dikes, ball and pillow structures and convolution are very common. Sandstones and 1-2 m thick sedimentary quartzite within the mudstones are usually rusty weathering, white, fine to medium grained, although one unit in the upper part of the formation contains angular, very coarse, pink feldspar sand grains. Thin planar stratification and large scale cross-stratification is common in the quartzites. Some thin, laminated dolomite beds occur in the mudstones in the upper cycle.

North of the Saltwater Cloud Pond Fault, the lithologies change with the appearance of sandy dolomites and dolomitic sandstones, interbedded with quartzites replacing much of the oolitic limestone-mudstone sequence. Mudcracks, crosslamination, crossbedding and intraformational breccia are common structures. A pink oolite bed forms a marker horizon in this part of the area. Shales and bioturbated shaly sandstone are common at the top of the formation. U-shaped burrows, *Corophoides* and simple tubular burrows are common trace fossils. Mudcracks occur at the base of the shaly sandstone.

The upper formation of the Labrador Group was deposited in a series of oolitic carbonate sand shoals probably forming at the shallow, high energy margin of the shelf. At times, it is possible these shoals were subaerially exposed as islands so that stromatolite complexes developed in the associated shallow shorelines. North of the Saltwater Cloud Pond Fault, intertidal carbonate flat sedimentation occurred probably in the lee of protective barriers formed by islands. The mudstones interlayered with the oolitic limestones may have been deposited westward of the oolite barrier whose geographical position likely migrated depending upon the volume of terrigenous sedimentation on the inner shelf. Alternatively, the mudstones may also represent periods when oolite formation was terminated by the influx of terrigenous material onto the shelf margin. The mudstones and thin sandstones are characteristic of mud dominated outer shelf deposits (Johnson, 1978). The thicker quartz sands are probably distal storm deposits washed eastwards from the inner sand dominated shelf represented by the Hawke Bay Formation. The abundance of sandstone dikes and sedimentary deformation in the mudstones probably reflects the tectonic instability of the shelf margin at this time.

Cambrian carbonate sequence (map unit 3)

The Cambrian carbonate sequence consists of two formations, the lower, consisting of limestone and the upper of dolomite.

A) Limestone formation (Equivalent to Micrite formation, Knight, 1978)

This unit overlies sharply and conformably the upper unit of the Labrador Group. It is approximately 80 m thick and consists of black to dark gray, argillaceous micrites, stratified micrites, bioturbated micrites with lenses of calcarenite and calcrudite, and oolitic limestones associated with a single unit of stromatolite. The base of the formation is usually dolomitic and shaly especially north of the Saltwater Cloud Pond Fault. Slumping of the limestones is common in the lower half of the formation. A 3-4 m bed of oolitic limestones with oncolites preserved at the top occurs in the upper part of the formation along Chimney Arm. The stromatolite bed consisting of domal mounds of SH-C and SH-V growth forms (Logan *et al.*, 1964), is associated with this oolite unit at Big Treytown Pond and at the mouth of Saltwater Cloud Pond.

Fauna collected from the formation includes the trilobites *Ehmania borealis* (Howell) and *Spencella (Solenopleura) pro'Avita* (Howell), and the inarticulate brachiopods *Patorina rotunda* Howell and *Micromitra cloudensis* (Howell) (Boyce, personal communication, 1979). These indicate an upper Middle Cambrian age.

B) Dolomite formation (equivalent to Dolomite and Unfortunate Cove formations, Knight 1978)

This formation which is at least 318 m and probably as much as 400 m thick consists of pale gray to dark gray, dolostones, gray to white, fine crystalline dolomites, dark gray to black, cherty dolostones and dolomites, green-gray dolomitic shales and minor black shales. It gradationally overlies the Middle Cambrian limestones. The formation includes strata equivalent to the Dolomite formation and Unfortunate Cove formation (Knight, 1977, 1978). The latter is now referred to as the cherty dolomite member of the Dolomite formation (see Knight, this volume). Only the cherty dolomite member of the formation can be distinguished in the area; the other lithological members of the Dolomite formation described by Knight, (1977, 1978, this volume) are not distinguishable.

In general, the formation consists of repetitive carbonate sequencs 2-5 m thick. These consist of dolostones and dolomitic shales or dolostones, stromatolites and dolomitic shales, in the lower 41 m of the formation. In the rest of the formation, sequences of mottled dolomites and dolostones, or dolarenites and dolostones with or without stromatolites occur together with some sequences of dolostone and dolomitic shale. The upper part of these sequences consisting of dolostone and/or dolomitic shale are usually very rich in subaerial features. These include mudcracks, dessication polygons, tepee structures, intraclastic, rip up breccias and pavements, fenestral porosity and some pseudomorphs of anhydrite. Small straight ripple marks also occur. Dolarenites may be oolitic or intraclastic and are usually crossbedded. Stromatolites are mostly isolated, domal mounds rich in styolites but generally lacking good internal structure. The mottled dolomites were originally thinly stratified and shaly before organic reworking and small scale soft sediment deformation which gives a knobbly appearance to the beds.

Interbedded at intervals through these repetitive sequences are thick bedded dolostone and dolomite sequences. These are well bedded and either of mottled dolostones, or of several beds of stromatolites. The latter are generally poorly defined and only bedding plane morphology aids in interpreting them as stromatolites. A thick unit of bedded dolostones consisting of alternating beds of fracture and fenestral porosity (Choquette *et al.*, 1970) lined by pink dolomite crystals forms a marker bed from Montgomery Pond to Shelley Whites Point. A collapse breccia disrupting stromatolites and stratified dolostones occurs at the top of a thick bedded and stromatolitic section at Shelley Whites Point, 67 m above the base of the formation.

The cherty dolomite member is well exposed in the area and consists of black and dark gray mottled dolomites and stromatolitic, fine crystalline, dolomites interbedded with buff weathering, mudcracked, pale gray dolostone. Chert layers are abundant. The base of the member is drawn at a sequence of large, stromatolite mounds and is well exposed on the shores of Northeast Arm. These mound horizons are correlated with similar mounds on the western side of the Northern Peninsula (Snow and Knight, 1979).

No fauna has been found in the formation in the area but is probably Upper Cambrian in age.

The dolomites were deposited predominantly in shallowing upward intertidal to supratidal and subtidal to supratidal sequences associated with an extensive development of carbonate shorelines and relatively humid hypersaline sabkha flats. Algal mats were widespread in the environment and stromatolite banks were important locally. The carbonates were periodically subaerially exposed leading to solution breccias forming in the thick bedded dolomite sequences.

Ordovician

Ordovician strata in the area includes the Lower Ordovician St. George Group and the Middle Ordovician Table Head and Goose Tickle Formations. The sequence is, however, structually dissected by thrust faults and no continuous section passing from Lower to Middle Ordovician occurs in the area.

Lower Ordovician St. George Group (map unit 4)

The St. George Group consists of three formations in the area.

A) Black dolomite and limestone formation (equivalent to Watts Bight formation, Knight, 1978)

This formation consists of black medium crystalline dolomite, limestone and chert. North of the Shoal Pond Fault, the unit is exclusively dolomite as it is elsewhere on the Northern Peninsula, (for description see Knight, 1977, 1978, this volume) but in the Roddickton area, south of the Shoal Pond Fault the dolomitization is restricted to a few beds totalling only 17 m thick. This thickness decreases southwards to 6 m and is located only at the base of the formation; the majority of which is composed of limestones with only patches of dolomite.

The unit overlies conformably and sharply the Upper Cambrian dolomites and is calculated to be approximately 86 m thick north of Northeast Arm but it probably thins to the southeast.

Large stromatolite mounds, 1-3 m diameter and 40-60 cm high and bioturbated, well bedded, black micritic limestones with layers of black chert nodules characterize the unit in the south. Dolomitization of burrows is widespread. Large coiled and partly coiled gastropods, gastropod opercula and some straight cephalopods occur rarely in the limestones. A few stromatolite mounds at the base of the unit have been observed in the unit in folded and foliated limestones west of Handy Harbour and northeast of Bide Head.

The unit was deposited in response to a major transgression that advanced rapidly westward across the Lower Ordovician platform. The limestones were deposited on the shelf in stromatolite banks and as extensive, subtidal bioturbated lime muds. The stromatolitic component is thinly developed in the southeast and occurs only at the base of the formation, reflecting the rapid transgression.

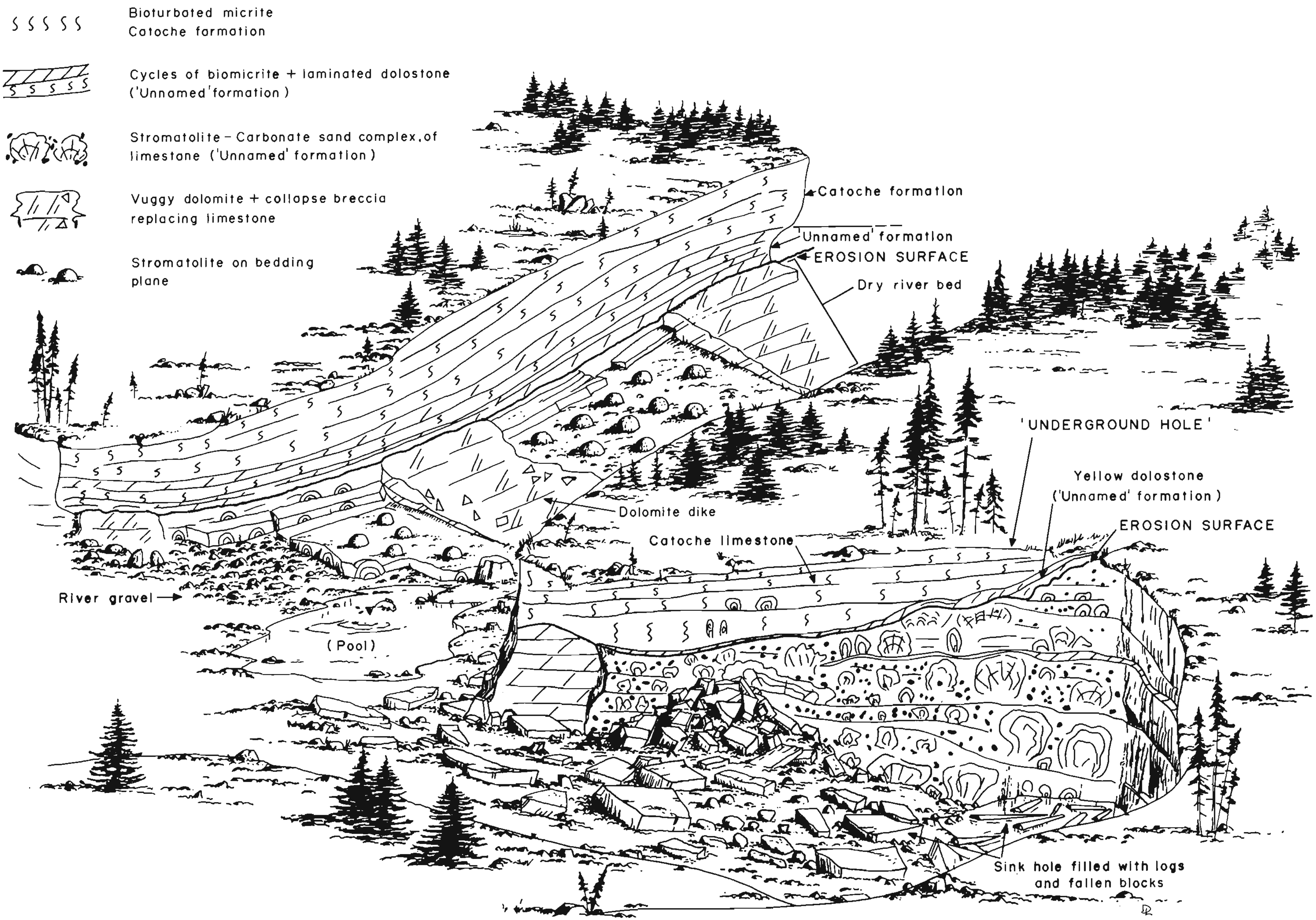
B) Limestone-dolostone formation (equivalent to Unnamed formation, Knight, 1978)

This is generally poorly exposed in the map area. It is best exposed along Beaver Brook and along woods roads west of Beaver Brook. Elsewhere, it is difficult to define due to lack of exposure but lithologies typical of the unit occur in a forest fire burn-over near Roddickton. The thickness of the unit also is variable. North of the Shoal Pond Fault, it is approximately 25 m thick, whereas on the shore near Roddickton, a thickness of approximately 54 m is calculated.

North of the Shoal Pond Fault, the formation sharply overlies the black dolomite of the basal formation of the St. George Group. The contact is probably a disconformity. A breccia composed of angular limestone and dolostone clasts set in a fine crystalline dolomite matrix and extending down into underlying black dolomite occurs at the contact. A similar breccia at the contact of the two units occurs elsewhere on the Northern Peninsula (Knight, this volume). Above the basal breccia, the formation consists of bioturbated and stratified micritic and biomicritic limestones interbedded with stromatolitic limestones and with laminated pale gray dolostones or yellow weathering dolomitic limestones. The lithologies are usually arranged in cycles of bioturbated micrite, stromatolite and laminated, usually mudcracked dolostone or dolomitic limestone. The cycles at the top of the formation resemble those above the "pebble bed" and disconformity at Boat Harbour in the north of the Northern Peninsula (see Knight, 1977, 1978).

A deposit of stromatolitic limestones and bio-intraclastic, sparry, calcarenites, at least 4 m thick occurs just north of the Shoal Pond Fault at the underground hole on Beaver Brook

FIGURE 3. SCHEMATIC DIAGRAM OF THE ERODED STROMATOLITE - CARBONATE BANK COMPLEX AT THE UNDERGROUND HOLE, BEAVER BROOK.



(figure 3). The deposit is transgressed by a downcutting erosion surface. Beneath the erosion surface, vertical dikes of vuggy, coarse crystalline, pinkish gray dolomites and dolomite breccias several to tens of metres wide abruptly replace the limestones of the stromatolite complex. The erosion surface is onlapped by the cycles of the upper part of the formation.

The limestone-dolostone formation is characterized by lithologies deposited in shallowing upward carbonate shoreline sequences including subtidal bioturbated lime muds, intertidal stromatolites and supratidal mudcracked dolostones or dolomitic limestones. These are typical of generally moderate to low energy conditions and indicative of a shallow shelf.

A high energy, stromatolite bank and carbonate sand shoal developed north of the Shoal Pond Fault and probably formed a topographic high in the generally flat lying shelf. This was subsequently subjected to dolomitization, karstification and erosion during a period of subaerial exposure of the platform late in the formation's history. The resulting disconformity probably correlates with the "pebble bed" disconformity at Boat Harbour (see Knight, 1978) since both are overlain by similar cyclic carbonate sequences that are characteristic of the upper part of the formation in both areas and are overlain by limestones of the Catoche formation.

C) <u>Bioturbated, well bedded limestone unit</u> (equivalent to the Catoche Formation, Knight, 1977, 1978)

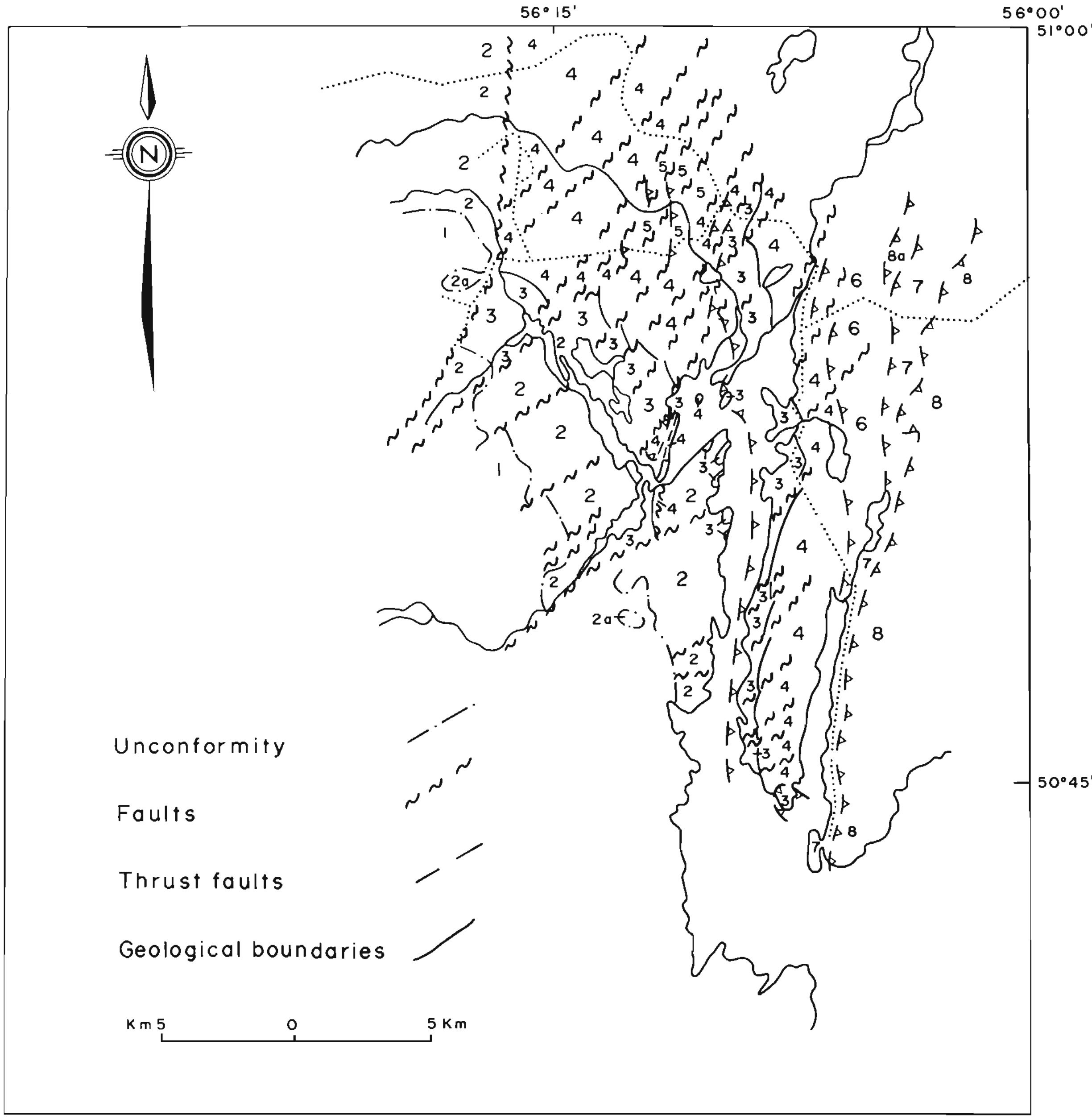
This unit consists of greater than 220 m of rubbly to massive, buff to pale gray weathering, blue-black to dark gray limestones. The formation underlies extensive areas of the northern part of the area and similar lithologies were mapped south to the southern end of the Bide Head Peninsula.

The limestones consist of well bedded, bioturbated micrites and biomicrites with lenses and layers of calcarenite and calcrudite and some layers of black chert nodules. Bedding varies between a few centimetres to 150 cm in thickness. The thickest beds occur in the upper part of the unit where they are associated with erosion surfaces separating beds of varying strike and dip. They probably formed as carbonate mud banks and appear to be more common south of the Shoal Pond Fault. Dolomitization of argillaceous laminae, drapes and burrows is common and locally affects the scour surfaces. Calcarenites and calcrudites occurring in the micrites are composed of rounded intraclasts and fossil debris. Concentrations of coiled and spiral gastropods and straight cephalopods, some of which are silicified or replaced by white calcite spar, are common on bedding planes. The largest fossils were associated with the mud banks. Sponges such as *Archeoscyphia, Receptaculites* and a pedunculate form also occur in the limestones.

Large stromatolite mounds with an irregular dolomite framework and associated with solitary sponges and biocalcarenites occur in the north of the area. The mounds resemble those noted by Knight (1978) northwest of Hare Bay and described by Stevens and James (1977) in Hare Bay. Limestone breccias composed of unbedded to crudely bedded micrite, biomicrite and dolomitic micrite rubble occur west of these mounds.

Crystalline dolomites (diagenetic carbonates of Knight, 1977, 1978) replace the upper part of the limestones north of Roddickton. These consist of dull, pale gray or cream colored dolomite mottles in dark gray dolomites which are bituminous in some beds. Porosity is high and some sparry dolomite and pseudobreccia (Cumming, 1968) is developed.

Trilobites were discovered on a small island near Davie Island. They include *Petigurus nero* (Billings),



8/8a	Hare Bay Allochthon
7	Deformed shales, limestone of uncertain age, marble and foliated limestone
6	Shale, limestone, dolomite - probably lower to upper Cambrian age
5	Middle Ordovician, Table Head & Goose Tickle Formations
4	Lower Ordovician, St George Group
3	Cambrian carbonate formations
2	Labrador Group (includes volcanic rocks (2a)
1	Pre-Cambrian basement

FIGURE 4

Geological Sketch Map of the Roddickton Area

Bolbocephalus convexus (Billings), *Isoteloides peri* Fortey, *Uromystrum* sp. nov., and *Bathyurina* sp. nov. (Boyce, personal communication, 1979). These are typical of the fauna that occurs in the base of the Catoche Formation at Boat Harbour (Boyce, personal communication, 1979).

The formation was deposited in response to a major transgression that affected the entire Ordovician platform. This produced a deepening of the shelf with deposition of subtidal, lime muds and bioclastic carbonate sands that host an abundant, soft bodied and skeletal fauna. Storms were probably important in fashioning mudbanks, producing erosion surfaces and transporting large quantities of previously deposited sediment across or off the shelf. North of the Shoal Pond Fault, stromatolite mounds with associated sponges and clean carbonate sands reflect a high energy shallower environment that probably formed a marginal shelf edge facies that extended from Roddickton to Hare Bay at this time (see Stevens and James, 1975).

Middle Ordovician (map unit 5)

This consists of the Table Head and Goose Tickle Formations. They are only positively identified in a dissected thrust slice in the Beaver Brook area.

The Table Head Formation consists of well bedded, blue-gray limestones which are massive, thickly bedded, bioturbated, fossiliferous and intraclastic micrites that generally lack dolomitization. Large, straight, cephalopods are common. These limestones are overlain by nodular, thinly stratified and shaly, highly fossiliferous limestone which pass up into black shales with thin limestones. The fauna includes:

Trilobites

Geragnostus sp., *Ampyxoides semicostratus* (Billings), *Niobe morrisi* (Billings) and *Nileid* gen. ind. Whittington (1965) (Boyce, personal communication, 1979)

Graptolites

Cryptograptus? tricornis schaeferi Lapworth, Glyptograptus cf. G. teretiusculus (Hisinger) and *Glyptograptus* sp. undet. (Skevington, personal communication 1979)

Inarticulate and articulate brachiopods and ostracods also occur.

Overlying gradationally is the Goose Tickle Formation composed of black shales and thin, green-gray, sandstones which exhibit flute casts, grading and are mostly internally laminated.

Map unit 6
(lithologies of thrust slice 2)

Three lithologies occur within the map unit which although highly deformed and recrystallized in places, are believed to be a conformable sequence.

At the base of the thrust slice, the sequence commences with dark gray to black, pyritiferous shales which are interbedded upwards with thin black limestones and laminated calcareous siltstones. Beds of oolitic-oncolitic and oncolitic-intraclastic limestones and limestone-conglomerate also occur near the top of the unit interbedded with and overlain by shales.

This unit is overlain by a thinly stratified black limestone which is characterized by yellow dolomitic laminae or thin beds. Scattered oolites and some fossil debris is visible locally. This, in turn, is overlain by a thick bedded, pale yellow weathering, white dolomite. Oolitic beds, mudcracks, disrupted bedding, fenestral porosity and mudflake breccias similar to the Upper Cambrian dolomites are preserved locally.

The lithologies of the thrust slice are correlated with the Lower to Upper

Cambrian authochthonous platform sequences in the west of the map area. The shale and limestone probably represent slope facies laterally equivalent to the shelf margin and outer shelf deposits of the autochthonous platform.

Map unit 7
(lithologies of thrust slice 3)

The dominant lithology of thrust slice 3 consists of cleaved blue-gray limestones and black to gray shales and phyllites. Close to the basal thrust the limestones become white, foliated marbles. The least deformed limestones show dolomitized bioturbation and some fossil debris. Along the Conche road, the limestones are overlain by dark gray shales with silty laminae which are in turn overlain probably structurally by sandstones of the Hare Bay Allochthon.

On the east side of Bide Arm, the limestones are cleaved and foliated and are interleaved with black to green-gray phyllites and shales. Dolomite and thin limestone beds also occur in the phyllites.

The lithologies of the thrust slice are probably of Ordovician age and have been assigned a Middle Ordovician age in previous studies (Smyth, 1973).

CAMBRIAN AND LOWER ORDOVICIAN PALEOGEOGRAPHY OF THE RODDICKTON AREA.

Sedimentation in the area began in the Lower Cambrian with predominantly siliciclastic deposition involving fluvial to marine sedimentation. This commenced in response to the early stages of rifting and formation of the Proto-Atlantic (Williams *et al.*, 1974b). Carbonate sedimentation was established in the Middle Cambrian and maintained into the Lower Ordovician. Carbonate sedimentation occurred platform wide in three megacycles related to transgression and regression (see Table 1). Transgression produced mound facies of large stromatolites and bioturbated lime muds, consistent with a subtidal shelf environment. Regression produced very shallow shelf conditions with numerous shoaling upward carbonate sequences deposited in unrestricted, near normal marine to restricted, hypersaline peritidal conditions.

The general lithologies and environmental interpretation of the various rock units for the west and east side of the northern part of the Northern Peninsula are summarized in Table 1. Variation within the Roddickton area are also included and a number of conclusions become apparent.

1) A marked lithological change occurs in the Cambrian strata between the western side of the peninsula and the Roddickton area. This change coincides with the area of the Hatters Pond and Shoal Pond Faults.

2) There is also a distinct lithological change in the upper unit of the Labrador Group in the Roddickton area, coinciding with the Saltwater Cloud Pond Fault.

3) Lithological variations occur in the Lower Ordovician across the Shoal Pond Fault. This includes a reduction of the thickness of dolomitized strata in the basal black dolomite and limestone formation (Watts Bight formation) of the St. George Group, a thinner development of the "unnamed formation" in the vicinity of and south of the fault, and a predominance of lime muds southeast of the fault.

4) Facies in both Cambrian and Lower Ordovician suggest that marginal shelf conditions existed in the map area. In the Cambrian, oolite sand shoals were important in the upper formation of the Labrador Group, and to a lesser extent in the Middle Cambrian limestone formation. Widespread evidence of postdeposi-

		WEST SIDE OF NORTHERN PENINSULA (after Knight 1977, 1978; Schuchert & Dunbar, 1934)			RODDICKTON MAP AREA N.W.			S.E.
		FORMATION	LITHOLOGY	ENVIRONMENT	LITHOLOGY	ENVIRONMENT	LITHOLOGY	ENVIRONMENT
LOWER ORDOVICIAN	ST. GEORGE GROUP	SILICEOUS DOLOMITE	Dolostones, dolomitic shales, sand grains.	*Sabkha* HATTERS	Not So Far Observed POND FAULT			
		CATOCHE	Bioturbated, fossiliferous micrite lenses of calcarenite, minor stromatolite mounds.	*Subtidal shelf; lime mud and lenticular sands, minor organic mounds* ◄—— MAJOR	Bioturbated, fossiliferous micrite, lenticular calcarenite, stromatolite-sponge mounds with calcarenite. TRANSGRESSION	*Subtidal shelf; burrowed lime muds and sands.*	SHOAL POND FAULT Bioturbated biomicrite, mud banks, scouring.	*Deeper water outer shelf; lime muds*
		"UNNAMED"	Cycles of biomicritic and stromatolitic limestone and laminated dolomitic limestone. - - -'Pebble Bed'- - - - - Stromatolitic limestone, biomicritic, & stratified micritic limestone, cherty dolostone, pseudobreccia. Breccia	*Shallow shelf; shallowing upward peritidal cycles.* *Disconformity; exposure & solution.* *Unrestricted normal marine shallow shelf; intertidal and some subtidal & supratidal.* *Possible Disconformity*	Cycles of biomicritic & stromatolitic limestone & laminated dolomitic limestone. Erosion Stromatolite-calcarenite Biomicritic and stromatolitic limestone, dolostone Breccia	*Shallow shelf; shallowing upward peritidal cycles.* *High energy stromatolite-carbonate sand bank.* *Unrestricted normal marine shallow shelf; intertidal & subtidal with minor supratidal.* *Possible Disconformity*	Cycles of biomicritic limestone & laminated dolomitic limestone. Presence of disconformity not apparent Bioturbated micritic limestone. No apparent break	*Shallowing upward shallow shelf carbonates.* *Subtidal shelf*
		WATTS BIGHT	Black cherty crystalline dolomite, stromatolite mounds & bioturbated dolomite; minor limestone.	*Subtidal shelf; stromatolite banks and burrowed lime muds (now dolomitized).* ◄—— MAJOR	Black, cherty, crystalline dolomite, stromatolite mounds & bioturbated dolomite. TRANSGRESSION	*Subtidal shelf; stromatolite banks & burrowed lime muds (now dolomitized).*	Bioturbated micritic limestone & some stromatolite mounds. Basal black stromatolitic & bioturbated dolomite. Thinning southwards.	*Subtidal shelf; lime muds & some large stromatolite mounds.*
CAMBRIAN UPPER	CAMBRIAN CARBONATES	DOLOMITE Cherty dolomite member	Dark gray, stromatolitic and mottled, shaly dolomite and dolostone.	*Restricted hypersaline predominantly intertidal carbonates throughout formation.*	Consistent Throughout Northern Peninsula			
		Upper dolostone member	Bedded dolostones, minor dolarenite & stromatolites.	*Intertidal stromatolite banks & sand shoals*	Dolostones, dolomitic shales, stromatolites common, dolarenite, mottled shaly dolomite, breccia.	*Predominantly, restricted hypersaline shallow shelf; shoaling upward sequences of intertidal supratidal shoreline and carbonate flats.*	Lithologies consistent throughout the area. SALT WATER CLOUD POND FAULT	
		Stromatolite member	Stromatolite, oolite-intraclastic dolarenite, dolostone.					
		Lower dolostone member	Bedded dolostone and shale, minor small stromatolite.					
CAMBRIAN MIDDLE		MICRITE	Bioturbated micritic & biomicritic limestone, argilleous micrite, dolomitised at base and top, shale.	*Subtidal shelf; Burrowed lime muds* ◄—— MAJOR	Bioturbated, micritic and argilleous micritic limestone. Oolitic calcarenite, stromatolitic mounds; slump beds common. TRANSGRESSION	*Subtidal shelf; lime muds, oolite sand shoals & stromatolitic banks. Tectonically unstable.*	Bioturbated, micritic limestone oolitic calcarenite & oncolites. Thins to stratified limestone eastward.	*Subtidal shelf; lime muds & oolite sands & shoals.* *Thin slope limestones.*
CAMBRIAN LOWER	LABRADOR GROUP	HAWKE BAY	Well washed quartz sandstones, minor shale, muddy sandstones.	*Shallow subtidal; high energy inner shelf sand flat.*	Quartz sandstones, sandy dolomites, dolomitic sandstones, shales. Some mudstone, minor oolite.	*Mostly sheltered carbonate flat and sandy shoreline.*	Oolitic calcarenites & stromatolite, mudstone & minor quartz sandstones. Abundant soft sediment deformation.	*High energy oolite sand shoals & islands. Low energy, outer shelf muds. Tectonically unstable.*
		FORTEAU	Fossiliferous shales, muddy siltstones, minor carbonate & siliciclastic sands, archeocyphid reefs. Fossiliferous black shale in middle of unit.	*Shallow subtidal; low energy to some high energy muddy, shelf.* *Stable, quiet, restricted deposition*	Calcareous siltstone, shale, nodular limestone, minor limestone. Some oolitic limestone & thin quartz sandstone near top. Basal limestone unit; black shale & thin limestone in middle of formation.	*Outer low energy shelf; muddy siltstones with some shallow lime sand shoals. Some tectonic instability. Stable, quiet water stagnant basin conditions.*		
		BRADORE	Red and cream arkosic sandstone.		Red pebbly arkose & haematitic sandstones.	*Alluvial fan, pebbly-sandy braided stream.*		

TABLE 1 Summary of lithologies and environments of Roddickton map area and comparison and correlation with rock units of the western side of the Northern Peninsula. Double lines represent faults believed to be active or marking zones of lithological change during deposition.

tional deformation in both of these units suggest periodically unstable shelf margin conditions (Wilson, 1975).

In the Lower Ordovician, a high energy, stromatolite - carbonate sand complex which was subjected to erosion and karstification, suggests an elevated shelf area occurred in the "unnamed formation" just northwest of the Shoal Pond Fault. High energy shoal conditions were maintained in the overlying Catoche Formation with the deposition of stromatolite - sponge mounds and carbonate sands. Also important is the thicker development of stromatolite mounds in and complete dolomitization of the basal Ordovician (Watts Bight formation) just northwest of the same fault. Such stromatolite mound and carbonate sand facies are also common at shelf margins (Wilson, 1975).

5) Comparison of the autochthonous platform sequence in the western part of the map area to that in the thrust slices to the east indicates: *a*) the thick sequence of the upper unit of the Labrador Group and the overlying Middle Cambrian limestone rapidly thins when traced eastward into thrust slice 3 and
b) platform margin carbonates of the west change in character to thin shales and thinly stratified limestones with minor coarser beds, typical of toe of slope or foreslope deposits seaward of a shelf (Wilson, 1975) to the east. This suggests that the shelf edge at this time sloped away quite rapidly oceanward.

6) Upper Cambrian dolomites change their lithological character across the Hatters Pond Fault and form the most extensive and easterly preserved carbonate unit in the succession. The unit ccurs in thrust slice 3 and has been reported further east in a "carbonate window" within the Hare Bay Klippe (Smyth, personal communication, 1979) along the Croque highway. Such oceanward outbuilding of the platform commonly occurs in a regressive event with rapid sedimentation (Wilson, 1975).

Development of platform

Preserved Cambro-Ordovician strata suggest the Roddickton map area, marked the eastern margin of the ancient Lower Paleozoic platform. North and northeast trending faults, along which the basement probably floundered were important controls in the location of the platform margin and appear to have been active periodically throughout the Cambrian and Lower Ordovician. West of the Hatters Pond Fault, generally stable, flat, platformal conditions existed in Cambro-Ordovician times with facies extending over very wide areas. In the Roddickton area, facies such as oolite and carbonate sand shoals and stromatolite mounds are narrow in distribution, typical of the shelf margin. Slumping and soft sediment deformation especially in the upper Lower and Middle Cambrian strata suggest this margin was unstable during its history. The rubbly limestone breccias in the Catoche Formation near the Hatters Pond Fault may also reflect the response of thinly bedded limestones to similar Ordovician instability.

The position of the shelf margin was never static. In the upper unit of the Labrador Group and in the Middle Cambrian, the margin occurred in the vicinity of Chimney Arm with a fairly rapid drop off to thin slope deposits. A narrow oolite sand marginal facies marked the margin which, when exposed, formed islands and created a barrier. Carbonate mudflats developed on the sheltered lee of the islands. A transgressive event occurred in the Middle Cambrian but did not effect the position of the shelf margin. It is likely that the Hatters Pond and Saltwater Cloud Pond faults were active until this time. Regression occurred by the Upper Cambrian as sedimentation outstripped subsidence of the shelf and a thick sequence of restricted, carbonate flat (sabkha?) and shoreline sediments were deposited. The margin at this time migrated eastwards at least 8-12 km as the peritidal dolomites prograded over the old Middle Cambrian shelf edge and across the thin foreslope deposits. To do this, sedimentation must have at first outstripped subsidence and was later in approximate equilibrium. Although the platform was thus considerably enlarged in the Upper Cambrian, a change of sedimentation style does occur from stable platform in the west, across the Hatters Pond-Shoal Pond fault zone to that deposited in the Roddickton area. However, no evidence of platform instability due to fault movements has been noted for this time period.

A major and fairly rapid transgression initiated Lower Ordovician sedimentation. Evidence of stromatolite banks and high energy carbonate sands lying just northwest of the Shoal Pond fault zone suggest that the shelf margin shifted westward to the vicinity of this area. However, the wide foundation afforded by the Upper Cambrian dolomites allowed thick deposits of lime muds to be deposited east of this positive area and to form an outer shelf environment. Sedimentation in the map area within the Lower Ordovician can be correlated with that farther to the west on the stable platform. It formed in response to a transgression-regression megacycle (Watts Bight - unnamed formations) followed by later major transgression in the Catoche Formation. However, the lithologies characteristic of the basal trangressive part of the St. George Group (Watts Bight formation) and the overlying regressive stage (unnamed formation) that form the first Lower Ordovician megacycle are generally much thinner and more difficult to trace eastwards in the map area than on the stable western shelf area. This might be explained by a change of slope *i.e.* deeper conditions, southeast of the Shoal Pond Fault which caused a reduction in the effects of the regressive event. It may be that the northeast trending faults were active again in the Lower Ordovician and influenced the transgression.

STRUCTURE AND METAMORPHISM

The rocks of the Cambro-Ordovician platform in the Roddickton area have been variably deformed. Intensity of deformation increases eastwards and southwards. Authochthonous platformal rocks are only gently tilted in the north and west of the area north of the Saltwater Cloud Pond Fault. They become increasingly deformed however to the south of the fault. A number of important north trending thrust faults (figures 2 and 4) occur in the eastern half of the area. These repeat the stratigraphy in a number of imbricate thrust slices. Northeast trending high angle faults crosscut the stratigraphy and thrust slices.

Three phases of deformation occurred in the area. The earliest phase is probably related to westward emplacement of the Hare Bay Allochthon. Thrust faults and slices formed in the platform sequence at this time. Mylonitised limestones, foliated marbles, breccias and zones of intense deformation mark the thrusts. The thrusting can possibly be divided into two events. The earliest event emplaced thrust slices 1 and 2 along low angle thrust faults so that Cambrian strata overrode Lower Ordovician strata. This was followed by a later somewhat steeper thrusting or reverse faulting in which Ordovician strata (slice 3) overrode Cambrian strata of thrust slice 2. Tectonic wedges of green coloured sandstones (unit 8a) of the Maiden Point Formation (Smyth, 1973) occur along the sole of thrust slice 3 and suggest this thrusting post dates Middle Ordovician emplacement of the Hare Bay Allochthon. Northwestward facing recumbent folding in limestones and tight isoclinal, vertical to slightly westward facing folds formed in strata adjacent to the thrust faults.

The second deformation in the area is characterized by steepening and folding of the D_1 thrusts as at Bide Head and refolding of the steep isoclinal folds into type 1 interference fold patterns (Ramsey, 1967). Folds are mostly upright to northwest facing, assymmetrical, open folds, which plunge northeast between 7° and 35°. A well developed axial planar cleavage is developed in the limestones and is the pervasive cleavage seen throughout the area.

A flat to gently southeast dipping, widely spaced crenulation cleavage, locally transposing the S_2 cleavage in shale units of thrust slice 2, represents the third phase of deformation. Its proximity to the thrust faults and flatlying attitude suggests it is related to late locallized movements along the D_1 thrusts.

High angle, northeast trending faults displace the stratigraphy and thrust faults in the area. The late faults are usually clean, sharp breaks with only minor brecciation although they are parallelled by numerous fractures and minor faults. Sinistral strike slip motion has occurred along many of these faults particularly in the south of the area. Drag folds with steep plunges and some overturning accompany the strike slip movement. The faults in the north of the area are normal or reverse faults which downthrow to the northwest.

A north trending, high angle, normal fault, the Hatters Pond Fault downthrows Cambrian and Lower Ordovician strata between 400-500 m against the Precambrian granites and Lower Cambrian siliclastics. The carbonates are brecciated for several metres close to the fault. This fault forms the eastward limit of Cambrian lithofacies and stratigraphy that is found across the northern tip and western side of the Northern Peninsula. This suggests it probably was an early basement fault that influenced sedimentation during the formation of the Lower Palaeozoic western platform. The fault was later reactivated following the Taconic and Acadian tectonic events.

The sedimentary rocks close to the Hare Bay Allochthon are metamorphosed to greenschist facies. Chlorite is common in deformed shales and along small thrust faults. Recrystallization of both limestone and dolomite occurs, the dark colored limestones turning usually to white, foliated marbles and the dolomites recrystallizing to white crystalline dolomite marbles. Chert is usually bleached in the more intensely deformed area.

ECONOMIC GEOLOGY

Minor zinc mineralization is known in the map area (Sauerbrei, 1964; Siragusa, 1966; Phillips Management, 1975), but none of their showings were located during the mapping. No new showings were discovered.

The previously known mineralization occurs in both Cambrian and Lower Ordovician strata, and this is concentrated along the Upper Cambrian - Lower Ordovician boundary and at the disconformity within the Lower Ordovician.

A number of soil geochemical zinc anomalies were located on the Bide Head Peninsula (Sauerbrei, 1964; Siraggusa, 196). These occur mostly just below the upper contact of the cherty dolomite member of the Upper Cambrian dolomite formation in thrust slice 1. Traces of sphalerite and pyrite occur, and in the best showings chip samples analysed up to 4.79% Zn, 0.15% Pb and 19.20 g/t Ag. At least one geochemical anomaly is associated with a northeast trending fault but no mineralization was found.

Zinc mineralization is concentrated in two areas north of Roddickton. A cluster of showings of trace to minor amounts of sphalerite and pyrite occur just northwest of Montgomery Pond and straddle the Upper Cambrian - Lower Ordovician boundary (Phillips Management, 1975). A significant showing of 15.4% Zn and minor pyrite is said to occur on a peninsula on the coast of Northeast Arm. This showing is, however, not located on maps (Phillips Management, 1975) but descriptions suggest it probably occurs in strata associated with the same geological units as the Montgomery Pond showings.

A second zinc showing was located by Phillips Management (1975) near the Underground Hole on Beaver Brook. The showing of greenish-yellow sphalerite occurs in the strata beneath the erosional disconformity (Figure 3). The sphalerite occurs in the dikes of vuggy dolomite that replace the stromatolitic limestone. Grades of 1-3% zinc were estimated. However, no sphalerite was located when the showing was examined, although pale green-yellow, cubic fluorite crystals are disseminated in the dolomite.

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