# GEOLOGY OF THE AREA SOUTHWEST OF HARE BAY, GREAT NORTHERN PENINSULA

by

Svend Stouge and Steve Godfrey*

## INTRODUCTION

Mapping, at a scale of 1:50,000, of the Cambro-Ordovician clastic carbonate sequence in the Hare Bay south area (Figure 1) was completed during 1981; part of it had previously been mapped in 1979 (Knight, 1980a; Knight & Saltman, 1980) and in 1980 (Stouge, 1981). The map area also includes the sedimentary rocks within the "White Arm Window" (Smyth, 1973). The work represents the culmination of the "Daniel's Harbour mapping project" begun in 1976 (Knight, 1977a, b, 1978, 1980a; Knight & Edwards, 1978a, b; Knight & Snow, 1979; Knight & Saltman, 1980; Stouge, 1981).

The Lower Paleozoic stratigraphy of southern Hare Bay has previously been studied by Cooper (1937), Smyth (1973), with additional information by Williams (1975). Betz (1939) mapped the rocks in the southern part of the area for the Newfoundland Government. Bostock *et al.* (1976) presented 1:125,000 scale maps of the region. Knight (1980a, b), Knight & Saltman (1980) and Stouge (1981) reported on and revised the stratigraphy of the Cambrian to Middle Ordovician platformal sequence.

## LOCATION AND ACCESS

The map area is located in White Bay East District of the Great Northern Peninsula. The area includes the southern shore of, and islands within, Hare Bay (Figure 1). Supplies and services necessary for maintenance of field camps are available from the communities of Englee and Roddickton in the south and Main Brook in the north.

The Plum Point road, which connects with the Great Northern Peninsula highway, is located in the southern part of the area, where it connects with the Roddickton and Main Brook roads. Smaller roads branch off the Main Brook-Roddickton road to Croque, St. Julien's (Grandois) and Conche. Wood roads (Road 16 and 18) provide access from Main Brook and the Main Brook road to the western edge of the area along the north side of Salmon River. Coles Pond can be reached by wood roads from the Conche Road and from the Main Brook road and access to the northeast side of the White Arm Window is possible by a north trending logging road. The remainder of the area is accessible either by boat or by aircraft; mobility is enhanced by the Salmon River, which in wet weather is navigable from Rubes Steady to Main Brook. Coastal exposures are accessible by boat. Float-plane service is available in Main Brook.

## GEOLOGIC SETTING

The area is entirely within the Humber Zone of the Newfoundland Appalachians (Williams, 1979).

The following tectonic elements are present within the map area (Figure 2):

(1) an inlier of Precambrian crystalline rocks of the Grenville Basement;

(2) a Cambrian-Ordovician silici-clastic-carbonate sequence unconformably overlying the crystalline inlier;

(3) an easterly derived, Middle Ordovician quartzofeldspathic flysch sequence that locally conformable

* Present address: Department of Geology, Memorial University of Newfoundland, St. John's.

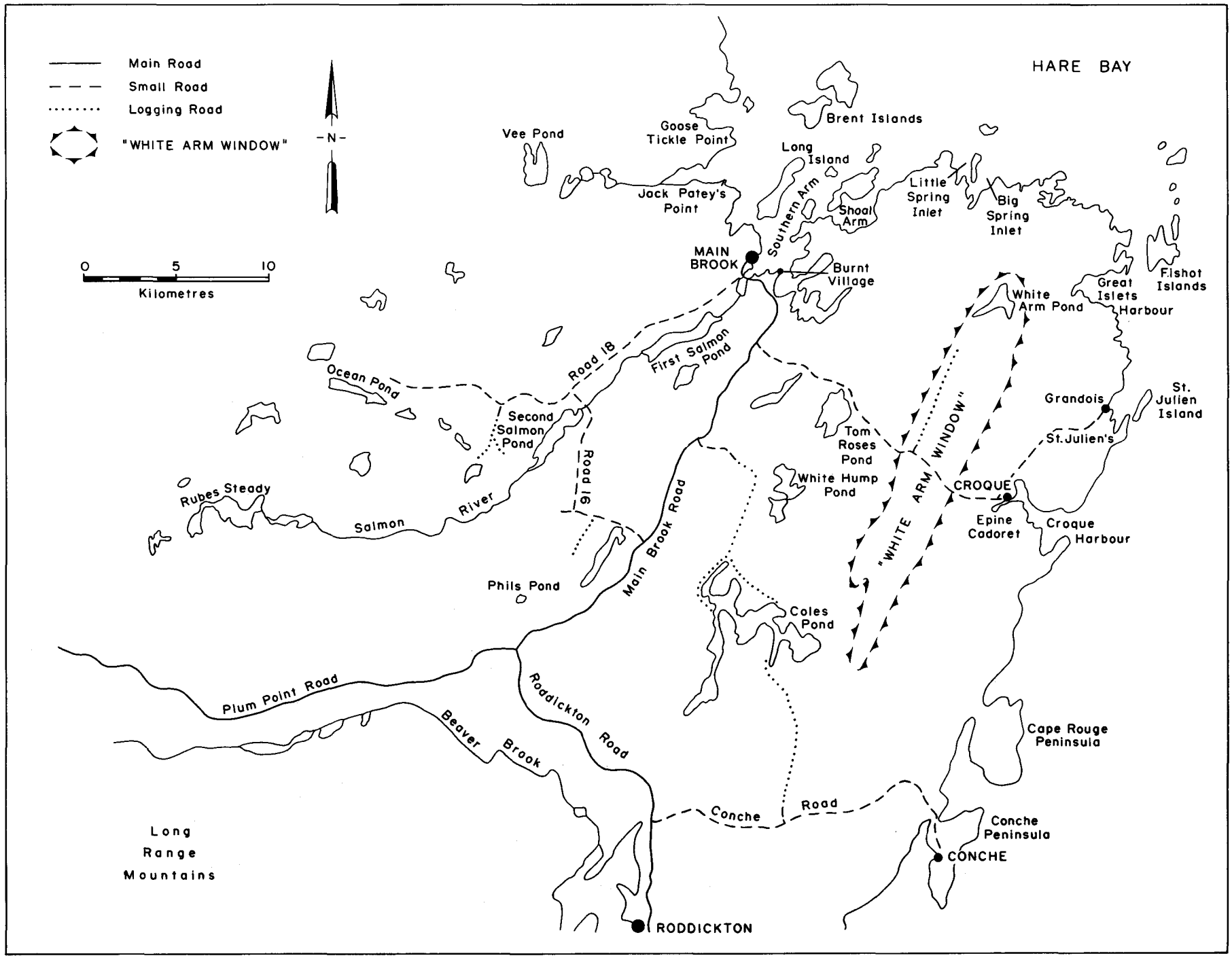



Figure 1 – Location Map of the Hare Bay South area.

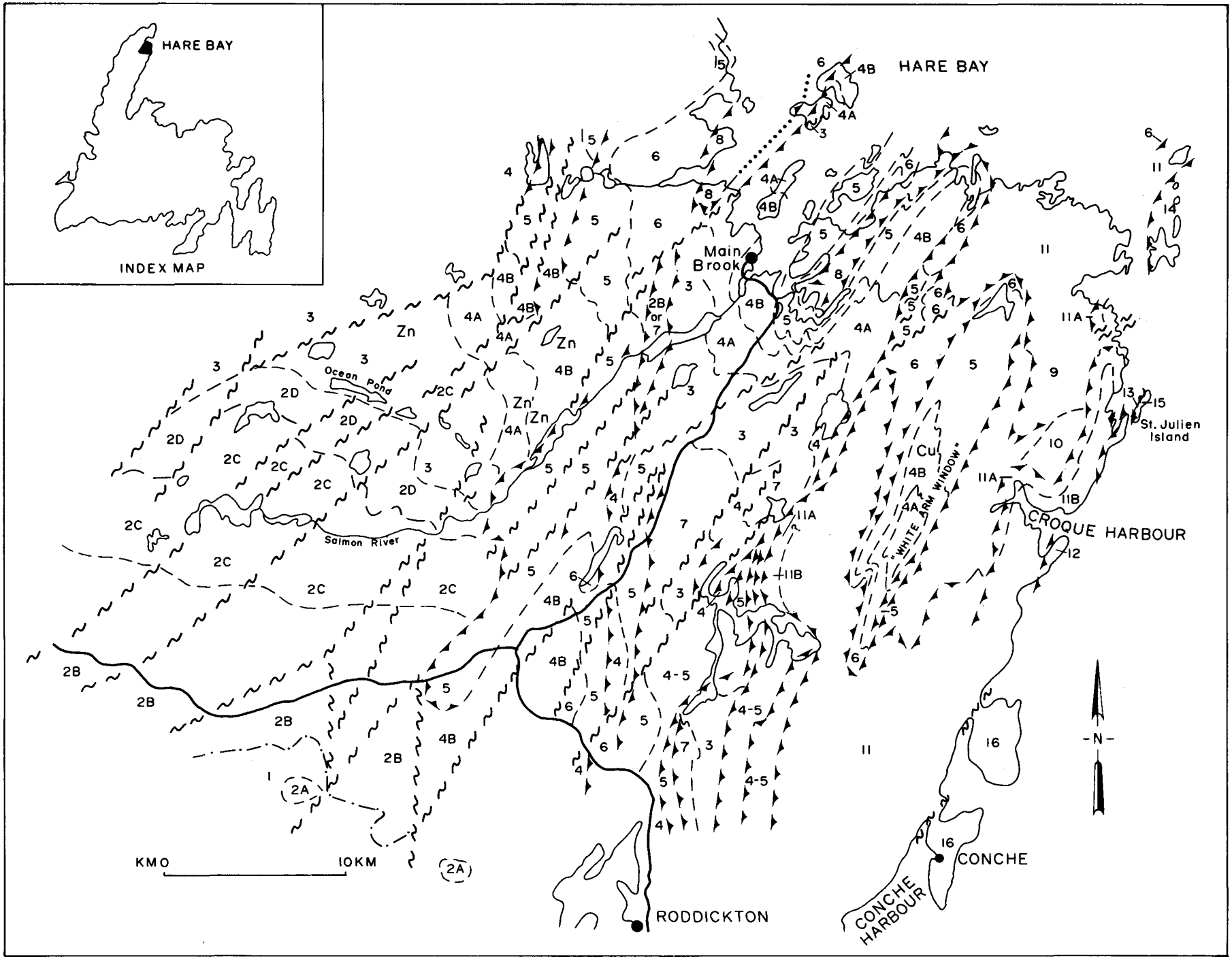



Figure 2 – Geological sketch map of the Southwestern Hare Bay area.

## LEGEND

### COVER ROCKS

CARBONIFEROUS

16 Gray and brown bedded sandstone, siltstones and shales with plant fossils; red conglomerates.

SILURIAN

15 Red polymictic conglomerate and minor graywacke.

### ALLOCHTHONOUS ROCKS

PRECAMBRIAN–LOWER CAMBRIAN

St. Anthony Slice assemblage

14 **Goose Cove schist and Green Ridge amphibolite:** Amphibolite and greenschist derived from tuffs, mafic agglomerates and volcanic rocks. Minor black and green pelitic schist and marble.

Grandois Slice

13 **Grandois Group (Irish limestone):** Sandy limestone (lime turbidite)

Maiden Point Slice Assemblage

12 **Croque Head Slice:** Coarse to fine grained sandstone and conglomerate; minor volcanic rocks.

11 **Maiden Point Slice:** Coarse to fine grained sandstone and conglomerate; minor volcanic rocks.

10 **Melange:** Black and bright green shales with ultramafic blocks.

9 **Epine Cadoret Slice:** Black and gray slates; minor sandstones.

?LOWER ORDOVICIAN

Northwest Arm Formation

8 Black and bright green shales with blocks of green chert, parted limestone, dolostone, pillow lava and massive bedded, coarse sandstones. Generally disrupted to form melange.

## PARAUTOCHTHONOUS ROCKS

**LOWER CAMBRIAN**

7 Gray, white weathering shale; ribbon limestone with dolomite laminae; oolitic and oncolitic limestone; minor stromatolitic mounds. Equivalent to Unit 2.

## AUTOCHTHONOUS ROCKS

**MIDDLE ORDOVICIAN**

6 **Goose Tickle Formation:** Green-gray pyritiferous siltstone and shale; minor brown weathering sandstone and conglomerate at the top; black shale with limestone nodules/beds.

5 **Table Head Formation:** Massive bedded micrite, biomicrite; nodular bedded micrite-biosparite and hemipelagic limestone, shaly at the top; black nodular chert common in massive bedded micrite.

**LOWER-MIDDLE ORDOVICIAN**

4 **St. George Group:** Bioturbated micrite, dolomitic bioturbated micrite, interbedded massive dolostone, finely laminated dolostone and bioturbated limestone; minor dolostone; stromatolite and sponge mounds common; chert abundant.

**CAMBRIAN-?LOWER ORDOVICIAN**

3 **Port au Port Group equivalents:** Massive bedded dolostone, gray homogeneous, yellow weathering; dark gray, brown dolostone, chert, stromatolitic mounds; minor shale, finely laminated dolostone and vuggy dolostone; massive bedded dark bluish gray micrite at the base.

**EOCAMBRIAN?-CAMBRIAN**

2 **Labrador Group:** White quartzite and conglomerate; reddish brown basalt and agglomerate; red to pink arkose, minor conglomerate; brown to gray shale/minor crossbedded sandstone, lime nodules and limestone beds. Fossiliferous (**Salterella** and trace fossils).

**PRECAMBRIAN**

1 **Long Range Complex:** Granodiorite; granite, some amphibolite and foliated granodiorite.

overlies the carbonate platformal rocks; (4) a parautochthonous assemblage of clastic and carbonate sediments; (5) allochthonous slices of clastic sedimentary and volcanic rocks of the Hare Bay Allochthon (Gillis, 1966; Smyth, 1971, 1973). The slices in the map area are referred to as the Epine Cadoret Slice, Northwest Arm Slice, Maiden Point Slice assemblage, Grandois Slice and St. Anthony Slice assemblage.

## BASEMENT ROCKS (PRECAMBRIAN)

### UNIT 1

Precambrian crystalline basement underlies the Long Range Mountains in the southwesternmost extremity of the map area. Gneiss complexes, a variety of granites and other intrusive rocks are predominant lithologies of the Grenville Orogen. The rocks are cut by a swarm of northeast trending basic dikes (Williams *et al.*, 1974).

## AUTOCHTHONOUS ROCKS (?PRECAMBRIAN-MIDDLE ORDOVICIAN)

The Eocambrian? to Middle Ordovician strata are collected in five groups/formations (Units 2-6) (Table 1). The sequence is divided into the Eocambrian?-Lower Cambrian to Middle Cambrian Labrador Group (Unit 2), carbonates of the Port au Port Group (Knight, 1980b) of Middle to Upper Cambrian and possibly Lower Ordovician age (Unit 3), the St. George Group of Lower to Middle Ordovician age (Unit 4), and the Middle Ordovician Table Head (Unit 5) and Goose Tickle (Unit 6) Formations. The Goose Tickle Formation is structurally overlain by a melange unit (Unit 8) which forms the base of the allochthon.

### UNIT 2 - THE LABRADOR GROUP

The Labrador Group consists of mixed siliciclastic and carbonate sediments with some mafic volcanics at its base. The group unconformably overlies the Precambrian basement (Unit 1) in the southwest corner of the map area. It outcrops in the area between the Salmon River and Beaver Brook. The group is locally well exposed along the Plum Point Road east of the Main Brook-Roddickton Road.

Four formations in the Labrador Group are recognized in the area.

#### Subunit 2A - Volcanic rocks

Subunit 2A consists of tholeiitic, predominantly subaerial mafic volcanics (Strong & Williams, 1972; Strong, 1976). The volcanic rocks outcrop locally as outliers upon Precambrian basement (Knight & Saltman, 1980).

#### Subunit 2B - Bradore Formation

The rocks of subunit 2B occur in the southwestern part of the Roddickton map area. They unconformably overlie the Precambrian basement and are presumed to be earliest Cambrian in age.

They consist of red-brown weathering, immature conglomerates and medium to fine grained, arkosic sandstones which show crossbedding.

The rocks of subunit 2B are not well exposed, because glacial till covers the strata and because the unit weathers easy. Blocks of subunit 2B lithologies are easy to recognize and locally are common in the glacial tills.

#### Subunit 2C - Forteau Formation

Subunit 2C consists of green-gray, pyritiferous and calcareous siltstones. Minor black to gray shales, mottled pink limestones and some thin sandstones are present. This formation was described in detail by Knight & Saltman (1980).

The subunit is highly fossiliferous and lime nodules and limestone beds contain abundant *Salterella* that give a Lower Cambrian age for the formation.

### Subunit 2D - Hawke Bay Formation equivalents

This subunit, consisting of mixed lithologies of oolitic limestones, mudstones and shales, was described by Knight & Saltman (1980). In the area north of Beaver Brook the lateral equivalent strata are quartzites of the Hawkes Bay Formation. South of Beaver Brook the quartzites disappear and pass into subunit 2C.

## UNIT 3 - PORT AU PORT GROUP EQUIVALENTS

A Middle to Upper Cambrian (?Lower Ordovician) carbonate sequence named the Port au Port Group elsewhere in western Newfoundland (Knight, 1980b) includes two informal subunits in the map area. The lower subunit consists of limestone and the upper one is predominantly dolostone.

### Subunit 3A - (Equivalent to Micrite Formation of Knight, 1978; and March Point Formation, Knight, 1980b)

This subunit conformably overlies the Labrador Group. It occurs in a broad belt trending north-northwest from Salmon River Valley east and westward. It consists of black to dark gray, argillaceous micrites, stratified micrites and bioturbated micrites. Lenses of sparry biosparites and oolitic limestones associated with stromatolites are secondary. Fossils have not been recorded in the map area, but Knight & Saltman (1980) reported the presence of trilobites from lateral equivalent limestones, suggesting a late Middle Cambrian age.

### Subunit 3B - (Dolomite Formation, Knight, 1978, 1980a; Petit Jardin Formation, Knight, 1980b)

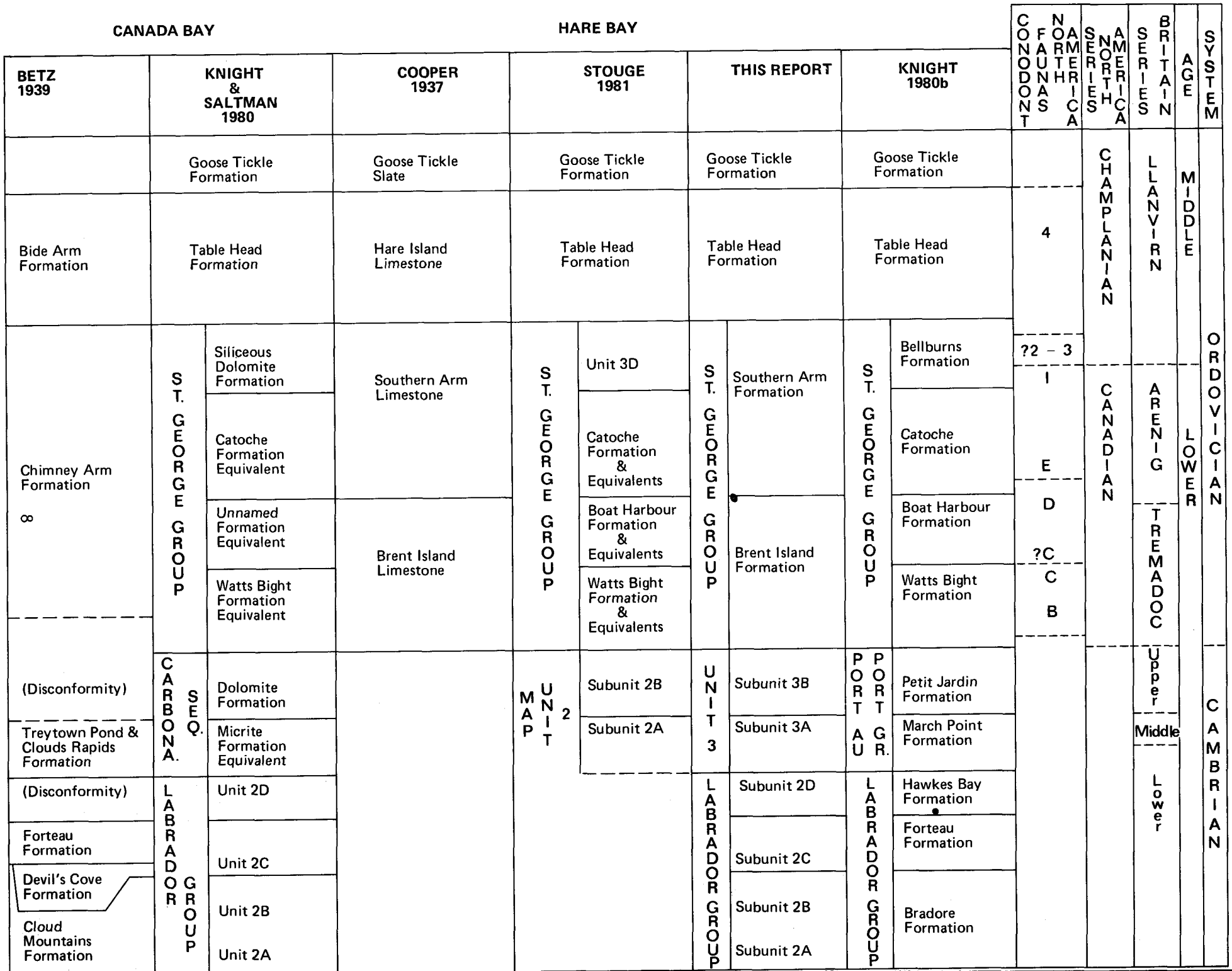
Subunit 3B gradationally overlies 3A. Subunit 3B is well exposed along the Main Brook road and the Croque road. It consists mostly of pale gray to dark gray dolostones. Other lithologies include gray to white fine crystalline dolostones, dark gray to black cherty dolostones and brown gray shales. Stromatolitic mounds and finely laminated light gray dolostones occur at specific horizons. Repetitive sequences consisting of mottled dolostone with minor dolomitic shale and stromatolitic mounds are common. Mudcracks, intraclastic breccias and some ripple marks are present in the sequences.

The dolostones of subunit 3b are nonfossiliferous in the map area. The subunit is correlated lithologically with dolostones of the Petit Jardin Formation elsewhere on the Great Northern Peninsula. The Petit Jardin Formation is dated as Upper Cambrian; it may extend into the Lower Ordovician.

The Petit Jardin Formation is subdivided into four members elsewhere on the Great Northern Peninsula (Knight, 1980a, b). Within the map area subdivision of the dolostones is not possible, as has been noted elsewhere in the Hare Bay and Roddickton areas (Knight & Saltman, 1980; Stouge, 1981). Subunit 3B is also recorded within the parautochthonous sequence (Unit 7) where it outcrops on the Conche Road near the Roddickton Road. Here the dolostones are white, thick bedded and pale yellow weathering. Locally, mudcracks and mudflake breccias are preserved but mostly the subunit is recrystallized.

## UNIT 4 - THE ST. GEORGE GROUP

The St. George Group consists of two units in the area (Cooper, 1937). Elsewhere on the Great Northern Peninsula, it has been subdivided into four (Knight, 1978) or three formations (Knight & Saltman, 1980; Stouge, 1981). At this stage, however, it is considered best to separate the St. George Group into two subunits or formations that are broadly the same as the Brent Island Limestone and the Southern Arm Limestone of Cooper (1937). In general, both formations consist of sediments deposited in a transgressive/regressive event and may include a disconformity


CANADA BAY
HARE BAY
BETZ 1939
KNIGHT & SALTMAN 1980
COOPER 1937
STOUGE 1981
THIS REPORT
KNIGHT 1980b
CONODONT FAUNAS NORTH AMERICA
SERIES NORTH AMERICA
SERIES BRITAIN
AGE
SYSTEM
Goose Tickle Formation
Goose Tickle Slate
Goose Tickle Formation
Goose Tickle Formation
Goose Tickle Formation
Bide Arm Formation
Table Head Formation
Hare Island Limestone
Table Head Formation
Table Head Formation
Table Head Formation
4
CHAMPLANIAN
LLANVIRN
MIDDLE
ORDOVICIAN
Chimney Arm Formation
∞
ST. GEORGE GROUP
Siliceous Dolomite Formation
Catoche Formation Equivalent
Unnamed Formation Equivalent
Watts Bight Formation Equivalent
Southern Arm Limestone
Brent Island Limestone
ST. GEORGE GROUP
Unit 3D
Catoche Formation & Equivalents
Boat Harbour Formation & Equivalents
Watts Bight Formation & Equivalents
ST. GEORGE GROUP
Southern Arm Formation
Brent Island Formation
ST. GEORGE GROUP
Bellburns Formation
Catoche Formation
Boat Harbour Formation
Watts Bight Formation
?2 – 3
I
E
D
?C
C
B
CANADIAN
ARENIG
TREMADOC
LOWER
(Disconformity)
CARBONA. SEQ.
Dolomite Formation
Micrite Formation Equivalent
MAP UNIT 2
Subunit 2B
Subunit 2A
UNIT 3
Subunit 3B
Subunit 3A
PORT AU PORT GR.
Petit Jardin Formation
March Point Formation
Upper
Middle
Lower
CAMBRIAN
Treytown Pond & Clouds Rapids Formation
(Disconformity)
Forteau Formation
Devil's Cove Formation
Cloud Mountains Formation
LABRADOR GROUP
Unit 2D
Unit 2C
Unit 2B
Unit 2A
LABRADOR GROUP
Subunit 2D
Subunit 2C
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Subunit 2A
LABRADOR GROUP
Hawkes Bay Formation
Forteau Formation
Bradore Formation

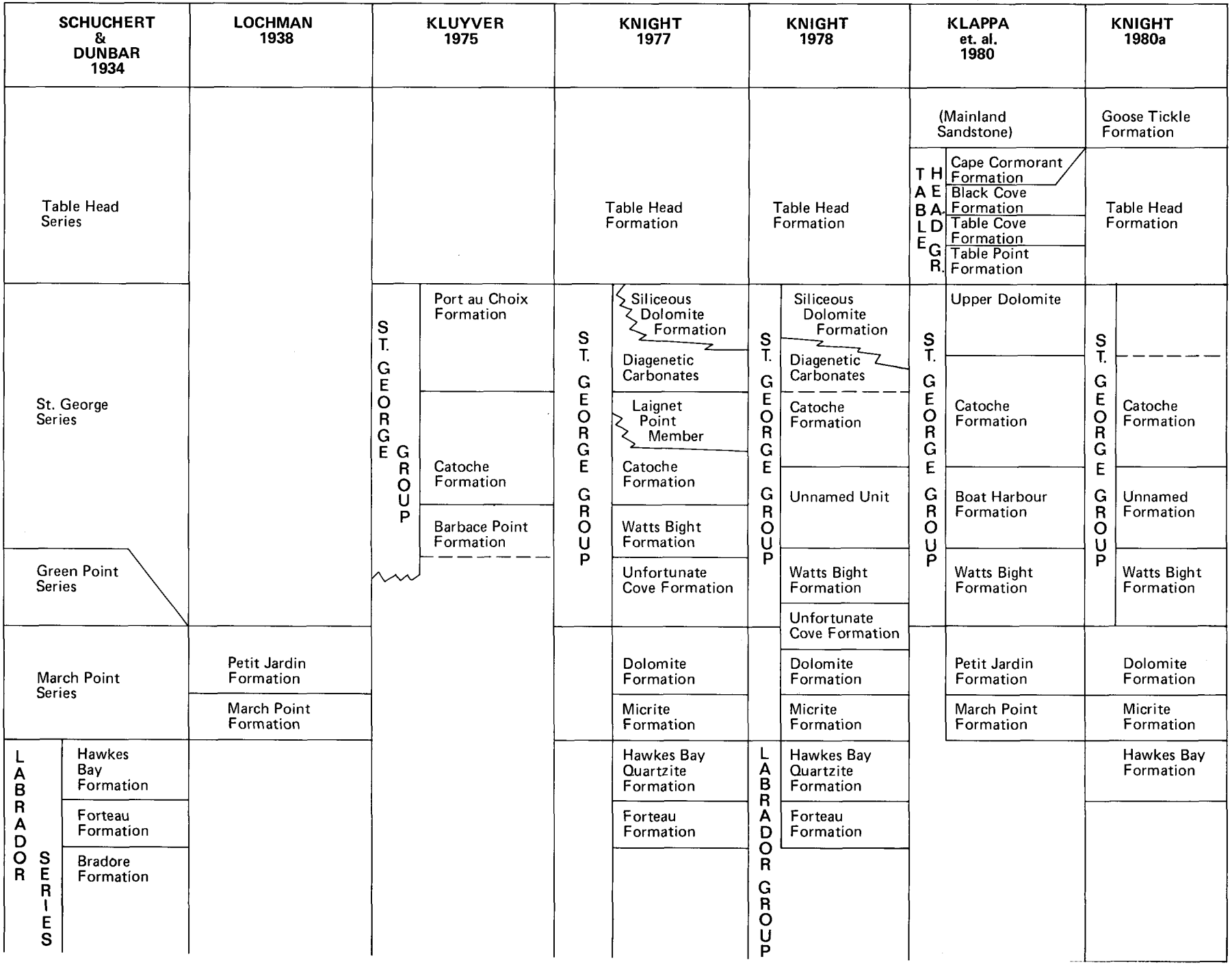


Table 1: History of stratigraphic nomenclature of the autochthonous Cambrian-Ordovician rocks on the Great Northern Peninsula. Data from Schuchert & Dunbar, 1934; Cooper, 1937; Lochman, 1938; Betz, 1939; Kluyver, 1975; Knight, 1977; 1978; 1980a,b; Knight & Saltman, 1980; Klappa, *et al.*, 1980; Stouge, 1981.

near the top of the subunits (Stouge, 1981, 1982).

### Subunit 4A - Brent Island Formation (Equivalent to Watts Bight and Boat Harbour Formation of Knight, 1978, 1980a)

A good section of the Brent Island Formation is exposed along the shores of Long Island. Other occurrences include the southern part of North Brent Island and northern part of South Brent Island. The unit is locally well exposed along the Main Brook, Croque and Roddickton roads.

This lower subunit of the St. George Group consists of intercalated, dark gray to black crystalline dolostone, pale gray dolostone, large stromatolite and (?)sponge mounds, 1-3 m in diameter and 40-60 cm high, and bioturbated, well bedded, black micrites. Chert is common within these lithologies as irregular shaped bands and nodules. Massive bedded dolostones interbedded with finely laminated dolostones and dolomitic micrites, arranged in repetitive sequences, form the upper part of the subunit. A disconformity expressed as a 'pebble bed' occurs within these dolostones (Stouge, 1981).

Fossils including gastropods, conodonts and some cephalopods are common in the subunit but trilobites are scarce. The conodonts indicate an upper Lower Canadian age (Midcontinent Fauna B-D of Ethington & Clark, 1971) *i.e.* Lower Ordovician.

### Subunit 4B - Southern Arm Formation (equivalent to Catoche Formation and Siliceous Dolomites of Knight (1978) and Catoche Formation and Unit 3D of Stouge (1981))

The Southern Arm Formation is best exposed along the coast and on the islands in Southern Arm. The base is exposed on North Brent Island and the top is exposed in Little Spring Inlet.

Subunit 5B consists of well, massive and medium bedded, bioturbated micrite commonly with argillaceous stringers. The micrites are succeeded by large stromatolite and sponge(?) mounds (for a preliminary description see Knight & Saltman, 1980; Stouge, 1981; Stevens & James, 1975). The sequence of mounds is stratigraphically succeeded by massive dolostones and cycles of bioturbated micrite, stromatolite and laminated, usually mudcracked dolostone or dolomitic limestone.

Locally, crystalline dolostones replace the upper part of the limestones and form 'pseudobreccias'. The alteration is commonly spatially related to faults.

Trilobites recovered from the lower half of subunit 4B on Brent Island include *Petigurus nero* (Billings) (Stouge, 1981) *Bolbocephalus* n.sp. (=Gen. et sp. indet Poulsen, 1937). *Bathyurina* sp. and *Illeanus* sp. have been recorded along the road to Roddickton (D. Boyce, personal communication, 1981) within the upper half of the subunit 4B. These fauna indicate an Upper Canadian, *i.e.* Lower Ordovician age, for the limestones. Conodonts include *Oepikodus communis* and *Bergstroemognathus extensus*, which correlate with Midcontinent Fauna E-1 of Ethington & Clark (1971). The same species have been recorded from the upper half of the Catoche Formation at its type section on the west side of the Great Northern Peninsula (Stouge, 1982).

The cyclic top of the St. George Group yielded ?*Eoneoprioniodus* sp. and it is Whiterockian or Middle Ordovician in age.

### UNIT 5 - TABLE HEAD FORMATION (EQUIVALENT TO HARE BAY LIMESTONE OF COOPER, 1937)

In Hare Bay, Cooper (1937) applied the name Hare Bay limestone this unit, which he correlated with the Table Head "Series" of Schuchert & Dunbar (1934).

Subsequent workers referred the strata to the Table Head Formation (Bostock *et al.*, 1976; Knight & Saltman, 1980; Stouge, 1981). Traditionally, the Table Head Formation comprises lower Table Head limestone, middle Table Head limestone and shale, and upper Table Head black shale (Schuchert & Dunbar, 1934). It has more recently been redefined as a group and subdivided into three formations by Klappa *et al.*, (1980).

Generally, lower Table Head limestones are well exposed. Good sections exist in Little Spring Inlet, Big Spring Inlet, Shoal Arm, southeast coasts of Southern Arm and along the shore east of Burnt Village. The lower Table Head limestones consist of massive to medium well bedded, blue-gray to black micrites. The micrites are characterized by argillaceous stringers and bioturbation is common. Fossils including trilobites, cephalopods and gastropods are present in moderate numbers. Black chert is commonly present as nodules or form coherent layers. Locally, as on Road 16, southeast of Salmon River, the limestones contain beds of light gray micritic limestones intercalated with dark gray to brown, hard micrites of middle Table Head affinity.

Middle Table Head consists of nodular bedded, micritic limestones and biosparites separated by brown shale. The shales increase up section and the subunit passes gradationally into the black shales of the upper Table Head; locally the two subunits cannot be readily separated. The middle Table Head is rich in brachiopods, trilobites, cephalopods and very abundant conodonts (Fahraeus, 1970; Stouge, 1980a, b, 1981). The upper Table Head contains graptolites and phosphatic brachiopods.

The middle Table Head and upper Table Head are generally poorly exposed, although complete sequences occur at Little Spring Inlet, Big Spring Inlet and east of Jack Patey's Point. Inland, sporadic occurrences were noted at Phils Pond and west of the intersection of Plum Point/Main Brook - Roddickton Roads, where the strata are part of a fault breccia.

## UNIT 6 - GOOSE TICKLE FORMATION

The Goose Tickle Formation gradationally overlies shales of the Table Head Formation. The formation includes bedded siltstones and shales intercalated with easterly derived sandstones (Cooper, 1937; Stevens, 1970; Tuke, 1968; Smyth, 1973; Stouge, 1981). The sandstones are gray-green, brown or black. They are graded and include complete Bouma sequences (Bouma, 1962) as well as carrying basal sole marks such as flute casts. The formation coarsens upwards and contains conglomeratic layers near the top.

The Goose Tickle Formation is well exposed along the shores of Hare Bay. Inland, the outcrops are mostly covered, but have been exposed in several abandoned quarries seen along Road 16.

Fossils are sparse and only fragmented graptolites have been recorded. North of the map area, Erdtmann (1971a, b) recorded graptolites of Middle Ordovician age.

## PARAUTOCHTHONOUS ROCKS

In the map area, parautochthonous rocks occur in a number of thrust slices that trend north-northeast. They are well exposed along the Main Brook road, at White Hump Pond and along the shores in the western part of Coles Pond. The parautochthonous rocks structurally overlie the Table Head Formation (Unit 5) on the Main Brook road. They structurally overlie the St. George Group (Unit 4) at White Hump Pond and the Port au Port Group at Coles Pond. The maximum distance of transport for the thrust slices is interpreted to be 10-14 km judging from the extension of the laterally equivalent autochthonous rocks (see Knight and Saltman, 1980; Stouge, 1981).

Some of the lithologies of the parautochthonous rocks matches with those of the autochthonous rocks, and they were included in the Goose Tickle Formation (Unit 6) by earlier workers (Bostock *et al.*, 1976).

Three lithologies occur within the parautochthonous sequence, namely gray to black shales, bedded oolitic and micritic limestones and dolostones. The rocks are generally highly deformed and are not easy to separate on the map at the scale of 1:50,000. The three lithologies once formed a conformable sequence, and it is likely the bedded limestones at least correlate with Middle Cambrian limestone of subunit 3.

UNIT 7

This map unit begins with a gray to black shale. Typically, it is pyritiferous and it weathers white-gray and is associated with a dark gray to green arkose. Upwards the shales become interbedded with thin bedded limestone, laminated calcareous siltstone and oolitic-oncolitic limestones to form the lower half of map unit 7.

This is then superseded by a middle sequence of thin bedded limestones interbedded with thin siltstone and yellow finely laminated dolostone beds. This is, in turn, overlain by massive bedded oolitic limestone, oncolitic stromatolites and oncolite beds. This sequence most probably correlates with Subunit 3A or the March Point Formation of the Port au Port Group.

Thick bedded dolostones equivalent to the Petit Jardin Formation (Subunit 3B) of the autochthon form the top sequence of the parallochthonous rocks.

## THE HARE BAY ALLOCHTHON

The Hare Bay Allochthon forms the northernmost sample of transported rocks in the Newfoundland Appalachians (Stevens, 1970; Smyth, 1973; Williams, 1975). In the map area, the Hare Bay Allochthon extends from Big Spring Inlet to the east. It trends south-southwest throughout the map area and continues across Canada Bay in the south outside the map area. The Hare Bay Allochthon is about 100 km long and about 40 km across at its widest part. South of Hare Bay, the allochthon is about 40 km long and 20 km across.

The rocks represent a collection of more easterly terrains that once lay at the ancient continental margin of Eastern North America (Stevens, 1970). The maximum distance of transport for the top slices in the Hare Bay Allochthon is estimated at 80 km (Williams and Smyth, 1973). The allochthon is underlain in most places by shaly melange with sedimentary, volcanic, plutonic and locally serpentinite blocks (Unit 8).

The allochthon consists of contrasting rock groups and structural slices which structurally overlie each other (Williams, 1975) (Table 2). The slices, in structural ascending order are: the Northwest Arm Slice, the Maiden Point Slice assemblage, Grandois Slice, Milan Arm melange (Slice), Cape Onion Slice and the St. Anthony Slice assemblage. The lower structural slices (Maiden Point Slice assemblage and the Grandois Slice) consist predominantly of clastic sedimentary rocks. The intermediate Cape Onion Slice of the Hare Bay Allochthon consists mainly of volcanic rocks and some graptoliferous shales. The ophiolite slice or the St. Anthony Slice assemblage overlies all others. It has travelled the farthest west and now lies on autochthonous rocks. A narrow metamorphic aureole, which is attached to the stratigraphic base of the St. Anthony Slice assemblage has been related to obduction and to the beginning of the transportation towards the east (Williams and Smyth, 1973).

In the southern Hare Bay area (Figure 2), the Hare Bay Allochthon comprises the Northwest Arm Slice (Williams, 1975) (Unit 8), the Maiden

**HARE BAY ALLOCHTHON**

**(from Smyth, 1973; Williams, 1975; Bostock, et al., 1976; Smyth, 1980, pers. comm., this report)**

| GROUP | FORMATION | SLICE ASSEMBLAGE/SLICE | LITHOLOGIES | AGES |
|---|---|---|---|---|
| ST. ANTHONY GROUP | WHITE HILLS Peridotite | ST. ANTHONY SLICE | *Harzburgite, dunite and minor pyroxenite* | Lower Ordovician |
| | GREEN RIDGE Amphibolite | | *Green to black hornblende-plagioclase schist.* | |
| | GOOSE COVE Schist | | *Polydeformed and metamorphosed sequence of green agglomerate and mafic pillow lavas.* | |
| | IRELAND POINT Volcanics | | *Agglomerates and mafic pillow lavas* | Lower Cambrian. |
| | Cape Onion Formation | Cape Onion slice | *Mafic pillow lava, agglomerate and black graptoliferous shale.* | Upper Cambrian |
| Milan Arm Melange | | Milan Arm Melange | *Black and green shaly matrix with blocks of periodite, volcanic rocks, amphibolites and graywackes.* | Lower Ordovician |
| GRANDOIS GROUP | IRISH Formation | GRANDOIS SLICE | *Lime turbidites.* | U. Cambrian to L. Ordovician |
| MAIDEN POINT GROUP | MAIDEN POINT Sandstone | MAIDEN POINT SLICE ASSEMBLAGE: CROQUE HEAD SLICE | *Graywacke, quartz-pebble conglomerate, mafic pyroclastic rocks and pillow lava.* | Precambrian to Early Cambrian |
| | MAIDEN POINT Volcanics | MAIDEN POINT SLICE | | |
| | MAIDEN POINT Group or GOOSE TICKLE Formation | EPINE CADORET SLICE | *Black and gray slates and minor sandstones.* | Precambrian to Early Cambrian or Middle Ordovician |
| | NORTHWEST ARM Formation | NORTHWEST ARM SLICE | *Black and bright green shale, buff siltstone, limestone, chert and limestone breccia.* | Lower Ordovician |

TABLE 2: Rock units and structural slices within the Hare Bay Allochthon, listed from structurally lowest (bottom) to structurally highest (top) in the allochthon. The units, which are present within the map area, are written in capital letters.

Point Slice assemblage (Williams, 1975) (Units 11, 12,), the Grandois Slice (Unit 13), and the new Epine Cadoret Slice (Unit 9), which structurally underlies the Maiden Point Slice. The Epine Cadoret Slice is separated from the Maiden Point Slice assemblage by a melange (Unit 10). A small part of the St. Anthony Slice assemblage (Unit 14) structurally overlies the Croque Head Slice (Unit 12) (Table 2) of the Maiden Point Slice assemblage south of Croque Head. On Fishot Island east of the map area, a metamorphic aureole occurs at the base of the St. Anthony Slice (Smyth, 1973; Williams and Smyth, 1973; Jamieson, 1977; Jamieson and Strong, 1981). Toward the west, the Hare Bay Allochthon sedimentary rocks are emplaced onto the carbonate platform. In southern Hare Bay, the Maiden Point Slice has been eroded in its central part to expose the autochthonous St. George Group, Table Head and Goose Tickle Formations in a structure named the White Arm Window (Smyth, 1973).

## UNIT 8 - NORTHWEST ARM FORMATION AND SLICE

The Northwest Arm Formation (Cooper, 1937) forms a separate slice (Williams, 1975) within the Hare Bay Allochthon. It has a chaotic internal structure. It consists of finely bedded black and bright green shale, which are rich in pyrite. Interbeds of gray and buff weathering sandstones, gray to light brown crossbedded dolostones and hemipelagic limestones, limestone breccia and buff to dark gray to green chert and argillite. Blocks of pillow lava and ophiolitic rocks occur in the unit. The shales form a matrix around the blocks.

According to Williams (1975), the disrupted Northwest Arm Formation should be distinguished from melanges by its lack of volcanic blocks and other exotic blocks. Based on this mapping, the exposures within the map area next to and within the Maiden Point Slice assemblage are melanges. Only at Jack Patey's Point and Goose Tickle Point are the volcanics apparently missing. Along the shoreline from Shoal Arm to Little Spring Inlet abundant pillow lava blocks occur.

## UNIT 9 - EPINE CADORET FORMATION AND SLICE

The name of this at present informal unit is derived from Epine Cadoret, which forms the inner southwestern cove of the Croque Harbour fiord complex. The rocks of Unit 9 are exposed in the inner part of the cove west of Croque and along the road to St. Julien's. The Epine Cadoret formation and slice outcrops extensively on the St. Julien's map area near to and north of the community of Croque.

The rocks consist of fine grained argillite, graywackes and dark gray-brown to black slates. The rocks weather a light gray to white color and the sequence apparently coarsens upwards.

The affinity of the Epine Cadoret rocks is uncertain. The rocks may be allochthonous equivalents of the Goose Tickle flysch (Smyth, 1973) because of the upward coarsening of the unit and its lithic similarity to the Goose Tickle Formation. Alternatively, the clastic sediments may be correlative with the Maiden Point Formation and form the oldest slice of the Maiden Point Slice complex. Presently, no conclusive data are available to resolve the problem and the question is left open.

## UNIT 10

Unit 10 is a narrow melange unit that structurally overlies the Epine Cadoret Slice. It is overlain structurally by the Maiden Point Slice. Unit 10 is well exposed along the road to Grandois (St. Julien's).

Unit 10 has a chaotic internal structure. It consists of finely bedded black and bright green shale, which are

rich in pyrite. Large exotic serpentine blocks (10 x 20 m) characterize this unit.

## UNITS 11-12 - MAIDEN POINT FORMATION AND SLICE ASSEMBLAGE

The Maiden Point Formation (Tuke, 1968, formerly Maiden Point Sandstone of Cooper, 1937), occurs in several structural slices collectively referred to as the Maiden Point Slice assemblage. In the map area, the Maiden Point Slice (Unit 11) is separated by a melange from the structural superimposed Croque Slice (Unit 12) (Smyth, 1973). Both contain rocks of the Maiden Point Formation.

The Maiden Point Formation includes a lower sequence of volcanic rocks overlain by a more prominent sequence of monotonous graywackes, sandstones, shales and quartz-pebble conglomerates.

### Subunit 11A - Maiden Point volcanic rocks

The volcanic rocks within the map area outcrop in a continuous belt from Great Islets Harbour in the north to Croque Harbour in the south. Outcrops of volcanic rocks also occur along the western margin of the allochthon at Coles Pond and toward the Croque road in the north.

Dark green, massive basalts account for the bulk of the exposed volcanic rocks. Felsic volcanics containing secondary amphibole and epidote, outcrop 2 km north-northwest of Grandois. Altered mafic agglomerates and tuffs are commonly present.

The volcanic rocks of the Maiden Point are interpreted to be related with rifting (Smyth, 1973) and opening of the proto-Atlantic ocean (Williams & Stevens, 1974). Jamieson (1977) provided data that suggested the volcanics had been subjected to high pressures during obduction of the Hare Bay allochthon.

### Subunit 11B - Maiden Point sandstones

The sequence comprises coarse gray lithic sandstones, quartz-pebble conglomerates, gray sandstone and interbeds of siltstone and shale. The sandstone is gray to white and typically weathers to a rusty brown color. The rocks are moderately sorted, locally conglomeratic, and contain graded beds. Clasts within conglomeratic horizons consist almost entirely of white and blue quartz.

The blue quartz, granite and metamorphic rock fragments in the Maiden Point sandstones indicate a source to the west in Grenvillian rocks of the Long Range Mountains. This is supported by the finer grained lithologies found towards the east within more distal parts of the westerly derived sequence.

## UNIT 13 - GRANDOIS GROUP AND SLICE

Unit 13 is well exposed on St. Julien Island and belongs to the Grandois Group. It consists of minor brecciated sandstones overlain by siliceous limestone and shales. The upper part of the formation is developed as sandy limestone. The limestones were named the Irish Limestone by Smyth (1973). They were included with adjacent conglomerates of the St. Julien Island Formation in the Grandois Group by Williams (1975). However, Smyth (personal communication, 1981) now believes, by comparison to rocks in the Sops Arm area, that the St. Julien Island Formation may be Silurian in age. Only the Irish Formation is thus assigned to the group.

The age of the limestones is unknown. It is possible, however, that they correlate with the Cooks Brook Formation (Stevens, 1970) of the Humber Arm Supergroup in the south (Smyth, 1973). This correlation would suggest a late Cambrian age.

## UNIT 14 - GOOSE COVE SCHIST AND GREEN RIDGE AMPHIBOLITE OF THE ST. ANTHONY GROUP AND SLICE ASSEMBLAGE

The St. Anthony Group includes the Ireland Point volcanics, Goose Cove schist, Green Ridge amphibolite and White Hills peridotite. It outcrops predominantly in the area north of Hare Bay where it has been well described and studied by several workers (Tuke, 1968; Smyth, 1973; Malpas, Stevens and Strong, 1973; Williams and Smyth, 1973; Williams, 1975; Jamieson and Strong, 1981) and warrants no further documentation here.

In the map area the St. Anthony Slice overlies the Croque Head Slice (Unit 12) of the Maiden Point Slice assemblage at Croque Head and the Maiden Point Slice (Unit 11) at Fishot Islands. The structural base of the St. Anthony Slice in the map area coincides with the Goose Cove schist.

The Goose Cove schist consists of polydeformed and metamorphosed green tuff, agglomerate and mafic pillow lava. Minor graywackes, black slates and marbles also occur. The rocks are metamorphosed to greenschist and epidote amphibolite grade.

The Green Ridge amphibolite consists mostly of green to black hornblende-plagioclase schists that were derived from mafic volcanic rocks. They range from hornblende granulite to amphibolite facies.

## UNIT 15 - ST. JULIEN ISLAND FORMATION

Unit 15 outcrops on the eastern half of St. Julien Island where it is faulted against the Grandois Group (Unit 13). The formation is possibly Silurian in age (Smyth, personal communication, 1981).

The formation consists of approximately 60 m of polymictic conglomerate and interbedded red to green and purple graywacke. Red quartzite, vein quartz, acid volcanic rocks and granite form the clasts in the conglomerates.

## UNIT 16 - CARBONIFEROUS SEDIMENTARY ROCKS

Gently folded Carboniferous sedimentary rocks are well exposed on the Cape Rouge Peninsula and Conche Peninsula. The sedimentary rocks are divided into two formations: the Crouse Harbour and the Cape Rouge Formations (Bostock *et al.*, 1976). The Crouse Harbour Formation consists of gray to lesser brown-red conglomerate, some sandstone, thinly bedded gray mudstones and minor dolomite. The Cape Rouge Formation consists of gray to brown sandstones, siltstones and mudstones. Dolomite beds also occur. Plant fossils preserved in the siltstones indicate a Mississippian age for the formation.

## STRUCTURAL GEOLOGY

The autochthonous carbonate sequence is gently folded in the west and cut by several high-angle faults. The rocks display increasing structural complexity eastward where they are tightly folded and imbricated along a series of northeast-trending thrust faults. The rocks are locally sheared and metamorphosed to marble, particularly within the White Arm Window and along the western edge of the Maiden Point Slice assemblage.

Three deformational events are recognizable in the map area. The first deformation ($D_1$) largely confined to the transported rocks, is related to assembly and emplacement of the Hare Bay allochthon. Second generation structures ($D_2$) fold and displace $D_1$ features and are, in turn, offset by faults of $D_3$ age.

The earliest recognizable deformation $D_1$ is confined to transported rocks of the Maiden Point and Epine Cadoret slices, and to melange zones at the interface between the

autochthon and allochthon (Northwest Arm Formation). The uppermost part of the autochthonous sequence (*i.e.* the Goose Tickle Formation) also contains structures correlative with the $D_1$ event, and moreover, appears to form the melange matrix near Jack Patey's Point.

$D_1$ deformation is characterized by west verging tight to isoclinal mesoscopic folds. The folds are parallel and asymmetric, have southeast dipping axial planes and variably plunging axes. Penetrative slaty cleavage, oriented axial planar to the isoclinal folds, is well developed in pelitic rocks of the transported sequence, the melange zone and the autochthonous Goose Tickle Formation. Beds of competent limestone and sandstone within and proximal to the melange zones commonly exhibit bedding parallel to extensional features (pinch and swell structure and boudinage). $D_1$ structures reflect the high strains attendant with assembly and emplacement of the allochthon.

$D_1$ structures are folded about macroscopic $D_2$ fold axes. The $D_2$ folds are consistently west verging, but display considerable variation in geometry from west to east across the map area. The folds are gently open and upright in the western and central parts of the Salmon River area. Wavelengths decrease and amplitudes increase toward the east, where the folds have tighter closures and are locally overturned toward the west. Cleavage axial planar to the folds ($S_2$) is most prominent in the east, but is nowhere pervasive. Overturned limbs of the $F_2$ folds are commonly sheared out and define a series of low angle thrusts directed toward the northwest. Imbrication is most intense in the eastern part of the area, as seen at Coles Pond where autochthonous and allochthonous rocks are juxtaposed and repeated along a complex series of faults.

$D_1$ and $D_2$ structures are displaced by a series of dominantly northeast trending high angle faults ($D_3$). The faults are generally more numerous in the east, but remain a prominant feature in the gently folded terrain of the Salmon River and Eddies Cove West map areas. The fault zones are marked by steeply dipping joint systems parallel to the plane of displacement. The jointing surfaces are commonly spaced as little as 10-30 cm apart at the fault plane; the spacing gradually increases away from either side of the fault. Vein quartz is typically associated with the $D_3$ faults, particularly in the eastern, more deformed portion of the map area.

## WHITE ARM WINDOW

From White Arm Pond and toward the south, the Maiden Point Slice has been eroded to expose the White Arm Window (Smyth, 1973) (Figure 2).

The White Arm Window includes the Brent Island and Southern Arm Formations of the St. George Group, the Table Head Formation and the Goose Tickle Formation. The sequence is, however, structurally dissected by faults and strongly cleaved (both trending northeast). No continuous section passing from Lower to Middle Ordovician occurs within the window.

Where preserved, the lithologies do not differ from the units of the St. George Group, the Table Head Formation and the Goose Tickle Formation as seen elsewhere toward the west. Locally, the limestones/ dolostones are transformed into white and brown marble. Ghost bedding, however, can be recognized and supports the subdivision suggested here (Figure 1). The Goose Tickle Formation is transformed locally to either a disrupted unit or to a gray slate.

## MINERALIZATION

Mineral occurrences within the map area were reported by Knight & Saltman (1980), Knight (1980a) and Stouge (1981). Within the St. George Group, the Zn-bearing horizons occur both in the Brent Island and the Southern Arm

Formations. Minor Zn showings have also been noted within Cambrian dolostones of Unit 3 north of Ocean Pond (Figure 1). The St. George Group mineralization is located in secondary dolomitized dolostones and limestones ("Pseudobreccia"). The Cambrian mineralization occurs in tectonically brecciated zones and as small occurrences in the dolostones. The "pseudobreccia" and mineralization are distributed in northeast-southwest trending zones, some of which have a spatial relationship to $D_3$ fault trends in the central part of the Salmon River map area.

It appears also that structurally controlled vertical zones of metallic mineralization exist west of Salmon River. Mineralization occurs in the rocks below the main host beds as scattered, small, structurally controlled occurrences in the underlying Cambrian-Lower Ordovician units. With more information on the detailed structure of the Lower Ordovician, it may be shown that geometry of the structures is important for the location of mineralization (*e.g.*, tectonic brecciation occurs along the hinges of the folds; disseminated sphalerite mineralization in breccia occurs parallel to the axes of the folds). Also, the northeast-trending, $D_3$ fault planes apparently served as conduits for the influx of fluids which caused the extensive replacement of the carbonate host rocks.

The sphalerite mineralization may well be multileveled, and not stratigraphically bound. It was probably attenuated by the chemical unsuitability of certain stratigraphic units as host rocks. Generally, deeper (vertical) exploration beneath known ore bodies may be more effective than continuing shallow (lateral) exploration techniques.

Near the western boundary of the White Arm Window, chalcocite and malachite are associated with very minor galena and sphalerite. The mineralization occurs as disseminations in white quartz veins up to 20-45 cm wide, which cut light brown-yellow recrystallized dolostones. The quartz veins are typically associated with the $D_3$ faults. Stratigraphically, the mineralization occurs in the upper part of the Southern Arm Formation of the St. George Group. Similar setting and associated quartz veins proximal to faults occur in the eastern part of the window. No mineralization was discovered in these areas.

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