THE PRE-CARBONIFEROUS GEOLOGY OF SOUTHWEST WHITE BAY

by

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INTRODUCTION

The study area lies on the eastern side of the Long Range Grenville inlier in western Newfoundland. Autochthonous, Lower Paleozoic, clastic-carbonate rocks unconformably overlie the basement and dip steeply eastwards away from it. Structurally overlying the autochthon are a number of thrust sheets composed of graywacke, greenschist, ultramafic rocks and melange, and a pre-Silurian igneous complex that consists dominantly of tonalite. The thrust sheets are here collectively referred to as the Southern White Bay Allochthon, which is interpreted as a Taconic allochthon. A Silurian cover sequence, the Sops Arm Group, of dominantly subaerial, felsic volcanic rocks, coarse clastics and shallow marine sedimentary rocks locally unconformably overlies part of the allochthon, but in most places is in thrust contact or tectonically imbricated with it by Acadian orogenesis. A Siluro-Devonian igneous suite of granodiorite, gabbro and granite informally named the Gull Lake intrusive suite intrudes the Sops Arm Group. Carboniferous clastic rocks complete the sedimentary record and were deposited apparently in two separate basins in the south of the area on either side of the northeast trending intrusive suite. Hercynian thrusting locally juxtaposed the Sops Arm Group and part of the Allochthon on top of the Carboniferous rocks.

The Sops Arm Group hosts a number of gold and base metal occurrences and the Gull Lake intrusive suite hosts fluorite, molybdenite and pyrite mineralization.

A review of previous work in the area and a background to this project is given in Smyth (1981). The area was remapped in 1981 on 1:50,000 scale and preliminary 1:25,000 scale geological field maps of the area were recently released on open file (Smyth and Schillereff, 1981). The final map will be published at 1:50,000 scale.

GRENVILLE BASEMENT (UNIT 1)

The Grenville inlier is underlain by quartzofeldspathic gneiss, augen granite gneiss, amphibolite, anorthosite, gabbro and granite (Unit 1), collectively referred to as the Long Range Complex. It was not mapped in this study. The only information available on the southern part of the inlier is a reconnaissance map of Baird (1960). Access to the inlier, however, is good; the coast and fiords offer 100% exposure and the new Cat Arm access road now offers easy access to the inland plateau (Map 1).

DEVILS ROOM GRANITE (UNIT 2)

The Devils Room granite is an informal name applied by Lock (1969a) for a triangular shaped, posttectonic granite that intrudes the gneisses of the Long Range Complex west of Sops Arm (Map 1). Heyl (1937) and Lock (1969a, b) considered this granite to be Paleozoic in age and to be a part of the Gull Lake intrusive suite that was displaced 15 km northwards along a right lateral fault. Both the Devils Room granite and the Gull Lake intrusive suite were mapped and sampled for lithogeochemistry in the study to test this hypothesis. Mapping of the Devils Room granite was carried out by W. Dunford and the following is a summary of a report by him (Dunford, 1981).

The granite occurs in a series of shallow, inward dipping sheets. There is a variation in composition, texture and grain size from the margin to core and four subphases, three with gradational contacts, were delineated. The southeastern margin is a fault with the Coney Arm Group. The northern margin is marked by a strong lineament, here interpreted as a fault, but considered by Dunford as an intrusive contact. The southwestern contact was not located on the ground and is probably intrusive.

FELSITE (SUBUNIT 2A)

A narrow band of pink felsite borders the northern margin of the pluton. It is mostly massive but includes weakly foliated varieties. It consists of a fine aggregate of quartz + K-feldspar ± muscovite. No contacts were seen and the rock is either a dike into Subunit 2b or the chilled margin of the pluton.

MEGACRYSTIC K-FELDSPAR, BIOTITE GRANITE (SUBUNIT 2B)

The wide, outer zone of the pluton is characterized by K-feldspar megacrysts up to 10 cm across in a medium grained, red groundmass of quartz feldspar and biotite. Narrow felsite or aplite dikes were observed around the western margin.

PORPHYRITIC BIOTITE GRANITE (SUBUNIT 2C)

A red to pink to white, K-feldspar porphyritic biotite granite forms the next zone of the pluton. It consists of scattered feldspar phenocrysts up to 4 cm across in a medium to fine grained groundmass. Gradational contacts exist with Subunits 2b and 2d.

MEDIUMGRAINED, BIOTITE + MUSCOVITE GRANITE (SUBUNIT 2D)

A medium grained, pink to white, biotite ± muscovite granite occupies the central part of the pluton. Contacts with Unit 2c are gradational. It has a medium to fine grained groundmass with scattered quartz and feldspar phenocrysts.

DISCUSSION

Alignment of phenocrysts was rarely observed in the outer two zones (2b and 2c) and the inner zone is massive. The inward dipping sheeting, although grossly paralleling the changes in composition and texture, appears to be a late crystallization jointing effect. The medium grained nonporphyritic inner zone might be the chilled top of the intrusion.

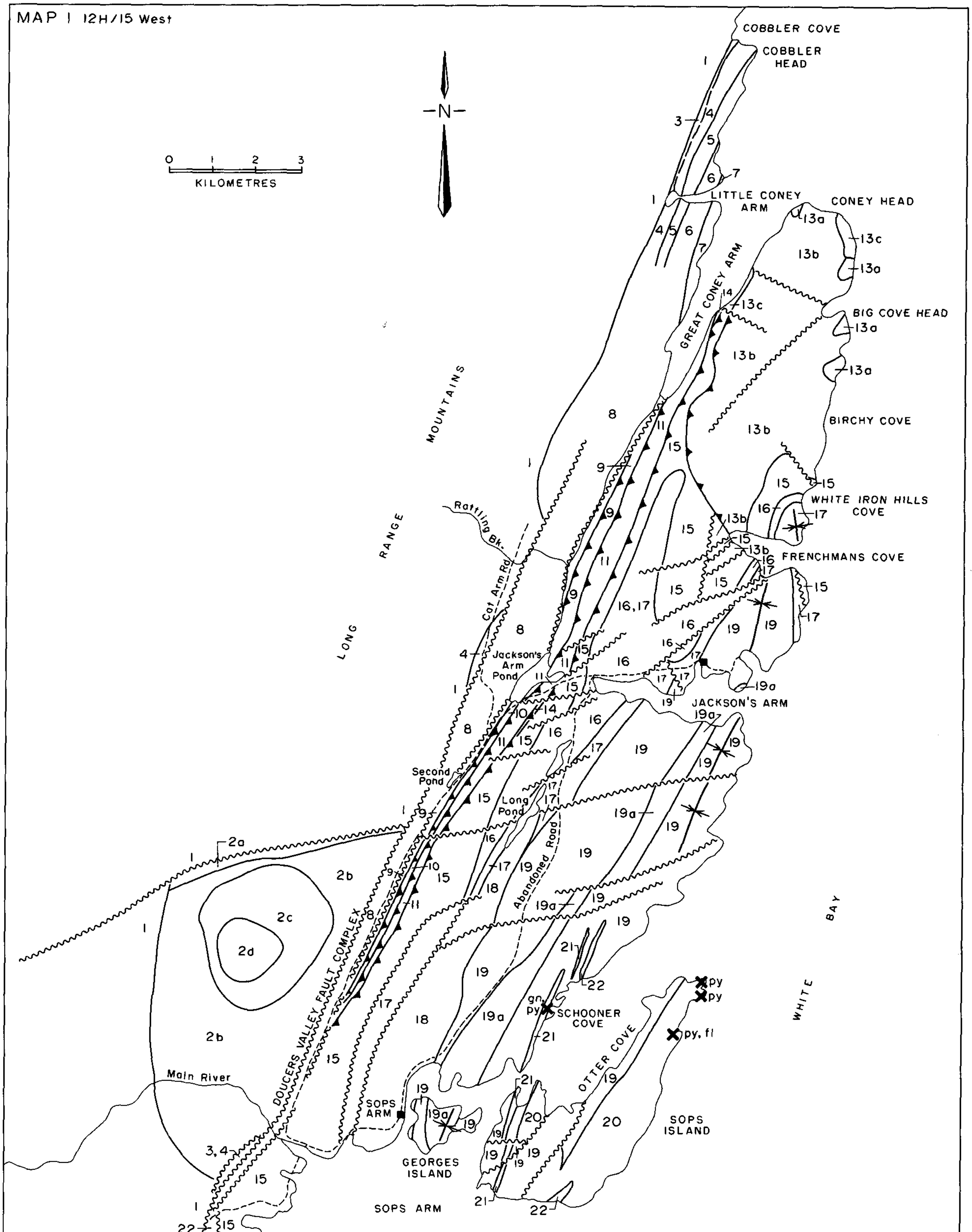
The age of the Devils Room granite is not known. Heyl (1937) and Lock (1969a) considered it to be Paleozoic in age based on lithological similarities with parts of the Devonian Gull Lake intrusive suite to the southeast. However, as the Devils Room granite lacks the variety of phases seen in this suite and as there is no evidence of either granite intruding the intervening Coney Arm Group, the Devils Room granite is here considered to be late Precambrian in age. It is probably similar to other posttectonic granites found in other parts of the Long Range Complex (Bostock *et al.*, 1976; Pringle *et al.*, 1971).

CONEY ARM GROUP - THE AUTOCHTHON (UNITS 3-8)

Clastic-carbonate rocks of the autochthonous Coney Arm Group (Lock 1969a, 1972a) lie to the east of, and locally unconformably overlie, the Long Range Complex (Maps 1 and 2). The Group is intensely deformed, however to the north of Great Coney Arm (Map 1), the rocks are vertically dipping, less deformed and a stratigraphy can be established. Rock units can be traced southwards with some success but more detailed mapping is required in inland areas to firmly establish the stratigraphy and structure.

BEAVER BROOK FORMATION (UNIT 3)

The Beaver Brook Formation (Heyl, 1937; Neale and Nash, 1963) is here redefined to include only the basal


MAP 1 12H/15 West
N
0 1 2 3
KILOMETRES
COBBLER COVE
COBBLER HEAD
LITTLE CONEY ARM
CONEY HEAD
GREAT CONEY ARM
BIG COVE HEAD
BIRCHY COVE
WHITE IRON HILLS COVE
FRENCHMANS COVE
JACKSON'S ARM
LONG RANGE MOUNTAINS
Rattling Bk.
Cat Arm Rd.
Jackson's Arm Pond
Second Pond
Long Pond
Abandoned Road
DOUCERS VALLEY FAULT COMPLEX
Main River
SCHOONER COVE
OTTER COVE
SOPS ARM
GEORGES ISLAND
SOPS ISLAND
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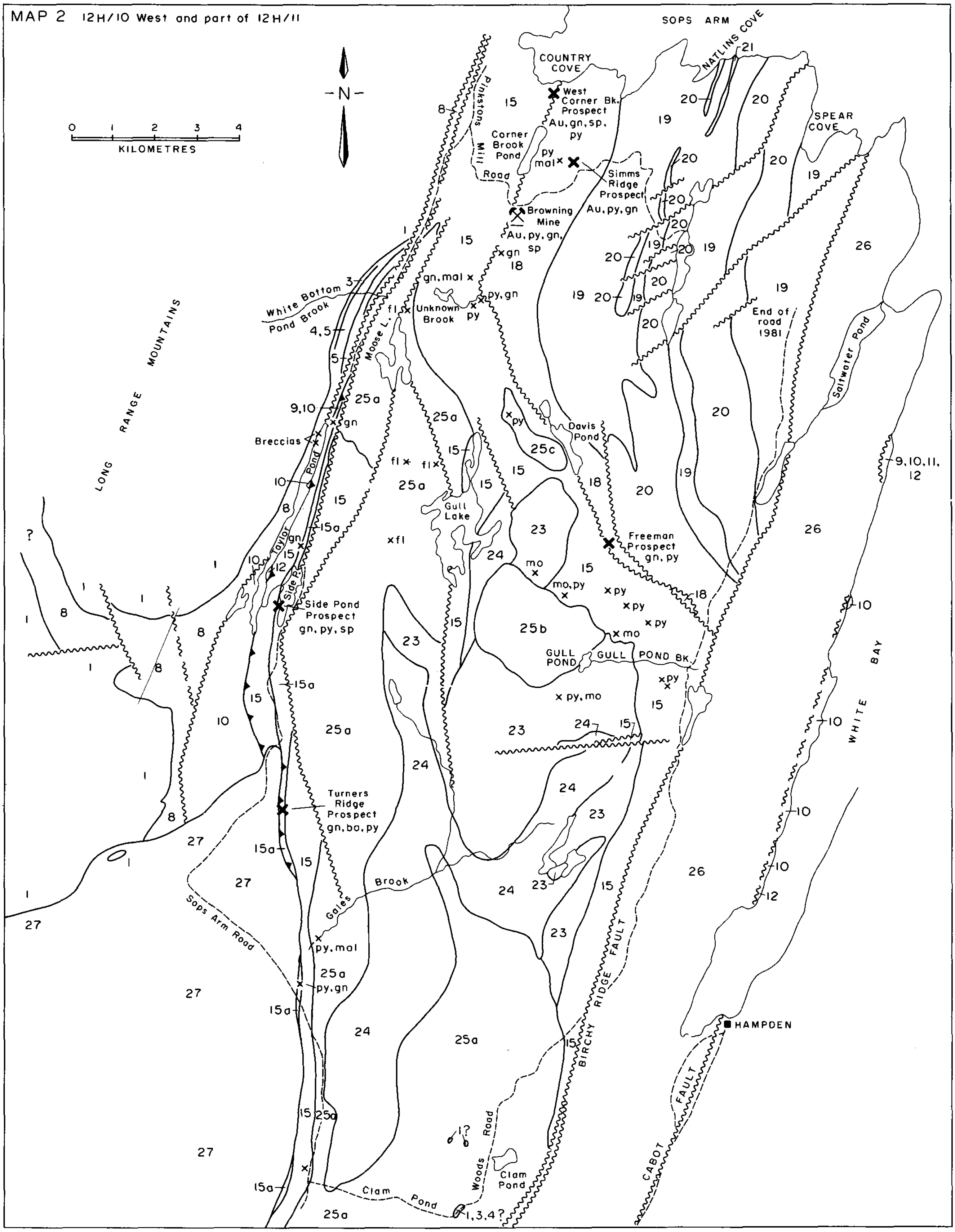

MAP 2 12H/10 West and part of 12H/11

LEGEND

CARBONIFEROUS AND OLDER(?)

27 **Deer Lake Group:** Poorly indurated, red conglomerate and sandstone.

26 **Anguille Group:** Well indurated, gray sandstone, shale, minor red beds.

DEVONIAN AND OLDER

GULL LAKE INTRUSIVE SUITE (Units 23-25)

25 25a, **Moose Lake granite:** Megacrystic, biotite granite; 25b, **Gull Pond granite:** Fine to medium grained, biotite granite; 26c, medium grained biotite granite.

24 Gabbro, diabase and mafic intrusion breccias.

23 Biotite granodiorite to tonalite.

SILURIAN

22 Pink felsite dikes and sills.

21 Quartz monzonite sills

SOPS ARM GROUP (Units 14-20)

Natlins Cove Formation (Units 19 and 20)

20 **Volcanic rocks:** Predominantly ash flow tuffs and rhyolite flows, minor mafic volcanic flows.

19 **Sedimentary rocks:** Limy siltstone and sandstone, minor limestone; 19a, Lighthouse Member, white sandstone.

18 **Simms Ridge Formation:** Slate and argillite, minor limestone.

17 **Frenchmans Cove Formation:** Bedded polymictic conglomerate and coarse sandstone.

16 **Jacksons Arm Formation:** Massive, polymictic conglomerate.

15 **Lower Volcanic formation:** Welded and unwelded ash flow tuffs, flow banded rhyolite, minor mafic flows; 15a, dolostone and thin bedded limestone.

14 Quartz-carbonate schist. Age and origin uncertain.

MIDDLE ORDOVICIAN TO CAMBRIAN(?)

SOUTHERN WHITE BAY ALLOCHTHON

13 **Coney Head Complex:** 13a, Gabbro; 13b, tonalite; 13c, graphic microgranite; 13d, muscovite leucogranite; 13e, zone of mafic to intermediate dikes.

12 Gabbro, trondhjemite, talc-carbonate schist.

11 **Murrays Cove Schist:** Polydeformed greenschist, mafic tuff, metagabbro and chert.

10 **Maiden Point Formation equivalents:** Fine to medium grained, dark green graywacke and slate.

9 **Taylors Pond Formation and Second Pond Melange:** Graphitic slate, minor calc- argillite, with exotic blocks and slivers.

MIDDLE ORDOVICIAN TO CAMBRIAN

CONEY ARM GROUP (AUTOCHTHONOUS)

8 Undivided recrystallized, limestone, dolostone and marble.

7 **Limestone formation:** Dark gray, recystallized limestone, minor cherty dolostone.

6 **Dolostone formation:** White dolostone, minor dark gray limestone.

5 **Hawke Bay Formation equivalents:** Quartzite, sandstone, sandy dolostone, oolitic limestone.

4 **Forteau Formation equivalents:** Graphitic slate, phyllite, calcareous schist and marble.

3 **Beaver Brook Formation:** Arkose, sandstone.

PRECAMBRIAN OR YOUNGER

2 **Devils Room Granite:** Undeformed granite, age unknown; 2a, fine grained, pink felsite; 2b, megacrystic K-feldspar biotite granite; 2c, K-feldspar porphyritic biotite granite; 2d, medium grained, biotite $\pm$ muscovite granite.

PRECAMBRIAN

LONG RANGE COMPLEX

1 Granite gneiss, amphibolite, anorthosite, gabbro and granite.

clastic rocks that directly overlie the Long Range Complex. Overlying marbles, phyllites and slates previously included in the formation are separated as another formation, thus making the stratigraphic divisions in this area consistent with those established elsewhere for the autochthonous sequence of western Newfoundland (see Schuchert and Dunbar, 1934; Knight and Saltman, 1980).

The type section of the redefined formation is at Cobbler Cove (Map 1) where an estimated 22 m of gray sandstone, pebble conglomerate, arkose and hematitic sandstone is exposed. The base and top of the formation are exposed but a small part of the sequence is hidden. The formation is lithologically identical to the Eocambrian Bradore Formation (Schuchert and Dunbar, 1934) exposed around the northern margin of the Long Range Inlier.

FORTEAU FORMATION EQUIVALENTS (UNIT 4)

The name Forteau Formation equivalents is provisionally assigned to the interbedded marbles, graphitic phyllites and schists that conformably overlie the Beaver Brook Formation. The formation marks the beginning of carbonate deposition on the western platform, which in the Canada Bay area to the north has been dated as extending from Lower Cambrian to Lower Middle Ordovician. The type section is along the shore of Cobbler Cove (Map 1).

The basal part of the formation is characterized by a white, bedded, marble that can be correlated with the Lower Cambrian Devils Cove Formation (Betz, 1939) in Canada Bay to the north. This is overlain by a mixed sequence of dark gray, fine grained, muscovite and graphite bearing pelitic schists, calcareous schists, with thin, prominent marble beds. The formation is characterized by quartz veins and pods and complicated recumbent folds.

Muscovite, sericite and locally biotite in the south define a strong S_1 schistosity that is folded about numerous, westerly verging recumbent folds.

HAWKE BAY FORMATION EQUIVALENTS (UNIT 5)

An interbedded sequence of oolitic limestone, sandy dolostone, orthoquartzite, limy slate and calcareous sandstone conformably overlies the Forteau Formation equivalents. The sequence occupies a similar stratigraphic position and is lithologically identical to the oolitic limestone-mudstone-quartzite formation of Knight and Saltman (1980) in Canada Bay, which they considered to be laterally equivalent to the Hawke Bay Formation on the western side of the Long Range inlier. For these reasons, the formation is provisionally named Hawke Bay Formation equivalents.

The formation is well exposed along the coast south of Cobbler Head (Map 1) but is locally disrupted by a thrust and minor normal faults. The base of the formation is drawn at the first appearance of interbedded limestones and dolostones overlying black, graphitic pelites of the Forteau Formation equivalents.

The basal part of the formation at Cobbler Head consists of five reddish weathering, gray dolomite beds from 0.5 to 1 m thick interbedded with dark gray oolitic and oncolitic limestones. A thrust fault that separates oolitic limestones from slates and phyllites of the Forteau Formation equivalents is exposed in a small cove 400 m south of Cobbler Head. The contact is marked by 2 m of breccia. The beds on the upper plate dip steeply to the east, whereas those in the sole are subhorizontal. The upper plate contains distinctive orthoquartzites. The orthoquartzites are fine grained, laminated, crossbedded and locally highly disrupted by slumps. They occur in laterally persistent beds up to 4 m thick.

DOLOSTONE FORMATION (UNIT 6)

A formation of thick, well bedded, white weathering dolostone, dolomitic limestone and minor gray limestone overlies the Hawke Bay Formation equivalent. It is excellently exposed on the sea cliffs at the entrance to Little Coney Arm (Map 1) where it faces eastwards in subvertical to overturned beds. The dolostones occur in beds up to 1 m thick and display numerous shallow water sedimentary features such as mud cracks, ripple marks, and thin dessication breccias along the tops of beds. These were incorrectly interpreted by Lock (1969a) as channel breccias.

LIMESTONE FORMATION (UNIT 7)

Near the entrance to Little Coney Arm (Map 1) the dolostone formation passes transitionally upwards into a sequence of dark gray limestones with abundant chert lenses and nodules and minor white dolostone interbeds. These pass up into a sequence of dark gray, rubbly weathering, limestones which form the top of the exposed sequence in Great Coney Arm.

The limestones at the base of the formation are extensively burrowed and contain algal mats and stromatolites. Stouge (personal communication, 1980) recovered conodonts from the middle part of this formation that indicate a Lower Ordovician (Canadian) age. Poorly preserved coiled gastropods were discovered 1.5 km south of Little Coney Arm.

Southwards from Little Coney Arm the beds deviate from the vertical and are folded, intensely tectonized and recrystallized. Bedding is obscure and in most places the formations described above could not be distinguished with certainty. Such rocks as shown on the map are undivided recrystallized limestone, dolostone and marble (Unit 8).

Breccias

A number of breccias in bands and pods up to 6 m thick are developed in the limestones and minor dolostones of Unit 7 in Rattling Brook (Map 1) and on the northwest side of Taylors Pond (Map 2). Those in Rattling Brook (Gorge tributary of Lock, 1969a) were interpreted by Lock (1969a, 1973) as synsedimentary breccias deposited in channels at the carbonate bank edge. However, the sedimentological evidence suggests that the immediately underlying formation (Unit 6) was deposited in an intertidal to supratidal environment. The carbonates were probably exposed periodically, leading to formation of dessication breccias along the tops of beds such as seen in the Little Coney Arm section. Unit 7 limestones were deposited in deeper water, probably subtidal conditions. There is no evidence to support Lock's thesis that these units formed as slope deposits traversed by channels in which breccias were deposited.

In Rattling Brook, the breccias occur in subvertical bands from 10 m to 0.5 m wide within a white dolostone and limestone sequence. They have sharp contacts with unbrecciated rock. The breccias are unsorted and ungraded with clasts up to 1 m across but most range from 30 to 50 cm across. The breccias have a pink to white calcite cement, but the thickest breccia horizon in Rattling Brook contains in addition a green clastic cement that is locally hematized. The clasts have well developed internal foliations and the haphazard orientation of the foliated clasts indicates the host was deformed prior to breccia formation.

These breccias clearly formed after the regional penetrative deformation and metamorphism and are probably tectonic in origin.

Similar breccias that postdate the regional deformation also occur at the northwest end of Taylor's Pond. There the breccias have a red, hematitic cement that is locally cleaved indicating later minor deformation in this area.

The breccias in both localities occur near the easternmost exposures of the Coney Arm Group, its boundary being a major fault line named the Doucers Valley Fault Complex (Lock, 1972a). The breccias are here considered to be the result of brittle deformation related to late tectonic movements (post-Acadian) on this fault.

SOUTHERN WHITE BAY ALLOCHTHON (UNITS 9-13)

Rocks that lie between the Ordovician and older Coney Arm Group and the Silurian Sop's Arm Group and separated from them by faults are considered to be allochthonous and are assigned to the newly proposed Southern White Bay Allochthon. The allochthonous nature of some of these rocks was first proposed by Williams (1977) but this work has identified additional slices and shown that the allochthon is much more extensive and lithologically diverse than first described.

Pre-Carboniferous rocks that outcrop along the southwest shore (Map 2) of White Bay (Hyde, 1979) are here also considered to be part of the allochthonous sequence, which were further imbricated during Hercynian orogenesis.

TAYLOR'S POND FORMATION AND SECOND POND MELANGE (UNIT 9)

Bordering the Coney Arm Group on its eastern side and separated from it by a high angle fault is a narrow belt of black, graphitic and pyritic slate and phyllite named the Taylor's Pond Formation (Lock, 1969a; Williams, 1977). The formation is characterized by laminated limy argillites up to 0.5 m thick and by numerous quartz veins and pods.

Apparently within the formation are areas of melange, the Second Pond Melange (Williams, 1977), and slivers of fine grained green graywacke.

The Taylor's Pond Formation is well exposed at the junction of Rattling Brook and Jackson's Arm Pond River and along the Jackson's Arm road (Map 1). Melange is best exposed in road cuts opposite Second Pond and an isolated serpentinite block occurs near the southeast end of Taylor's Pond (Map 2).

The age and stratigraphic position of the Taylor's Pond Formation is not known, but is here considered to be part of the allochthon; however, other interpretations are possible, *viz*

1. It stratigraphically overlies limestones of the Coney Arm Group and is correlative with Middle Ordovician Goose Tickle Formation which occurs at the top of the autochthonous sequence in western Newfoundland (*cf*. Williams, 1977).

2. It is a parautochthonous thrust slice of the Lower Cambrian Forteau Formation equivalents (Smyth, 1981). The melange and graywacke slivers were tectonically incorporated during thrusting.

3. It is allochthonous and possibly equivalent to the Tremadocian Northwest Arm Formation (Tuke, 1968) of the Hare Bay Allochthon to the north.

Interpretation 1 of Williams (1977) is rejected as the formation lacks flyschoid sandstones typical of the Goose Tickle Formation. In addition there is no evidence that the upper part of the autochthonous sequence, *viz* the Table Head Formation and the Goose Tickle Formation, is preserved anywhere in the area.

The difference between interpretation 2 and 3 is age and distance travelled of the two formations. If the formation is equivalent to the Forteau

Formation, then a simple reverse fault would juxtapose it against the limestones of Unit 7. On the other hand, if it correlated with the Northwest Arm Formation, then it presumable was transported from the paleo-continental slope that lay an unknown distance to the east.

The formation contains a number of impure limestone beds which might yield conodonts.

MAIDEN POINT FORMATION EQUIVALENTS (UNIT 10)

Medium to fine grained, green schistose graywacke and slate form a separate slice in the allochthon as well as tectonic slivers in shales of the Taylor's Pond Formation. The thrust sheet overlies the Taylor's Pond Formation and is structurally overlain by the Murray's Cove Schist. The rocks are named the Maiden Point Formation equivalents as they are lithologically identical to the lower Cambrian(?) Maiden Point Formation in the Hare Bay allochthon (Williams, 1975) to the north.

It outcrops from Jackson's Arm Pond 10 km southwards where it is removed along the Doucers Valley Fault Complex but reappears at Taylor's Pond to the south. The formation also occurs in post- Carboniferous thrust sheets on the southwest shore of White Bay (Map 2).

The graywackes are characterized by blue quartz grains and interbedded minor quartz pebble conglomerates typical of the type formation at Hare Bay.

MURRAYS COVE SCHIST (UNIT 11)

The Murrays Cove Schist (Lock, 1969a; Williams, 1977) forms the next highest thrust slice of the allochthon. It consists of polydeformed and metamorphosed mafic tuffs and breccias, with rare, thin, calcareous tuffs, red chert and metagabbro pods. Williams (1977) grouped the schists and nearby igneous rocks into the Coney Head Complex and stated that there was a structural and metamorphic gradation between them. However, this work has shown that the two rock types form separate structural units separated from each other by a thrust wedge of Silurian rocks (Map 1) and are consequently described separately.

The schists are intruded by rare, pretectonic, gray, feldspar porphyritic, felsic dikes from 0.3 m to 10 cm wide. The dikes occur throughout the formation but are more abundant towards the top at Murrays Cove.

The schists have been traced southwards from Great Coney Arm to near Sops Arm (Map 1) where they are pinched out along the Doucers Valley Fault Complex. South of Jackson's Arm they are difficult to distinguish in the field from adjacent mafic flows of the Sops Arm Group. However, the latter tend to be less schistose, and have interbedded polymictic conglomerate beds and red cherts.

The Murrays Cove Schist is identical to parts of the dynamothermal aureole that is underpinned to slices of ophiolite in the Hare Bay and Humber Arm Allochthons (Williams and Smyth, 1973).

UNIT 12

Unit 12 consists of slivers of deformed gabbro, trondhjemite and talc-carbonate schist and outcrops along the southwest shore of White Bay. It is interpreted as remnants of a disrupted ophiolite and as such is considered part of the Southern White Bay Allochthon.

Unit 12 is separated by steep, easterly dipping, reverse faults from the Anguille Group to the west and from greenschists of Unit 11 to the east. Ophiolitic rocks in the other western Newfoundland allochthons always form the highest structural slices and the disruption of this stacking order in White Bay is probably a result of the post-Lower Carboniferous reverse faults.

CONEY HEAD COMPLEX (UNIT 13)

The term Coney Head Complex (Williams, 1977) here refers to an intrusive sequence of gabbro and quartz gabbro (5%), trondhjemite and tonalite (90%), biotite microgranite (5%) and muscovite leucogranite (>1%) that occurs south of Coney Head (Map 1). Also included is a zone of intrusion breccia of the above rock types that is cut by a swarm of mafic to silicic dikes.

The exact age of the complex is not known. It is unconformably overlain (Williams, 1977) by rhyolite breccias of the Silurian Sops Arm Group at its southeast margin. Its western margin is a thrust contact with the Sops Arm Group. It is believed to be part of a Taconic Allochthon as first suggested by Williams (1977) as possible correlatives in the Humber Arm Allochthon and elsewhere likely formed in an oceanic domain east of the Baie Verte Lineament (Williams, 1977).

Gabbro grades into quartz gabbro (13a); both are medium grained and massive to locally foliated. Locally, they contain oval shaped, pegmatitic patches up to 30 cm across that consist of hornblende, feldspar and minor quartz. Layered schlieren, generally with northwest trends, were observed in coastal exposures south of Big Cove Head and west of Coney Head (Map 1). The schlieren occur as troughs and bands that are truncated by massive gabbro.

The gabbro-quartz gabbro is intruded by a medium to coarse grained tonalite (13b), which comprises over 90% of the complex. Spectacular intrusion breccias occur at the contacts with the gabbros and locally throughout the tonalite. At the contacts, the gabbro xenoliths have rounded and cuspate margins but within the tonalite some xenoliths are intensely flattened and define a northwest trending fabric. There is a gradation between tonalite and trondjhemite throughout the complex.

At Coney Head the tonalite-gabbro phases are intruded by a purple to red, biotite, graphic microgranite (13c). This unit is characterized by numerous small (5 to 10 cm) rounded and oval shaped inclusions of dark green diabase. Most are medium to fine grained and some have scattered feldspar phenocrysts. Composite silicic-mafic dikes occur in this unit.

In the Birchy Cove area (Map 1) the tonalite is cut by sheets of pink, medium to coarse grained, muscovite, alkali-feldspar granite (13d). They are extensively veined by quartz and contain pyrite disseminations.

On the east shore of Great Coney Arm, intrusion breccias are cut by numerous silicic and minor mafic porphyry dikes (13e). The silicic dikes resemble those in the Murray's Cove Schists nearby.

Deformation in the complex is variable. The early northwest trending foliation is rare. A penetrative, northeast trending Acadian cleavage is zonally developed especially at Coney Head, near the unconformity at White Iron Hills Cove and along the western margin of the complex within 1 km of the thrust contact with the Silurian Sops Arm Group.

SOPS ARM GROUP (UNITS 14-20)

The geology of the Silurian Sops Arm Group was previously well known from the work of Heyl (1937), Lock (1969a) and Noranda Exploration Ltd. (summarized in Dimmell, 1979). This work has refined the distribution of the various formations, especially north of Jackson's Arm. The only changes proposed here to the nomenclature of Lock (1969a) are as follows:

(1) The three basal volcanic formations - White Iron Hills, Main River and Stoney Hill - are grouped into one formation. As suggested by Lock (1972a) these are lateral facies

equivalents and extend the entire length of the map area. The Main River and Stoney Hill formations are well exposed and distinctive in their type area at Sops Arm and could be retained as members of the Lower Volcanic formation (informal name).

(2) Volcanic rocks near the top of the Group occur in three belts separated by sedimentary rocks. Each belt contains similar lithologies to the others and Lock's (1969b) five-fold subdivision of the upper volcanics, made from detailed examination of coastal exposures, were difficult to establish inland. Consequently, the terms are not used in this report but are referred to where appropriate.

QUARTZ-CARBONATE SCHIST (UNIT 14)

Unit 14 consists of a brown weathering quartz-carbonate-sericite schist. It forms a narrow band between greenschists of the Murrays Cove schist to the west and volcanic rocks of Unit 15 to the east. It is exposed on the Jacksons Arm road and at Great Coney Arm.

The age and origin of Unit 14 is uncertain. It contains an unidentified bright green mineral which could be either sericite or fuchsite. If it is the latter, then this rock could be an altered ultramafic and be part of the allochthonous sequence, but the field evidence suggests it is an altered felsic volcanic rock and hence is included in the Sops Arm Group.

LOWER VOLCANIC FORMATION (UNIT 15)

The Lower Volcanic formation consists predominantly of felsic ash flow tuffs, rhyolite flows with lesser mafic flows and minor interflow conglomerate, sandstone and dolostone. The formation extends from White Iron Hills Cove (Map 1) southwards parallel to the Doucers Valley Fault Complex. The basal parts of the formation are strongly sheared close to the fault. The formation is bifurcated by the Gull Lake intrusive suite south of Sops Arm (Map 2).

A felsic pyroclastic breccia unconformably overlies the Coney Head Complex at the White Iron Hills Cove. At the northwest side of Sops Arm (Map 1), the base of Unit 15 consists of sheared and altered rhyolite, now a quartz sericite schist, overlain by vesicular mafic flows and minor polymictic conglomerate. These are overlain by a sequence of flow banded rhyolites with minor welded crystal tuffs (Main River Formation of Lock, 1969a). This is overlain by a sequence of seven ash flow tuffs that are predominantly strongly welded (Stoney Hill Formation of Lock, 1969a). West of Long Pond (Map 1), the ash flows are overlain by a coarse, monomictic volcanic breccia that contains densely packed, subrounded, purple, feldspar porphyry clasts from 20 to 50 cm across. Some of the clasts have altered rims.

From the north end of Taylors Pond southwards to the south end of the map area, a thin dolostone-calc-argillite horizon (Subunit 15a) occurs within the Lower Volcanic formation. This horizon hosts subeconomic lead mineralization and was mapped and explored in detail by Noranda Exploration (Dimmell, 1979).

JACKSONS ARM FORMATION (UNIT 16)

The Jacksons Arm Formation (Heyl, 1937; Lock, 1969a) is a massive, unsorted, cobble to boulder, polymictic conglomerate unit. The conglomerates are similar to thin, interflow conglomerate horizons in the Lower Volcanic formation but in the north of the area they define a 600m thick unit that overlies the volcanics. South of Long Pond only minor conglomerate beds were observed and there is no mappable conglomerate formation. Its stratigraphic position is marked by a strong lineament suggesting that facies changes alone may not be responsible for its absence.

The formation is best exposed in Frenchmans Cove (Map 1) where it contains a number of intercalated mafic volcanic flows up to 4 m thick and rare sandstone beds.

The clasts are composed predominantly of felsic volcanic lithologies with rare argillite, sandstone, shale, chert, granite, gneiss and gabbro clasts.

FRENCHMANS COVE FORMATION (UNIT 17)

The Frenchmans Cove Formation (Lock, 1969a) consists of interbedded, pebble to boulder polymictic conglomerate and medium to coarse grained sandstone. It gradationally overlies and occurs in the same general area as the Jacksons Arm Formation (Map 1). The transition is marked by a decrease in clast size, increased sorting and the occurrence of well defined bedding in the conglomerates. Inland, it is often difficult to decide which formation an isolated conglomerate outcrop should be assigned to, and both formations should probably be viewed as members of one formation.

SIMMS RIDGE FORMATION (UNIT 18)

The Simms Ridge Formation (Heyl, 1937; Lock, 1969a) consists of a sequence of brown weathering, pale green-gray slate, siltstone, minor fine grained sandstone and limestone. It intervenes between the Lower Volcanic formation and the sandstones of the Natlins Cove Formation in the south of the area. To the north it pinches out between the Frenchmans Cove Formation and the Natlins Cove Formation near Long Pond and apparently was not deposited north of there. Northward shallowing of the basin and preponderance of coarse clastic rocks may account for its absence in that area (Lock, 1969a, 1972a).

Although the formation is named after Simms Ridge, a hill north of Pinkstons Mill Road (Map 2), the type section is on the south shore of Sops Arm. There the basal contact with the Lower Volcanic formation is unexposed but to the south at Unknown Brook (Map 2), the contact is a fault.

The characteristic feature of the formation is the occurrence of brown weathering, posttectonic siderite spots (Lock, 1969a). Their origin and significance has yet to be investigated. Fossiliferous limestones and marbles in beds up to 3 m thick are an integral feature of the formation. They contain gastropods, crinoids, corals and rare brachiopods that indicate a Middle Silurian age (Lock, 1972a).

NATLINS COVE FORMATION (UNITS 19 AND 20)

The Natlins Cove Formation (Heyl, 1937; Lock 1969a) consists of a mixed sequence of shallow marine sandstones and subaerial felsic and minor mafic volcanic rocks. The volcanic rocks occur in two belts on the south shore of Sops Arm and on Sops Island and this work has delineated another belt of volcanic rocks between the other two in the area south of the end of the Pinkstons Mill Road (Map 2). All three volcanic belts are composed of varying amounts of subaerial volcanics including flow banded rhyolite flows, ash flow tuffs, air fall tuffs, lahars, minor mafic flows and minor felsic intrusive rocks.

Lock (1969a) mapped the lower and upper belts and subdivided them into members. However, as the same lithology occurs in each of the three belts, it is difficult to decide in the field to which member an outcrop should be assigned. A further mapping problem exists in the region southeast of Davis Pond (Map 2) where the volcanic rocks of the Natlins Cove Formation lie adjacent to the Lower Volcanic formation. Both formations contain similar lithologies and it is possible that they could be the same formation repeated by folding and/or faulting. However, available top determinations suggest the volcanic sedimentary rocks of the Natlins Cove

Formation are interbedded and form an east-facing conformable sequence. A detailed paleontological study and structural analysis of the coastal exposures is necessary to confirm this. The abundant limestone beds throughout the formation contain poorly preserved macrofossils, but samples from Spear Cove (Map 2) were found to contain identifiable Silurian conodonts (Stouge, personal communication, 1980) indicating a useful field of future study.

Sedimentary rocks (Unit 19)

The dominant rock of this unit is a fine grained, gray, sandstone with lesser limy siltstone, shale and thin limestone beds.

In the north of the area the sandstones pass transitionally upwards from the coarser clastics of the Frenchman's Cove Formation. The transition is marked by the disappearance of coarse clastics and the appearance of limestones. South of Jackson's Arm sandstones and calcarenites of the formation gradationally overlie spotted slates of the Simms Ridge Formation.

Within the gray sandstones in the north of the area is a band of well bedded, white, medium grained sandstones and orthoquartzite named the Lighthouse Beds by Lock (1969a). The beds are well exposed at the lighthouse at Jackson's Arm where they display large scale trough crossbedding that indicate paleocurrent flow from the north. To the south, the beds are darker coloured and contain siltstone interbeds. They are not seen south of Georges Island (Map 1) where they apparently occupy the core of a north plunging syncline.

Conglomerate and coarse volcaniclastic rocks occur in spatial association with the volcanics. They are best exposed on the east shore of Sops Island.

Volcanic rocks (Unit 20)

Rhyolite: Pink to dark gray, flow banded rhyolites occur in each of the three volcanic belts. They contain both quartz and feldspar phenocrysts and bands of opaque minerals. Rhyolite is the dominant lithology in the easternmost belt. A part of this belt, exposed at Otter Cove on Sops Island, is underlain by what looks like a flow banded rhyolite in the field but was identified by Lock (1972b) as a rheo-ignimbrite.

Ash Flow Tuffs: Welded and unwelded, lithic and crystal lithic ash flow tuffs are common in all three belts. They overlie and are locally overlain by flow banded rhyolite. Individual flow units, separated by air fall tuffs and/or bedded epiclastic rocks can be distinguished on the highlands south of Sops Arm. Large parts of the upper belt on Sops Island are composed of pyroclastic breccias presumed to have been deposited by ash flows proximal to a vent.

Air Fall Tuffs: These are soft, poorly bedded and unsorted with lithic clasts from 1-5 cm across. They are best seen in Sops Arm 0.5 km west of White Point.

Mafic Volcanics: Mafic volcanic rocks occur in the central and eastern belts and consist of green, chloritized, vesicular and amygdaloidal flows with minor interflow mafic tuff and rare feeder(?) dikes. They are well exposed at the east end of Pinkstons Mill Road and on the shore of Spear Cove (Map 2).

Laharic Breccias: Lahars were recognized in the central and eastern volcanic belts on Pinkstons Mill Road and Sops Island. They consist of coarse rhyolite and feldspar porphyry clasts from 2 to 20 cm across dispersed in a tuffaceous matrix.

INTRUSIVE ROCKS

GRANITOID SILLS AND DIKES (UNITS 21 AND 22)

A number of pretectonic granitoid sills and dikes cut the Simms Ridge and Natlins Cove Formations. Most are fine grained, pink, rhyolites that are commonly cut by postcleavage, quartz-filled fractures and veins. A feldspar porphyritic sill which cuts the Natlins Cove sediments at Schooner Cove and on adjacent Sops Island was reported by Lock (1969a) to be a quartz monzonite. The adjacent fine grained sandstones are hornfelsed at the contacts.

GULL LAKE INTRUSIVE SUITE (UNITS 23-25)

The name Gull Lake intrusive suite is here proposed for the large suite of granodiorite, gabbro and diabase, megacrystic biotite granite and fine grained biotite granite that intrudes the Sops Arm Group south of Sops Arm (Map 2). It was previously referred to as the Gull Lake granite (Lock, 1969a) and the Gales Brook stock (Hyde, 1979) but this is the first recognition and definition of the various phases.

Granodiorite (Unit 23)

The earliest phase of the suite is a medium to coarse grained, biotite granodiorite to tonalite. The rock is light gray, massive to foliated and is interpreted as a pre- or syn-Acadian intrusion. Intrusive contacts with the Sops Arm Group are exposed on Gull Pond Brook and south of Davis Pond. Xenoliths of amphibolite and quartz-biotite-feldspar schists (metavolcanic rocks) are common near the contacts. The granodiorite is clearly intruded by the other phases of the suite.

Gabbro and diabase (Unit 24)

A roughly northeast trending Y-shaped belt of diabase and gabbro occupies the southern part of the suite. It consists mainly of massive, weakly foliated, subophitic diabase and microgabbro with minor mafic dikes and patches of pegmatitic gabbro. The gabbro and diabase form intrusion breccias and small intrusions within the earlier granodiorite; the contact with it is gradational over 500 m. Within the unit itself there are both sharp and diffuse intrusive contacts between diabase and gabbro.

A swarm of late to posttectonic diabase dikes cut the Maiden Point Formation equivalents south of Taylors Pond (Map 2). They were not observed to cut the adjacent Sops Arm Group and their age and relation to this unit is not known.

Moose Lake Granite (Subunit 25a)

The name Moose Lake granite is informally applied to the coarse grained to megacrystic biotite granite that forms a linear shaped pluton along the western and southeastern margin of the suite. It intrudes the Sops Arm Group and the earlier phases of the suite and west of Moose Lake is juxtaposed against the Coney Arm Group by the Doucers Valley Fault Complex.

The granite is pink to red, with microcline phenocrysts up to 8 cm long. It is generally massive except close to faults such as the Doucers Valley and Birchy Ridge faults where it is sheared with extensive chlorite alteration.

Dikes of the granite clearly crosscut cleaved Sops Arm Group sediments southeast of Moose Lake and in this area a biotite hornfels up to 1 km wide is developed in the country rocks. Amphibolites (metavolcanics) near the contact were incorrectly identified as Grenville Gneiss by Lock (1969a).

Large xenoliths of quartzo-feldspathic and calc-silicate gneiss occur within the Moose Lake granite near Clam Pond at the southern boundary of the map area. These highly deformed and metamorphosed rocks represent either fragments of the Long Range Complex or metamorphosed Coney Arm Group brought up in the granite.

Gull Pond Granite (Subunit 25b)

The name Gull Pond granite is here informally applied to an oval shaped pluton of fine to medium grained, biotite ± muscovite, pink, granite that lies west of Gull Pond. It intrudes the Sops Arm Group and the older granodiorite and diabase/gabbro and is considered to be a high level, separate pluton related to the Moose Lake granite. It is locally porphyritic with scattered feldspar phenocrysts up to 3 cm in size. Fine grained dikes of this granite occur outwards from it and clearly cut the country rocks posttectonically.

Another small, unnamed, medium grained, biotite granite pluton (Subunit 25c) occurs west of Davis Pond.

ANGUILLE GROUP (UNIT 26)

Lower Carboniferous and older(?) clastic rocks of the Anguille Group (Hyde, 1979) border the older rocks to the east along the southwest side of White Bay. The contact is a major, possibly dextral strike slip fault, named the Birchy Ridge Fault (Belt, 1969).

In the map area, the Anguille Group consists predominantly of coarse to fine grained dark gray micaceous sandstone, pebbly sandstone and black slate. These rocks are described in detail by Hyde (1979).

DEER LAKE GROUP (UNIT 27)

Clastic rocks assigned to the Visean Deer Lake Group occur to the southwest of the Gull Lake intrusive suite. Gently dipping red conglomerates and sandstones unconformably overlie all of the older geological elements. Westward directed thrusting of the Sops Arm Group and the Gull Lake intrusive suite over the Deer Lake Group has eradicated the unconformity in the Turners Ridge - Alder Brook region (Dimmell, 1979). The Deer Lake Group was also studied by Hyde (1979).

STRUCTURE

The occurrence of dated Ordovician, Silurian and Carboniferous rocks in the area affords a unique opportunity to unravel the effects of the various Paleozoic orogenies that occurred on the western margin of the Newfoundland Appalachians.

The mid-Ordovician Taconic Orogeny resulted in emplacement of the Southern White Bay Allochthon over the autochthonous Coney Arm Group. It produced west facing, recumbent folds with a penetrative muscovite-biotite schistosity in clastics of the Coney Arm Group and a strong, penetrative, greenschist schistosity in the Allochthon. Its upper age is bracketed by the unconformity of the Silurian Sops Arm Group on the Coney Head Complex.

The Acadian Orogeny (Devonian) affected the Sops Arm and Coney Arm Groups and the Allochthon. Intrusion of the syntectonic to posttectonic Gull Lake intrusive suite occurred at this time. Acadian thrusting resulted in imbrication of the Sops Arm Group with the Allochthon in the Doucers Valley Fault zone in the north of the area. Deformation and metamorphism in the Sops Arm Group increase towards this fault zone. Open, upright folds in the east become tighter and inclined towards the west.

Hercynian (Carboniferous) deformation produced upright, tight folds in the Anguille Group (Hyde, 1979) and locally juxtaposed the Anguille Group and the allochthonous rocks along steeply dipping faults north of Hampden. The Visean Deer Lake Group was not affected by this period of folding (Hyde, 1979) and may not have been deposited at that time. However, in the Turners Ridge area, the Sops Arm Group is locally thrust over the Deer Lake Group (P. Dimmell, personal communication, 1980).

Three major rectilinear northeast trending faults traverse the area; the Doucers Valley Fault Complex (Lock, 1969a, 1972a), the Birchy Ridge Fault (Belt, 1969) and the Cabot Fault (Wilson, 1962). All are interpreted to have dominantly strike slip movements in the Lower Carboniferous (Hyde, 1979) but their early history has not been documented. It is clear from map relations and down-dip rodding lineations in conglomerates of the Sops Arm Group that early movement on the Doucers Valley Fault was a westerly directed thrust. Minor dextral strikeslip faults splay northeastwards off the fault and may relate to Acadian(?) thrusting or to Hercynian strike slip movements. The Visean Deer lake Group apparently unconformably overlies the Doucers Valley Fault system providing an upper limit for the age of displacement.

MINERALIZATION

CONEY ARM GROUP

Apart from small pyrite occurrences, especially in the basal clastics, no metallic mineralization of any significance was noted in the Coney Arm Group. The marble deposits have been previously described by Bain (1937), Heyl (1937), Lee (1956) and Bedford (1957). The marbles lie adjacent to the Doucers Valley Fault Complex and are highly contorted and fractured thus making them unsuitable for use as building stone. However, their potential as mineral fillers is increased by recent access provided by the Cat Arm road which crosses the group west of Jacksons Arm Pond and at Little Coney Arm (Map 1).

SOUTHERN WHITE BAY ALLOCHTHON

Soapstone

Ultramafic knockers in the Second Pond melange opposite the Cat Arm base camp on the Jackson's Arm road (Map 1) are thoroughly serpentinized and locally altered to talc. The rock is extensively fractured but small quantities might be suitable for carving.

Chalcopyrite-molybdenite

A quartz-feldspar pegmatite up to 1.5 m across that cuts quartz gabbros of the Coney Head Complex 3.5 km south of Coney Head contains minor pyrite, chalcopyrite and molybdenite mineralization. The pegmatite could be related to the sheets of muscovite granite nearby to the south.

SOPS ARM GROUP

Galena-barite in dolomites

A dolomite horizon within the Lower Volcanic formation south of Taylor's Pond hosts two subeconomic, stratabound, galena deposits, the Turner's Ridge and Side Pond Prospects (Dimmell, 1979). Patchy mineralization occurs along the strike length of the dolomite from Taylor's Pond to Gales Brook, a distance of 20 km.

The mineralization occurs in association with barite, pyrite and rare sphalerite in fractures and veins. The fractures appear to postdate the regional Acadian deformation and for this reason the mineralization is interpreted as vein-type, possible related to intrusion of the nearby Moose Lake granite.

In the Turner's Ridge prospect, the mineralization occurs as a network of galena-barite veinlets up to 5 cm wide in brecciated dolomite. The Side Pond

Prospect consists of quartz-barite veins containing galena, pyrite and rare sphalerite cutting unbrecciated dolomite.

Another dolomite horizon within the Lower Volcanic formation 0.5 km northeast of Unknown Brook (Map 2) contains minor galena, malachite and azurite mineralization. A small area of medium grained granite occurs nearby which is here interpreted as an apophysis of the Moose Lake granite.

Pyrite + pyrophyllite in Lower Volcanics

Snelgrove (1935) reported a zone of pyrophyllite alteration in Unknown Brook hosted by felsic tuffs of the Lower Volcanic formation. Where the alteration is most intense, the tuffs consist of a compacted aggregate of spherulites up to 5 cm in diameter. The spherulites are flattened in the plane of the regional S_1 cleavage; they probably formed by devitrification during cooling of an ash flow.

Disseminated pyrite mineralization accompanied by pyrophyllite and sericite alteration occurs in the tuffs; however, no assays were reported by Snelgrove. The mineralization appears to accompany the regional shearing of the rocks. Posttectonic quartz veins contain scattered tourmaline crystals.

Rhyolites of the Lower Volcanic formation host minor malachite mineralization in a road quarry west of the Clam Pond road intersection. The mineralization occurs in brecciated rhyolite as fracture fillings and coatings.

Chalcopyrite, pyrite, galena in Simms Ridge limestone

Limestones within the Simms Ridge and Natlins Cove Formations south of Sops Arm contain small sulphide showings. Minor disseminated galena and pyrite in limestones near the base of the Simms Ridge Formation was discovered in Corner Brook. A 5 cm thick white limestone bed exposed in an old woods road 0.6 km east of Corner Brook contains pyrite stringers parallel to bedding. The rock is characterized by a green, malachite stain on weathered surfaces.

Gold, silver, galena in quartz veins

Mineralized quartz veins cutting bedded tuffs of the Simms Ridge Formation (Browning Mine), limestones and shales of the Simms Ridge Formation (Freemans Prospect), welded ash flow tuffs of the Lower Volcanic Formation (West Corner Brook Prospects and Unknown Brook Prospects), a felsite dike in the Simms Ridge Formation (Simms Ridge Prospect) and another in the Natlins Cove Formation (Schooner Cove Prospect) were the targets of the earliest exploration in the area (1898-1935) (see Snelgrove, 1935). The quartz veins contain variable amounts of pyrite, and galena and rare sphalerite, chalcopyrite and specularite. Gold and silver values were reported by the earlier workers (Snelgrove, 1935; Heyl, 1937) although no visible gold was seen by the authors.

The West Corner Brook, Browning Mine, Unknown Brook and Freeman prospects are all located at or close to the faulted contact between the Lower Volcanic Formation and the Simms Ridge Formation. In all prospects, the quartz veins postdate the regional penetrative deformation but some are warped, kinked or brecciated. The mineralization is considered not to be volcanogenic in origin but related to a post-Acadian hydrothermal vein system probably associated with the last phase of the Gull Lake intrusive suite, the veins being controlled by faults and fractures.

GULL LAKE INTRUSIVE SUITE

Pyrite gossans in granodiorite

Small pyrite gossans were discovered in breccias of the granodiorite phase of the Gull Lake intrusive suite south of Gull Pond (Map 2). The breccias have a green chloritic matrix which appears to be hornfelsed by the later phases. The breccias superficially resemble those found above porphyry deposits.

Fluorite and pyrite in the Moose Lake granite

A number of minor fluorite occurrences were discovered in the Moose Lake granite north and south of Moose Lake (Map 2). The fluorite occurs in small, discontinuous, narrow fractures and veins up to 10 cm x 1 cm in size. Near one of the occurrences 2 km southeast of Moose Lake, aplite dikes in the granite gave 10 times background total count readings on a BGS1 scintillometer.

An occurrence of pyrite and malachite hosted by brecciated and altered Moose Lake granite was located in 1981 on the south side of Gales Brook 1.7 km northeast of the Sops Arm road. The mineralization occurs in a gently dipping, quartz rich, shear zone 10 cm x 1.5 m in dimensions. This showing was originally discovered by H.R. Peters (personal communication, 1981) some twenty years ago.

POTENTIAL

Dolostone and minor limestone beds in the Lower Volcanic formation and in the Simms Ridge Formation encircle the northern part of the Gull Lake intrusive suite and are considered potential targets for skarn-type mineralization.

Potential for bulk tonnage, low grade gold deposits exists in the felsic volcanics of the Sops Arm Group. Most of the sericite alteration is concentrated in the Lower Volcanic formation close to the Doucers Valley Fault Complex. In most places it is accompanied by minor disseminated pyrite mineralization. Altered units discovered in 1981 will be assayed for gold and silver.

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