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TREPASSEY MAP AREA, NEWFOUNDLAND

H. Williams
A.F. King

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W.H. Poole

Authors' Addresses

H. Williams and A.F. King
Department of Geology
Memorial University of Newfoundland
St. John's, Newfoundland
A1C 5S7

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Preface

The Geological Survey of Canada began reconnaissance mapping to modern standards in the Island of Newfoundland the year the province joined Confederation. The publication of this report completes this program, which provides the foundation on which depend many of the geological studies currently being carried out by the Geological Survey and by other agencies. Trepassey map area although close to the capital city of Newfoundland had not been systematically mapped since pioneer studies in 1881 by Murray and Howley of the Geological Survey of Newfoundland.

The area is of considerable interest because of its significance to our understanding of global tectonics. It contains rocks bearing late Precambrian fossils and a glaciomarine unit both of which are important for establishing worldwide correlations. Gravel deposits suitable for road metal are abundant.

Studies such as this are the means whereby the Geological Survey makes available the information needed to facilitate the discovery of our nonrenewable mineral resources and thereby to promote regional development and lessen regional disparities.

D.J. McLaren
Director General
Geological Survey of Canada

Ottawa, September 1976

ADDENDUM and ERRATUM

The manuscript for this report was edited and approved for publication in September 1976 but other commitments precluded printing the accompanying map until early 1979. In the interval some new information became available and minor errors were discovered.

Abstract – 4th sentence:

Local disconformities *are*...

p. 1, col. 1, para. 2:

The Avalon Peninsula is part of the much *larger* Avalon Zone...

p. 1, col. 2, para. 2:

Initial maps were plotted at a scale of 1:50 000 for the entire area, for publication at the scale of *1:250 000*

p. 3, Table of Formations:

The Gibbett Hill, Cappahayden, Renews Head, Fermeuse, Drook and Mall Bay formations all contain microfossils. These are described in a paper by H.J. Hofmann, J. Hill and A.F. King. Precambrian microfossils, southeastern Newfoundland; in Current Research, Part B, Geological Survey of Canada, Paper 79-1B, p. 83-98, 1979.

p. 6, col. 1, para. 2:

Crosslamination is chiefly *unidirectional*...

p. 6, col. 2, para. 6 and 7:

1. conformable disposition....of *till-like beds* (mixtites), *varve-like units* (rhythmites)...;

2. .....Some clasts are well rounded...and *present*.

p. 9:

Figure 7 is inverted.

p. 11, col. 1, para. 2, sentence 6:

At the southeast corner of Holyrood Pond *the* Cape English Member...

p. 12:

Figure 11 is inverted.

p. 13:

Caption for Figure 13 should read *Sinuous vertical fractures*...

p. 21, col. 1, para 1, sentence 3:

The fault *surface* is not exposed elsewhere but its trace is marked by structural discontinuity throughout its length. *Precise correlation of Drook Formation rocks to the east and Drook-like rocks on the western side of the fault is a major problem.* Because similar...

p. 21, col. 2, para. 2:

A major positive aeromagnetic anomaly *crosses the entire Avalon Peninsula from Gaskiers Bay to Tors Cove (Papezik et al., 1975). Minor diabase intrusions along the lineament have yielded a K-Ar isochron age of 201 ± 2.6 Ma (J.P. Hodych, pers. comm., 1979).* Other positive anomalies coincide with Harbour Main volcanic rocks and the Gaskiers Formation.

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TREPASSEY MAP AREA, NEWFOUNDLAND

Abstract

All rocks described are of late Precambrian (Hadrynian) age. The oldest, a bimodal volcanic assemblage, the Harbour Main Group, is overlain by three sedimentary successions, which, in order of decreasing age, are the Conception, St. John's and Signal Hill groups. All contacts are conformable and most are gradational. Local disconformity is suggested by the occurrence of a volcanic pebble conglomerate at the base of the Conception Group where it is in contact with the Harbour Main Group, and by local truncation of irregular sandstone lenses at the top of the St. John's Group.

Volcanic rocks of the Harbour Main Group are mainly terrestrial. The Conception Group is dominated by green, marine, siliceous rocks and the authors propose that it be divided into five formations. A thick glaciomarine unit occurs near its base (Gaskiers Formation) and a profusely fossiliferous grey to red horizon at its top (Mistaken Point Formation).

The St. John's Group is a dominantly grey to black, sandstone-shale sequence that the authors propose be divided into three formations. The Signal Hill Group comprises four new formations of dominantly grey to red sandstone, mainly terrestrial.

A small, fault-bounded body of granite in the northeast part of the map area is similar to granite of the Holyrood Plutonic Series at Conception Bay. Dykes and stocks of Whalesback Gabbro are localized toward the base of the Drook Formation of the Conception Group.

The geological history of the map area suggests mainly terrestrial silicic volcanism during initial stages of development (Harbour Main) that was locally accompanied, but mainly followed by marine deposition of the Conception Group. The St. John's Group reflects a shoaling of the Conception marine basin, followed by deposition of deltaic terrigenous sandstones of the Signal Hill Group. Local tuff beds in the Mistaken Point and younger formations diminish upward in the stratigraphic section and record waning volcanic activity during encroachment of the earlier volcanic centres by thick Precambrian sedimentary deposits. Arkosic beds in the Conception Group toward the south and southwest (Cape English and Peter's River members of the Drook Formation) are derived from the southwest and imply unroofing of a granitic terrane.

No economic mineral deposits are known in the map area. Gravel deposits suitable for road metal are abundant.

Résumé

Toutes les roches décrites sont de la fin du Précambrien (Hadrynien). Les plus anciennes consistent en un ensemble volcanique bimodal, le groupe d'Harbour Main, qui est recouvert par trois successions sédimentaires, soit, par ordre d'ancienneté, les groupes de Conception, de St. John's et de Signal Hill. Tous les contacts sont concordants et la plupart sont graduels. Des discordances locales sont signalées par la présence de conglomérats de cailloux volcaniques à la base du groupe de Conception, à l'endroit où il est en contact avec le groupe d'Harbour Main, et par le rabotage local de lentilles gréseuses irrégulières situées au sommet du groupe de St. John's.

Les roches volcaniques du groupe d'Harbour Main sont surtout d'origine continentale. Dans le groupe de Conception, les roches siliceuses, marines et vertes prédominent et les auteurs proposent que ce groupe soit divisé en 5 formations. Près de sa base (formation de Gaskiers), on trouve un étage épais de sédiments glaciers et marins, et, à son sommet (formation de Mistaken Point), un horizon abondamment fossilifère de couleur allant du gris au rouge.

Le groupe de St. John's est une séquence grès-schiste argileux, de couleur variant surtout du gris au noir, que les auteurs proposent de diviser en trois formations. Le groupe de Signal Hill comprend quatre nouvelles formations de grès d'origine essentiellement continentale et de couleur variant surtout du gris au rouge.

Un petit amas de granite délimité par une faille, situé dans le nord-est de la zone représentée par la carte, est semblable au granite rencontré dans les séries de roches plutoniques d'Holyrood dans la baie de la Conception. Les dykes et les culots du gabbro de Whalesback sont situés près de la base de la formation de Drook du groupe de Conception.

L'histoire géologique de la zone délimitée par la carte traduit un volcanisme siliceux d'origine surtout terrestre intervenu pendant les stages initiaux du développement (Harbour Main); ce volcanisme a été localement accompagné, mais surtout suivi, par les dépôts marins du groupe de Conception. Le groupe de St. John's laisse apparaitre une élévation du bassin marin de Conception, suivie par des dépôts de grès terrigènes deltaïques du groupe de Signal Hill. Les couches de tuf volcanique que l'on trouve dans la formation de Mistaken Point et dans les formations plus récentes, sont moins abondantes vers le haut du profil stratigraphique et traduisent un déclin de l'activité volcanique pendant l'empiétement sur les centres volcaniques plus anciens par des dépôts sédimentaires épais du Précambrien. Les couches d'arkose situées dans le groupe de Conception, vers le sud et le sud-ouest (Cape English et Peter's River, niveaux de la formation de Drook), proviennent du sud-ouest et laissent supposer la mise à découvert d'un terrain granitique.

On ne connaît pas, dans la zone délimitée par la carte, de gisements de minerais exploitables; par contre, les dépôts de gravier utilisable pour la construction routière sont abondants.

TREPASSEY MAP AREA, NEWFOUNDLAND

INTRODUCTION

Location and Access

The map area consists of that part of the Avalon Peninsula in Newfoundland that lies east of St. Mary's Bay and south of 47°00' north. A highway extends around the periphery of the map area closely following the coast, with branch roads to St. Shotts, Cape Pine, Cape Race, and Chance Cove. Interior parts of the area are accessible by float plane or helicopter. The north-central extremity of the area can be reached by a private gravel road that leaves the main highway at Cape Broyle just north of the map area. The coastline is cliffed and rugged and there are few safe harbours or anchorages for even small boats. During the present study, the coastal geology was mapped using a 17-foot open boat based at Riverhead, Portugal Cove South and Renews.

Geological Setting

The Avalon Peninsula is part of the much higher Avalon Zone (Williams et al., 1972; 1974) that consists of upper Precambrian (Hadrynian) volcanic and sedimentary rocks locally overlain by Cambrian, Ordovician and younger Paleozoic strata. Similar rocks occur in Cape Breton Island, southeast New Brunswick and eastern Massachusetts. Still more southerly correlatives are found in Virginia and the Carolinas, thereby making the Avalon Zone one of the most continuous and best defined zones in the Appalachian Orogen. Comparable upper Precambrian volcanic and sedimentary rocks are known from scattered exposures in the nonmetamorphic southern parts of the British Caledonides and in the French Hercynides (Brioverian).

Previous Geological Work

The first geological report and map of Newfoundland by J.B. Jukes (1842) included a brief description of the rocks of the Avalon Peninsula. This was followed by the reconnaissance studies of A. Murray and J.P. Howley who together in 1881 published a map of the entire Avalon Peninsula showing the distribution of formations. They depicted a core of "Laurentian Gneiss" in the eastern part flanked by a concentric arrangement of "Huronian" slates, sandstones and conglomerates. Their Auriferous Slates and Sands (unit c) corresponds to the present Conception Group, their Aspidella Slates (unit d) to the Fermeuse Formation of the St. John's Group, and their overlying Signal Hill Grey Sandstone (unit e) to the Gibbett Hill Formation of the present Signal Hill Group.

Local studies include mapping of a coastal section between Cape Race and Biscay Bay by S.B. Misra (1969a; 1971) and another at Trepassey by I.S. Koh (1969). Much more of the coastal geology has been investigated recently by M.M. Anderson and W.D. Brückner and their observations were incorporated in a map by Brückner (in King et al., 1974). North of the map-area, the Avalon Peninsula was mapped by E.R. Rose (1952), R.D. Hutchinson (1953) and W.D. McCartney (1967), whose works are the standard references on regional geology of the Avalon Peninsula.

Present Study

The present survey was undertaken during the summers of 1974 and 1975 under contract with the Geological Survey of Canada, Department of Energy, Mines and Resources in order to determine the geological history and mineral potential of most of southern Avalon Peninsula. It represents the first systematic mapping on a regional scale since the early pioneer work. As a result of this study the upper Precambrian rocks have been subdivided into formations, their distribution mapped, and the regional structure determined. Of particular interest is the tillite, indicative of a Precambrian glaciation, and the rare and therefore important well-preserved Precambrian fossils. There are no economic mineral occurrences in the area.

The coastal geology was investigated in some detail using a small open boat, and inland traverses were run from roads and rivers and along trails and transmission lines. A helicopter was used to map the inaccessible interior parts of the region. Initial maps were plotted at a scale of 1:50 000 for the entire area, for publication at the scale of 1:125 000.

Acknowledgments

Most of the mapping was conducted by the authors except for local traverses by G.W. Einarson, B.A. Greene, and E.Y.C. Hsu. We are most grateful for this assistance. The authors also wish to acknowledge the assistance of Alex Pittman and Cyril Breen who acted as cheerful, competent companions. Special thanks are extended to John Fleming, Director of Mineral Resources, Newfoundland Department of Mines and Energy, who kindly arranged for helicopter support. The second author also wishes to thank Trevor Ford of Leicester Univeristy for showing him the Charnian succession and for discussions on Late Precambrian fossils. He also wishes to acknowledge National Research Council of Canada Grant A-7052 in support of his field work on the Avalon Peninsula.

Physiography and Glaciation

The cliffed, rugged shoreline exposes continuous rock sections, but inland the terrain is flat to mildly undulating and covered by barrens and bog that are interrupted by wooded river valleys. The Harbour Main volcanics and Whalesback Gabbro are well exposed in the vicinity of Butter Pot and Red Hill. Similarly, the Drook Formation is well exposed in a series of open folds north of Biscay Bay. Elsewhere, large inland tracts are covered by glacial till and muskeg. The surficial geology of the Avalon Peninsula was described by Henderson (1972).

Butter Pot is the highest point in the area at 280 m. The flat to gently undulating inland surface varies between 120 and 210 m sloping gently toward the shoreline. Coastal cliffs are mostly between 30 and 90 m in elevation.

Bedrock geology largely controls the physiography of the map area. The youngest Precambrian rocks occur in major folds that roughly follow the present coastline, with the oldest volcanic, sedimentary and intrusive rocks forming the core of the map area. Steep coastal cliffs of resistant

sedimentary rocks (e.g. Gibbett Hill, Cape Ballard, and Gaskiers formations) parallel the strike of beds. On the other hand, less resistant argillites of the Fermeuse Formation follow the major indentation at Trepassey Bay. Resistant sandstones and conglomerates of the Signal Hill Group form the north-trending Bantam and Ballard banks (Williams and Lilly, 1965); (the same beds reflected as a bathymetric structure) may continue southward to the west-aligned Nickerson Bank and Lamb Rock. Collectively, these shoals parallel the coastline and onshore bedrock structure.

Resistant beds of the Gaskiers and Drook formations form prominent rock ridges in some inland areas. Other ridges that are conspicuous on aerial photographs east of Holyrood Pond and in the north-central part of the area are composed of gravel. The gravel ridges are controlled by bedrock structure and they trend parallel with nearby rock ridges. All are shown as defined structural trends on the accompanying geological map.

Glacial striae trend east to southeast in the eastern part of the area and local determinations are southwest in westerly parts, indicating ice movement from the central part of the peninsula toward the coast. Renews and Fermeuse harbours cut sharply across bedrock structural trends and parallel the southeast direction of ice movement in the eastern part of the map area. Similarly, the northeast-trending embayments of Holyrood Pond, St. Mary's Bay, Mall Bay and Colinet Passage parallel the direction of ice movement in the western part of the map area.

GENERAL GEOLOGY

General Statement

Trepassey map area is composed of upper Precambrian (Hadrynian) volcanic and clastic sedimentary rocks that are intruded by gabbro and granite and folded into broad, upright, gently-plunging anticlinoria and synclinoria.

The oldest rocks comprise a bimodal volcanic assemblage, the Harbour Main Group (Rose, 1952). It is overlain by an assemblage of dominantly green, siliceous volcaniclastic sedimentary rocks of the Conception Group (Rose, 1952), in turn conformably overlain by light to dark grey shale and sandstone of the St. John's Group, followed by grey to red sandstone of the Signal Hill Group.

The Harbour Main Group is undivided, except for the informal distinction between silicic and mafic volcanic rocks denoted by subletters on the accompanying geological map.

The Conception Group is divided into five new formations, Mall Bay, Gaskiers, Drook, Briscal, and Mistaken Point. These represent the first regional subdivision of this group. It includes a thick Precambrian glaciomarine unit (Gaskiers) toward its base and profusely fossiliferous Precambrian strata at its top (Mistaken Point). In the east, the Drook Formation of the Conception Group overlies the Harbour Main volcanics with structural conformity. In the west, the Drook is underlain by the Gaskiers and Mall Bay formations with the base of the sequence unexposed. This suggests either eastward overstep of the Drook Formation onto the Harbour Main, or else that the Gaskiers and Mall Bay formations in the west are time equivalents to part of the Harbour Main volcanic sequence in the east. The Briscal Formation appears to be a southwesterly-derived coarse clastic facies of the Drook Formation that thins toward the northeast part of the map area. The Mistaken Point Formation is of uniform thickness throughout the map area, and its fossiliferous beds have been traced 12 km north of the map area to Cape Broyle.

The St. John's Group is divided into three new formations, the Trepassey, Fermeuse, and Renews Head. Grey sandstones of the Trepassey Formation are gradational and conformable with underlying, coarser and thicker bedded pale red sandstones at the top of the Conception Group (Mistaken Point Formation).

The Signal Hill Group is divided into four new formations, the Cappahayden, Gibbett Hill, Ferryland Head, and Cape Ballard. Thin evenly bedded siltstones of the Cappahayden Formation are structurally conformable above irregularly bedded Renews Head sandstones of the St. John's Group. In most places there is erosional truncation of uneven Renews Head beds at the contact.

A small, fault-bounded body of granite in the northeast part of the area is similar to granite of the Holyrood Plutonic Series (McCartney, 1967) to the north. There the granite cuts the Harbour Main volcanics and it is interpreted to be older than the Conception Group (McCartney, 1967). In the present map area, the granite is referred to as Holyrood granite.

Dykes and small stocks of gabbro that cut the Drook Formation west of Red Hill are referred to as the Whalesback Gabbro. Its age and relationships to nearby groups are unknown.

Harbour Main Group

Volcanic rocks that constitute the oldest exposed strata in the map area are assigned to the Harbour Main Group (Rose, 1952) because they are continuous with Harbour Main volcanics north of the map area (McCartney, 1967; Mullins, 1970). The largest exposures are along the axis of the Red Hill Anticline. Nearby to the east, volcanic rocks are brought up along a bifurcation of the Frenchman's Cove Fault, and Harbour Main volcanic rocks occur in an anticlinal core on the east side of the Peter's River Fault at the north edge of the map area. Most of the volcanic rocks are massive without apparent layering so that thicknesses are difficult to estimate. Up to 1500 m of volcanic rocks are probably represented in the Red Hill Anticline.

Most of the volcanic rocks are bright red to pink and grey tuffs and agglomerates. Some are coarse and unsorted but fine grained silicic tuffs, welded tuffs, lithic crystal tuffs and flow banded rhyolites are also represented. Mafic volcanic rocks are massive, fine grained, dark green to purplish basalts.

At Butter Pot (not to be confused with the Holyrood "Butter Pot" north of the map area) and in a smaller inlier to the south, the volcanic rocks are mainly silicic tuffs and agglomerates with volcanic rock fragments up to 15 cm diameter. Other silicic volcanic rocks occur at the south end of Red Hill and are mainly red tuffs, welded tuffs, and porphyritic to flow-banded rhyolites. Mafic volcanic rocks constitute most of the Red Hill inlier.

Volcanic rocks exposed at a bifurcation of the Frenchman's Cove Fault are mixed purplish mafic lava and grey silicic rocks that are intensely fractured. The volcanic rocks east of Peter's River Fault are purplish lavas that form the southern extremity of a large mass of mainly silicic Harbour Main volcanics which extends 65 km north to Conception Bay.

The base of the Harbour Main Group is not exposed. It is overlain by the Drook Formation of the Conception Group along the west side of the Butter Pot inlier and at the south end of the Red Hill inlier. A thin basal conglomerate marks the Conception-Harbour Main contact northwest of Butter Pot. The conglomerate is probably less than 30 m thick and it

Table of Formations

Era	Group thickness (metres)	Formation thickness (metres)	Lithology
Hadrynian	Signal Hill >1450	Cape Ballard >260	Upper part: thick bedded, buff weathering grey sandstone and quartz granule conglomerate. Lower part: grey to purple shale and grey siltstone (50 m).
		Ferryland Head 250	Thin- to medium-bedded grey and red sandstone. Red, wavy bedded sandstone and shale (High Rocks Member) locally at base.
		Gibbett Hill 760	Thick bedded, light grey sandstone, thin bedded, dark grey sandstone and siltstone, local calcareous sandstone ellipsoids.
		Cappahayden 175	Laminated, fissile, light grey siltstone.
	Local erosional disconformity		
	St. John's 1950	Renews Head 300	Thin, lenticular bedded, dark grey sandstone and minor shale.
		Fermeuse 1400	Grey to dark grey and black shale, thin lenses of buff weathering sandstone and siltstone.
		Trepassey 250	Medium- to thin-bedded, graded, grey sandstone and shale.
	Conception	Mistaken Point 400	Medium bedded, grey to pink sandstone, green, purple and red shale, minor tuff. Fossils.
		Briscal 1200 in SW <100 in NE	Thick bedded, grey sandstone, green to grey argillite, red sandstone and arkose, locally grey, thin bedded siltstone and shale (southern coarse facies of Drook Formation).
		Conformable contact with Drook Formation	
		Whalesback Gabbro	Medium grained, massive gabbro.
		Intrusive contact with Drook Formation only	
		Drook 1500	White weathering, green, grey and buff, and locally red to purple argillaceous chert, siliceous siltstone, sandstone, silicified tuff, locally thick sandstone with shale, siltstone and minor purple argillite. Intercalated grey, coarse grained sandstone (Peter's River Member), grey to red sandstone (Cape English Member), grey pebbly siltstone and shale (Clam Cove Member), and mafic pillow lava (Biscay Member).
		Conformable on Gaskiers in west; probably disconformable on Harbour Main in east	
		Gaskiers 250-300	Grey mixtite, intercalated rhythmites of mudstone, siltstone and sandstone with dropstones, and conglomerate. Red agglomerate of South Point Member locally at top.
		Mall Bay >800	Green siliceous siltstone and argillite, grey sandstone, black, green and purple argillite and chert, tuffaceous sandstone, green siliceous tuff and agglomerate, white quartzose sandstone and minor limestone.
	Fault contact of Drook Formation with Holyrood Plutonic Series		
	Holyrood Plutonic Series		Medium grained, massive pink granite.
	Fault contact with Harbour Main Group, but intrusive contact north of map area. Cobbles of similar granite occur in Gaskiers Formation.		
	Harbour Main >1500		Red, pink and grey silicic tuff, agglomerate, pink to red rhyolite and welded tuff; massive dark green to purplish basalt.

has pebbles of grey silicic volcanic rocks like those of the underlying Harbour Main. At the south end of Red Hill, the Conception-Harbour Main contact is difficult to locate precisely, possibly because of local interlayering of sedimentary and volcanic rocks in the contact zone. In one place at the very southern tip of the inlier, red volcanic outcrops are separated by a 60-m exposure gap from pebbly red sandstone and siltstone. The latter is followed southward by continuous Conception lithologies so that the pebbly beds are thought to mark a red clastic horizon at the Harbour Main contact. Where unsorted, some of the red pebbly rocks are similar to mixtites of the Gaskiers Formation. It is noteworthy that virtually all of the pebbles and boulders in the basal conglomerate of the Conception Group near Colliers Bay are andesite, basalt and diabase (McCartney, 1967, p. 31). The lack of felsic fragments there and the lack of mafic volcanic fragments in the Butter Pot conglomerate strongly suggest a local origin for the detritus of these beds with sediment derived from proximal exposures of volcanic rocks. However, evidence of an angular unconformity at the base of the Conception Group appears to be restricted to the Holyrood area (McCartney, 1967, p. 96).

In the western part of the map area, Harbour Main volcanics are the most common clasts within the Gaskiers Formation. Immediately beneath and toward the top of the formation at Great Colinet Island, green splashy agglomerates and red agglomerates, respectively, indicate proximal volcanism. These volcanic rocks and associated sediments of the Conception Group are possibly Harbour Main equivalents.

Here and there throughout Avalon Peninsula volcanic rocks of the Harbour Main Group contain prehnite and pumpellyite (Papezik, 1974). Local development of fine grained actinolite in a prehnite-bearing sample of a mafic volcanic flow at Red Hill indicates local metamorphic conditions that approach greenschist facies (V.S. Papezik, pers. comm., 1976). Similar fine grained actinolite occurs in nearby mafic volcanic rocks of the Biscay Member of the Conception Group. None of the rocks in the map area are metamorphosed higher than greenschist facies.

Conception Group

The Conception Group (Rose, 1952) occurs throughout Avalon Peninsula and is dominated by green to grey siliceous sedimentary rocks that are mainly of volcanic provenance. As well, it includes tuffaceous sediments, tuffs, and minor mafic pillow lava. In the map area, the Conception Group is noted for the occurrence of mixed, unsorted sedimentary units ("mixtites" of Schermerhorn, 1966) toward its base (Gaskiers Formation). These have been interpreted as Precambrian tillite (Harland, 1964; McCartney, 1967; Brückner and Anderson, 1971; and Henderson, 1972). Of equal note is the occurrence of late Precambrian fossils in the Mistaken Point Formation at its top (Anderson and Misra, 1968; Misra, 1969b). The dominantly silicic green rocks of the Conception Group (Drook Formation) directly overlie the Harbour Main Group in the Red Hill Anticline but farther west they overlie the Gaskiers and Mall Bay formations with the base of the sequence unexposed.

Figure 1. Discrete quartz-rich beds and composite bedsets, Mall Bay Formation, La Haye Point. Tops to right. (GSC 203104)

In the southwestern part of the map-area, Conception Group rocks above the Gaskiers Formation (Cape English and Peter's River members of the Drook Formation) are mostly coarse, thick bedded sandstones. Similar sandstones assigned to the Briscal Formation form a continuous thick unit above the Drook from Gull Island to Cape Race. In the northeastern part of the map area, the Briscal Formation is virtually absent and north of Aquaforte, the uppermost formation of the Conception Group (Mistaken Point) directly overlies cherts of the Drook Formation. The Briscal Formation is regarded therefore as a coarse facies of the upper parts of the Drook Formation.

At Cape English, Briscal-like lithologies transgress downward to lie almost directly upon the Gaskiers Formation. These western occurrences are not mapped as part of the Briscal Formation as they are overlain by thin bedded cherts assigned to the Drook Formation near Shag Rock of southeastern Holyrood Bay.

In Torbay map area, Rose (1952) divided the Conception Group into the Conception slate and Torbay slate but did not propose a formal division. In the Harbour Grace map area, Hutchinson (1953) defined the Hibbs Hole Formation near the top of the group and this formation appears to be a correlative of the Mistaken Point in the present map area. In southern Avalon Peninsula, Misra (1971) proposed a three-fold subdivision of the Conception Group in coastal exposures between Biscay Bay and Cape Race. His formations, from oldest to youngest are the Drook, Freshwater Point, and Cape Cove. The boundaries of the Drook Formation are slightly modified by our work so that it now includes most of the Freshwater Point Formation. The latter is not a regionally mappable unit and the name Freshwater Point Formation is dropped. We retain Misra's type section at Drook but locate the top of the formation one mile east of Freshwater Point. On the other hand, the Cape Cove Formation is divided into three new units (Briscal, Mistaken Point, and Trepassey), each mappable on a regional scale. The upper boundary of the Cape Cove Formation coincides approximately with the Trepassey-Fermeuse contact, and its lower boundary roughly with the Drook-Briscal contact. The name Cape Cove Formation is therefore dropped.

Mall Bay Formation

The name Mall Bay Formation is proposed for the buff to grey interlayered quartzose, volcaniclastic and argillaceous sandstone and grey to green and purple siliceous argillite and chert that underlies the Gaskiers Formation. The rocks are exposed on the west limb of the Colinet Passage Syncline and they form the cores of the La Haye Point and Crossing Place anticlines. The base of the formation is not exposed in the map area. Its top is drawn at the first appearance of mixtite of the Gaskiers Formation.

The Mall Bay Formation has an exposed thickness of about 800 m in the La Haye Point area and this locality is the most readily accessible reference section. Thickness estimates are difficult elsewhere either because of a lack of continuous exposure or because of minor folds and faults in local stratigraphic sections.

At La Haye Point, the formation has discrete or single beds and "simple" to "composite bedsets" (Reineck and Singh, 1973) of grey to buff sandstone, grey siltstone and black,

Figure 2. Discrete limestone bed, Mall Bay Formation, La Haye Point. Tops up. (GSC 203104-A)

green and purple mudstone and chert (Fig. 1). There are also distinctive beds of light grey quartzose and arkosic sandstone and local beds of buff-weathering thin limestone (Fig. 2). The sequence is flysch-like in that the beds are laterally persistent and show vertical rhythmic variation of grain size, bedding type and bedding thickness. Sequential development of sedimentary structures is common and involves parallel, convolute, ripple and ripple-drift lamination.

Single sandstone beds are even and parallel, varying from 5 to 30 cm in thickness. They have sharp bottoms, grading, ripple lamination, and sharp tops with local symmetrical ripples. Crosslamination is chiefly undirectional and indicates currents to the south and southeast. Ripple surfaces indicate reworking, possibly by wave and tidal currents.

Composite bedsets of a lenticular bedded facies occur in even parallel units up to several metres thick. These have thin (1 to 10 cm) symmetrical to asymmetrical, ripple-bedded sand lenses and silt laminae alternating in a mud matrix. The alignment of straight ripple crests in this mudstone facies varies considerably and there is no evidence of a single direction of current or wave activity. The bedsets probably represent a relatively low energy environment with fluctuating quiescent to turbulent flow conditions.

Facies similar to those at La Haye Point are well exposed at the top of the Mall Bay Formation at False Cape. There, a 30-m unit of lenticular bedded facies passes stratigraphically upwards into the sandy facies. Linguoid and straight-crested asymmetrical ripples indicate a wide range of current directions, mainly toward the east and southeast.

At Mall Bay Harbour, thin (1-10 cm) to medium (10-30 cm) bedded, graded sandstones with pink volcanic fragments alternate with evenly bedded green argillites with local purple to buff, grey and pink, thin interbeds. Some of the argillite beds, from 1 to 2 cm thick, display dark green bottoms and lighter green tops.

Elsewhere, much of the Mall Bay Formation resembles Drook lithologies and it includes thick sandstone beds with volcanic rock fragments, green siliceous argillites and cherts, and grey to green siltstones.

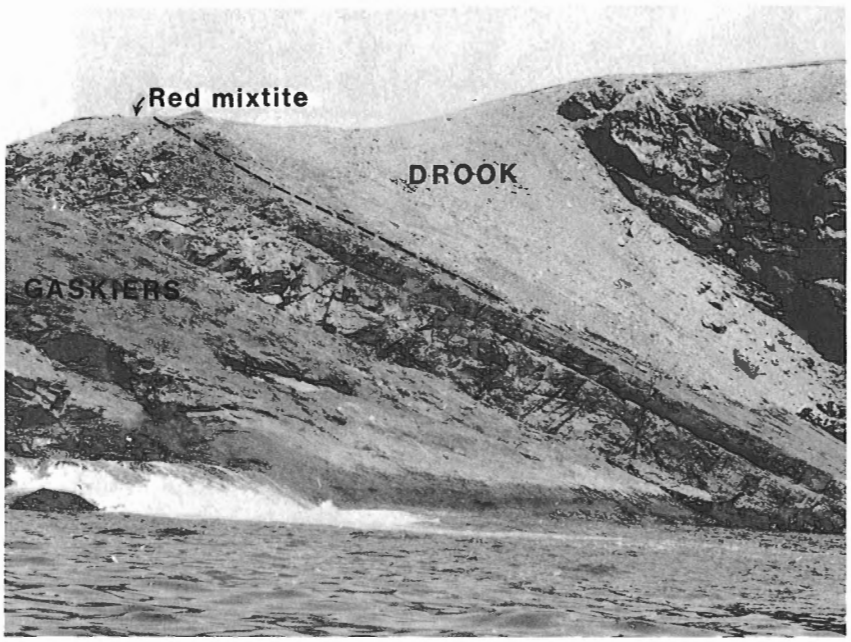


Figure 3. Gaskiers-Drook Formation contact, False Cape. (GSC 203104-B)

The La Haye Point, False Cape and Mall Bay Harbour sections are distinctive. The sandstone facies there may represent delta-front sheet sands deposited above lenticular bedded facies and recording times of flooding in a delta system (e.g. Allen, 1959). Also noteworthy is the occurrence of a similar mudstone facies in the Nyborg Formation of Norway that is interpreted as interglacial and separating Eocambrian lower and upper tillite formations (Reading and Walker, 1966).

Beds included in the Drook Formation at Frenchman's Cove that occur below the Clam Cove Member of the Drook resemble Mall Bay strata in the La Haye Point section. If the Frenchman's Cove and La Haye Point beds are equivalent, then this suggests that the Clam Cove Member of the Drook Formation is a Gaskiers correlative.

Gaskiers Formation

The Gaskiers Formation is the most distinct and easily recognizable unit of the Conception Group. It consists of unsorted and internally unlayered, till-like beds (mixtites), separated by thinner stratified units of grey to green mudstone, siltstone, sandstone and conglomerate. The distribution of the formation clearly defines the Colinet Passage and St. Mary's synclines, and the La Haye Point and Crossing Place anticlines.

The Gaskiers Formation varies in thickness from 250 to 300 m, but at Little Colinet Island, beyond the map area, it is not more than 190 m. Its base, drawn at the first appearance of mixtite above the Mall Bay Formation, is generally sharp and conformable. The top of the formation is defined by red mixtite that is overlain by less than a metre of red mudstone. At the south end of Great Colinet Island, the formation includes a red agglomerate (South Point Member) that is interlayered with red mixtite and sandstone at the top of the formation.

Simplified geological maps and stratigraphic columns of the best exposed and least deformed coastal sections at South Point, North Point and Double Road Point are shown in Figures 4 and 5. Other sections are exposed south of Gaskiers and at Frapeau Point. The reddish top of the formation is usually marked by a distinct morphologic bedding surface (Fig. 3) in most coastal sections. Inland, the formation forms prominent ridges north of Frapeau Point and at Great Colinet Island. The boundaries of the Gaskiers Formation are easily defined in all coastal sections. The shoreline section south of Gaskiers is selected as the type section because of accessibility and extent and continuity of exposure.

The main features of the Gaskiers Formation are:

1. conformable disposition of a distinctive lithostratigraphic unit consisting of mixtites, rhythmites, conglomerate, disrupted beds, mudstone and agglomerate within a uniformly thinner bedded marine sequence;
2. presence of poorly sorted angular clasts in a greenish grey to dark yellowish brown sandy matrix. Some clasts are well rounded and examples of faceted and striated clasts are common. Most are locally derived but a few are exotic to the Avalon Peninsula;

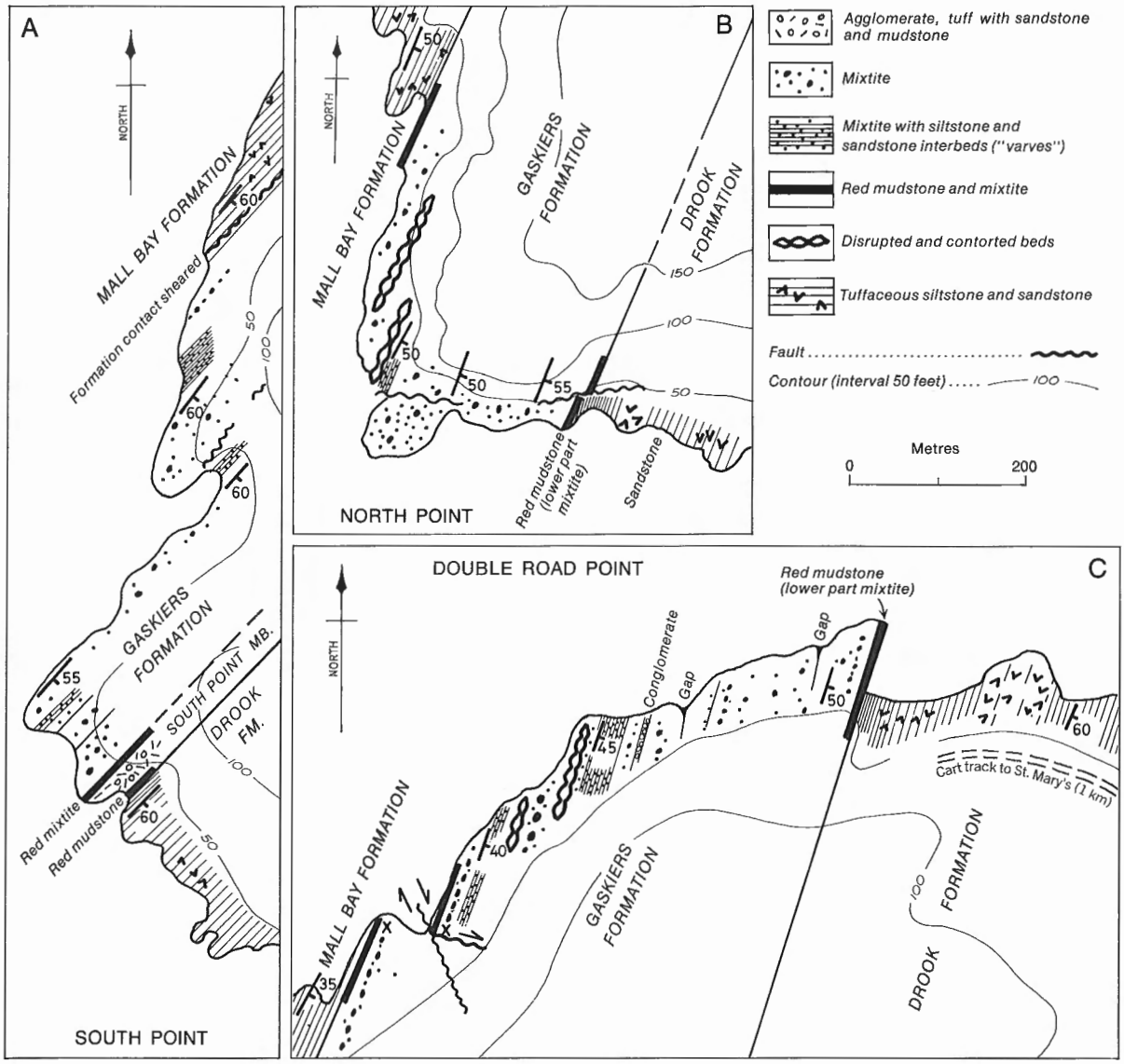


Figure 4. Structure and stratigraphy of the Gaskiers Formation at South Point, North Point and Double Road Point.

3. repetition in the lower part of the formation of mixtite, contorted beds of sandstone, well-stratified sandstones and siltstones with local outsize clasts or dropstones;
4. red mixtite and mudstone, and local red agglomerate, at the top of the formation;
5. wide geographic extent.

Mixtite units are thick, massive and polymictic. The most common clasts are red to pink silicic volcanic rocks, vesicular to massive basalt, a variety of coarse grained pink to red granites, porphyritic granite, granophyre, diorite, siltstone, quartz, volcanic-pebble conglomerate, quartzite and foliated granite. Most are intrabasinal but some, e.g. quartzite and foliated granite, are exotic to the Avalon Peninsula. The most common clasts are small and between 2 to 10 cm in diameter. A few are conspicuously large granite boulders up to 2 m in diameter. Tabular and equant shapes predominate with at least partial rounding of corners and edges. The largest clasts are subrounded, and faceted and striated clasts can be found in most places. Large slabs of sandstone and siltstone, up to a few metres across, are associated with disrupted bedded units within the formation.

The clasts are set in a muddy sandy matrix and generally form less than 10 per cent of the rock (Fig. 6). In the Double Road Point section (Fig. 4), lower mixtite units contain up to 15 per cent clasts decreasing to less than 5 per cent toward the top of the formation. Locally, tabular clasts are oriented and form imbricate zones.

Individual mixtite units have sharp bottoms without obvious scouring of underlying beds. The tops of typical units are also sharp and planar. Some tops are graded and pass upward into laminated siltstones; others show a variety of syndepositional and post-depositional structures and fabrics. Locally the tops are scoured with infillings of cross stratified sandstone, or marked by crude, wedge-shaped gravel infillings. Tabular clasts are locally oriented in an upright position at the top of some units.

Thin, rhythmically bedded, grey to green mudstone, siltstone and sandstone (rhythmites), separate the mixtites and form units up to 10 m thick. Good examples occur below the lower disrupted unit at Double Road Point and above a disrupted unit at North Point (Figs. 4 and 5). Most conspicuous are rhythmites consisting of even parallel layers

of light coloured fine sand or coarse silt, and darker layers of clay with local granules, pebbles, or outsize dropstones (Fig. 7). Some sandstones are structureless but others display convolute lamination, ripple-drift lamination and small-scale slump folds. All indicate transport to the east and southeast. Irregular, discontinuous, disrupted units of contorted sandstones and siltstones locally resemble ptygmatically folded rocks where slumped in a muddy matrix.

The base of the Gaskiers Formation is marked by red mudstone in some places and it is several metres thick near False Cape. There, the red mudstone contains pebbles and cobbles, and local boulders up to a metre in diameter that rest at the base of the unit. Red mixtite is everywhere present at the top of the formation. It has a matrix of red mud and is capped in most places by less than a metre of red mudstone.

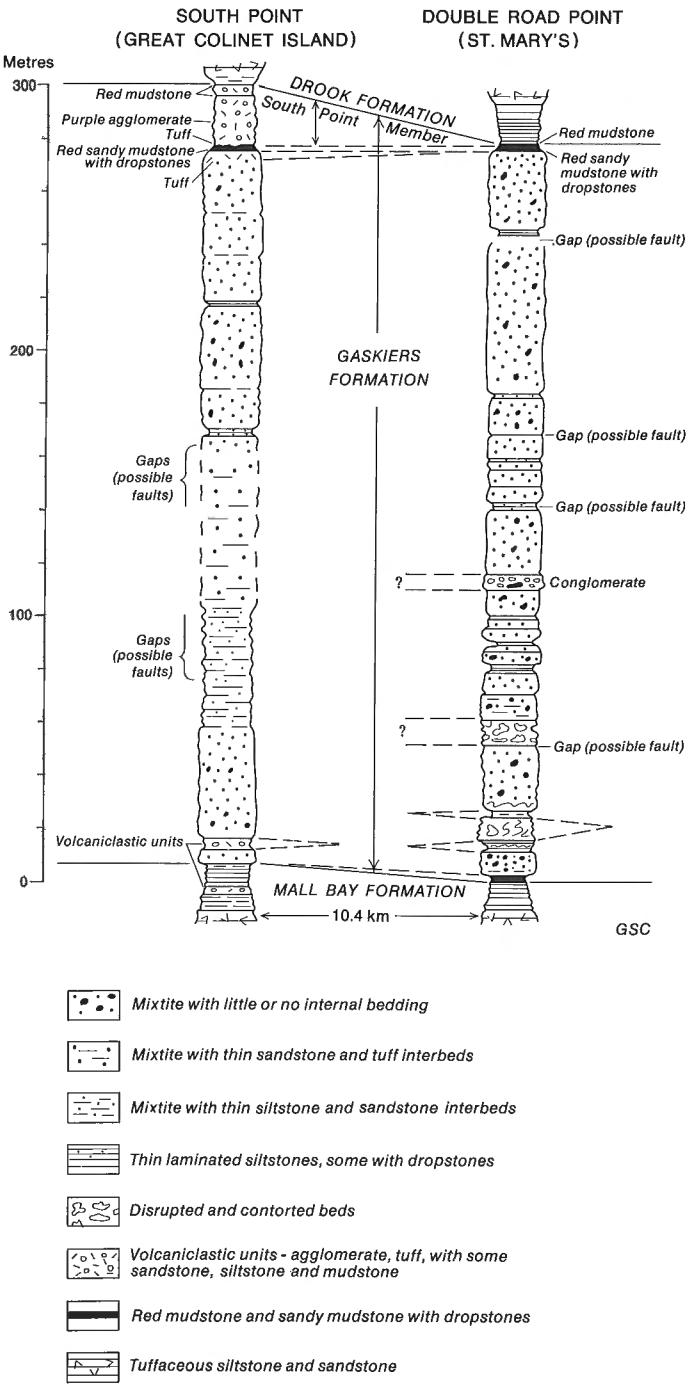


Figure 5. Thickness and lithic variation within the Gaskiers Formation at South Point and Double Road Point.

At the southern end of Great Colinet Island, the top of the Gaskiers Formation includes about 20 m of reddish agglomerate (Fig. 8) that overlies red mixtite (Figs. 4 and 5). The agglomerate is overlain by about 10 cm of red mudstone and thin bedded sandstone, followed by 3 m of purple agglomerate with red mudstone fragments, capped by a metre of red mudstone at the top of the formation. The volcanic rocks are referred to as the South Point Member of the Gaskiers Formation.

The Gaskiers Formation has been interpreted as a late Precambrian tilloid (McCartney, 1967) and as a tillite (Harland, 1964; Brückner and Anderson, 1971; Henderson, 1972). Convincing sedimentological evidence for glaciation in the late Precambrian has been presented elsewhere (e.g. Harland, 1964; Spencer, 1971; Wright and Moseley, 1975; Williams, 1975).

We suggest that the Gaskiers Formation is a Precambrian tillite formed by a combination of processes. The mixtite units, particularly those in the upper part of the formation with striated faceted cobbles and boulders, were probably deposited from floating ice in a marine shelf environment. A wide geographic extent for the mixtites and their anomalous position within a thick marine sequence of Conception sediments are further corroboration of a glacial marine origin.

Similar lines of evidence have been used by researchers on late Precambrian tillites in the North Atlantic region to postulate deposition from floating ice (Spencer, 1971, p. 65-69). Studies of modern glaciomarine sediments, such as in the Ross Sea (e.g. Carey and Ahmad, 1961; Chriss and Frakes, 1972), have shown that sediments similar to till could be produced by intense ice rafting where very little reworking of sediment by bottom currents was taking place, or where rates of rafting were sufficient to mask the effects of reworking.

Exotic or far-travelled clasts in the Gaskiers Formation are thought to have been transported at some stage by moving ice. However, an unknown proportion of locally derived clasts has been transported by nonglacial processes. For example, in the South Point section some mixtites at the top of the formation contain penecontemporaneous volcanic detritus, including air-fall bombs, blocks and lapilli. The absence of the South Point Member in other sections may indicate more distal volcanic centres, or alternatively other sections may have been protected by an extensive ice sheet. A modern analogue might be the volcanic centre of Mount Erebus and the nearby Ross Ice Shelf.

Many well bedded, channelled and cross-stratified mixtites and other facies, particularly in the lower half of the Gaskiers Formation, provide evidence of a complex of syn- and post-depositional processes. Re-entrainment and subsequent deposition of fine clastics by turbidity currents would account for the thin and rhythmically bedded sandstones and siltstones. Winnowing of fine material by bottom currents would result in lag deposits such as the conglomerates. Downslope movement by gravity is one broad mechanism that would explain the origin of the disrupted and contorted beds. The folding probably occurred shortly after deposition of the sands as a result of collapse and superficial flow, a process common among modern tills (e.g. Boulton, 1972).

Unsorted pebble beds that resemble some mixtites of the Gaskiers Formation occur locally in the overlying Drook

Figure 6. Mixtite of Gaskiers Formation, Double Road Point. (GSC 203104-C)

and Briscal formations of the Conception Group. A 5-m-thick coarse pebbly bed with dispersed unsorted fragments of white quartz, volcanic rocks, slumped laminated sandstone, and blue weathering shale occurs in the Briscal Formation on the north side of Gull Island Cove. Other unsorted pebble beds occur in the Drook Formation above Harbour Main volcanics at the south end of the Red Hills Anticline, and in the Clam Cove Member of the formation. A poorly sorted quartzite and volcanic pebble bed also occurs in the Drook Formation at the north end of Chance Cove Brook. Some of these beds may be local mud and debris flows, possibly representing mountain moraine that flowed as a slurry into marine environments.

The apparent absence of the Gaskiers Formation in the eastern part of the map-area suggests that a shoreline once existed in that direction. Tillites similar to those of the Gaskiers Formation are known at several localities on the west side of Conception Bay; possible stromatolites associated with a tillite south of Bacon Cove, Conception Bay (G. Nixon, pers. comm., 1974) suggest a nearshore environment of deposition in that area. A few other occurrences are known east of the Harbour Main terrane at Flatrock and Cape St. Francis, and elsewhere along strike to the southwest (E.Y.C. Hsu and W.D. Brückner, pers. comm., 1975).

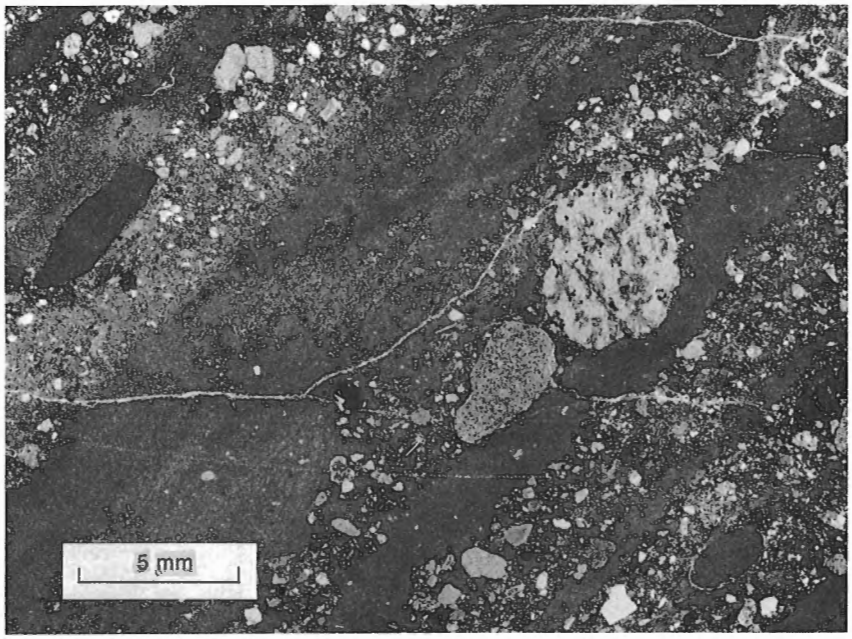


Figure 7. Rhythmites with dropstones, Gaskiers Formation, Double Road Point. Tops to upper left. (GSC 203104-D)

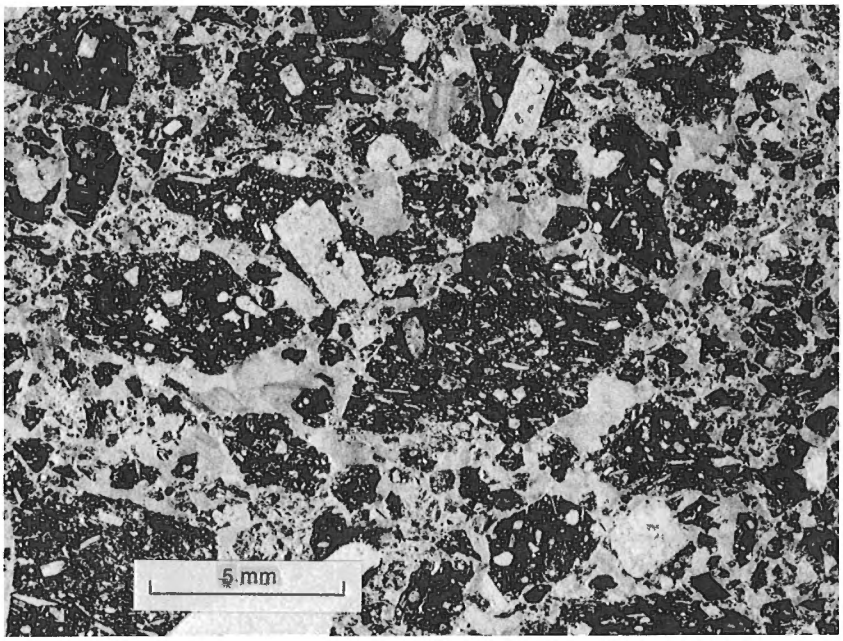


Figure 8. Agglomerate of the South Point Member, Gaskiers Formation, South Point, Great Colinet Island. (GSC 203104-E)

Drook Formation

The Drook Formation, modified after Misra (1969a; 1971), is the thickest and most extensive (post-Harbour Main) lithic unit in the map area. Its white weathering, grey to green and buff siliceous siltstones, argillites, cherts, and sandstones are the most widely recognized lithology that defines the Conception Group throughout the Avalon Peninsula. In most places, the rocks are thin bedded (Fig. 9) and they contrast in gross appearance with the overlying, thick bedded Briscal sandstones. In a few places the rocks are red to purple.

The Drook Formation is about 1500 m thick and occurs throughout the entire Avalon Peninsula. In the map area, it conformably overlies the Gaskiers Formation at St. Mary's Bay and the Harbour Main Group toward the east where its base is marked by a local conglomerate, suggesting disconformity.

Toward the base of the formation at St. Mary's, Great Colinet Island, Frapeau Point and Shoal Bay, coarse sandstone beds up to 2-m-thick alternate with typical green, thin bedded siltstones and argillites. The sandstone beds commonly display grading and

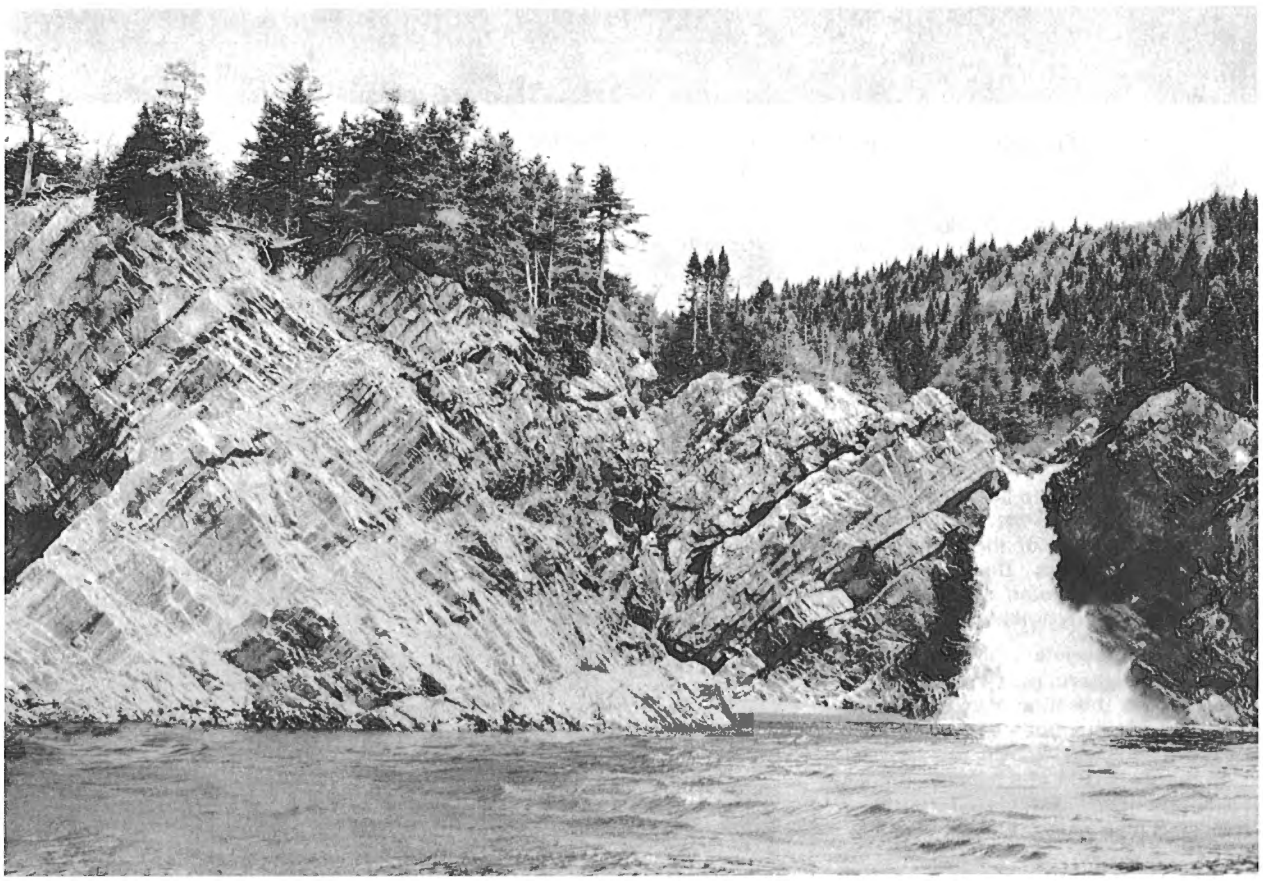


Figure 9. Thin bedded cherts and siliceous argillites of the Drook Formation, north side of Aquaforte Harbour. (GSC 203104-F)

internal slump structures, and at Shoal Bay, asymmetric ripples indicate currents toward the north. At the headwaters of Chance Cove Brook, the Drook Formation includes a conspicuous fragmental bed with white quartzite clasts up to 10 cm in diameter in a grey green, sandy matrix.

Four members are recognized in the formation: the Cape English, Peter's River, Clam Cove and Biscay. The Cape English and Peter's River members are characterized by coarse, thick, grey sandstone beds up to 2 m thick that alternate with thinner bedded units. Most are graded and some weather pale red. A single, massive, reddish weathering sandstone bed at Cape English is about 10 m thick. Similar coarse, reddish beds in a roadside outcrop at St. Stephens contain pink to red volcanic fragments and display slumped lenses. At the southeast corner of Holyrood Pond and Cape English Member has medium- to thick-bedded grey sandstones with convolute structures that alternate with thin bedded green cherts and shales. Sole markings are common and indicate that the coarse clastics were transported from the southwest toward the northeast. Bluish, grey weathering shale beds, from 5 to 10 cm thick, in the same Holyrood Pond section are similar to the common bluish weathering clasts that occur in the Briscal Formation at Gull Island Cove and in the Gibbett Hill Formation farther east.

The Clam Cove Member consists of slumped, buff weathering sandstone and siltstone with transposed lozenge-shaped sandstone lenses separated by thin shale zones. Some beds are pebbly, but all of the pebbles are sedimentary and of local derivation. This member is more arenaceous than typical Drook, although it locally contains thin chert and argillite beds.

The Drook Formation beneath the Clam Cove Member consists of thin bedded, buff weathering sandstone with discrete whitish sandstone beds. This lithology is unlike the typical green cherty Drook above the Clam Cove Member, and is more akin to the Mall Bay Formation as exposed at La Haye Point.

The Biscay Member of the Drook Formation consists of two thin, mafic volcanic horizons 8 km northeast of Northwest Pond. Both are green and altered, and locally display pillows with chert filling pillow interstices.

The Drook Formation is much sandier and thicker bedded toward the southwest at Cape English and Peter's River. These sections are facies equivalents of thinner, cherty beds found toward the northeast. Numerous paleo-current determinations made at Holyrood Pond indicate that the coarse sands were derived from the southwest. This contrasts with a northerly and northeasterly provenance of some Conception rocks lower in the section and with a possible northeast provenance for Conception Group rocks north of the map-area at Conception Bay.

Briscal Formation

Briscal[1] Formation is the name proposed for the coarse thick-bedded sandstones that occur conformably above the Drook Formation from Gull Island Point to Cape Race. Its maximum thickness is about 1200 m and it is well exposed in coastal sections of the Gull Island, St. Shotts, Biscay Bay, and Cape Race synclines. In the northeast part of the map area, the formation is thin (<100 m) and poorly exposed, but it is locally defined as a narrow unit between the Drook and Mistaken Point formations on the south shore of Aquaforte Harbour. The base of the Briscal Formation is marked by the change from thin bedded siliceous rocks of the Drook Formation to thick bedded sandstones and thick olive green

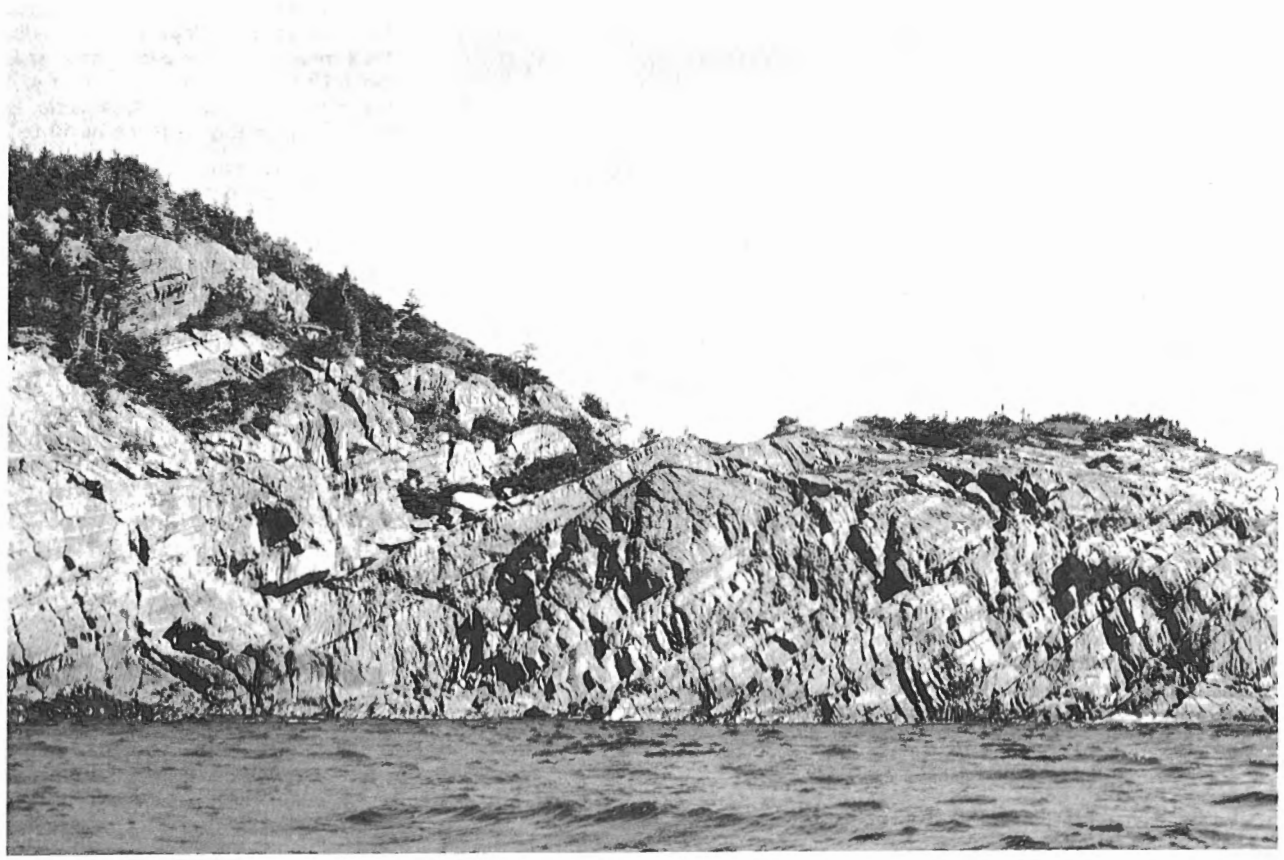


Figure 10. Medium bedded sandstones, Mistaken Point Formation, Cape Broyle. (GSC 203104-G)

[1] The name is derived from the former settlement of Briscal Harbour.

Figure 11. Late Precambrian fossils, Mistaken Point Formation, Mistaken Point. (GSC 203104-H)

argillite units. Sandstone beds average from 1 to 2 m thick and are commonly graded. At Gull Island Cove, the formation includes purple to green shale and coarse reddish sandstone with irregular slumped lenses of granule conglomerate. Arkosic sandstones with pink feldspar fragments and pebbles of bluish weathering argillite are common east of the cove. A 5-m-thick unsorted unit occurs on the north side of Gull Island Cove and the underlying section includes two additional 2- to 3-m-thick, coarse, unsorted beds.

The Briscal Formation is in part lithologically similar to the arenaceous varieties of the Drook Formation at Cape English, St. Stephens and Peter's River. It is, therefore, regarded as a coarse sandy facies of the Drook Formation that thins and disappears immediately north of the map area near Aquaforte. Its direction of derivation is unknown but its distribution and increasing coarseness toward the southwest suggest a provenance in that direction.

At the eastern end of the type section at the now-abandoned settlement of Briscal Harbour, bedding surfaces display amoeboid-shaped structures that are possibly of organic origin.

Mistaken Point Formation

The name Mistaken Point Formation is proposed for the thin- to medium-bedded, grey to pale red sandstones and purple shales that conformably overlie the thick bedded grey to olive Briscal sandstones and shales (Fig. 10). It is exposed in coastal sections of the St. Shotts, Biscay Bay and Cape Race synclines. It is also well exposed at Fermeuse in the Kingman's Syncline and Aquaforte Anticline. North of the map area it has been traced in coastal exposures to Cape Broyle where it directly overlies the Drook Formation. An outlier of the formation, about 1.5 km wide, occurs north of Biscay Bay in the Biscay Bay Syncline. The formation is approximately 400 m thick throughout the map area.

The Mistaken Point Formation passes downward into the Briscal Formation by interfingering and the boundary is arbitrary. East of Biscay Bay the zone of interfingering of medium- to thick-bedded sandstones and shales is about 10 to 30 m thick, but west of Biscay Bay the thickness of this zone is over 30 m and probably as much as 50 to 75 m.

At its type section on Mistaken Point the formation is profusely fossiliferous with a variety of frond-like and disc-like impressions (Anderson and Misra, 1968; Misra, 1969b; 1971; Anderson in King et al., 1974) (Figs. 11, 12). The late Precambrian forms occur on bedding plane surfaces that commonly display asymmetric wave ripples (Fig. 13). In all cases, the fossils occur beneath dark, thin, tuff horizons that are less than 1 cm thick. Fossil horizons are most common toward the top of the formation and five or more fossiliferous horizons are easily identified at the type locality.

Spindle-like impressions (Fig. 14A, F) tend to be aligned with their long dimension parallel to ripple troughs. Glaessner (in Misra, 1971, p. 986) has suggested that they represent "... a new floating colonial Hydrozoan of the Order Thecata". Disc-like impressions are of several varieties (Fig. 14C). Most are comparable with **Charniodiscus concentricus** Ford (1958), from the Precambrian Charnian succession of Leicestershire. A rather rare variety at Mistaken Point, with numerous concentric annulations, bears close resemblance to an impression in the Charnwood succession described by Ford (1968, p. 13) and thought to resemble **Cyclomedusa davidi** Sprigg, which is found in the Ediacara fauna of Australia as well. Disc-like forms with radial depressions (Fig. 14B) are probably medusoid impressions. Frond-like impressions at Mistaken Point, which

Figure 12. Late Precambrian fossils, Mistaken Point Formation, Mistaken Point. (GSC 203104-I)

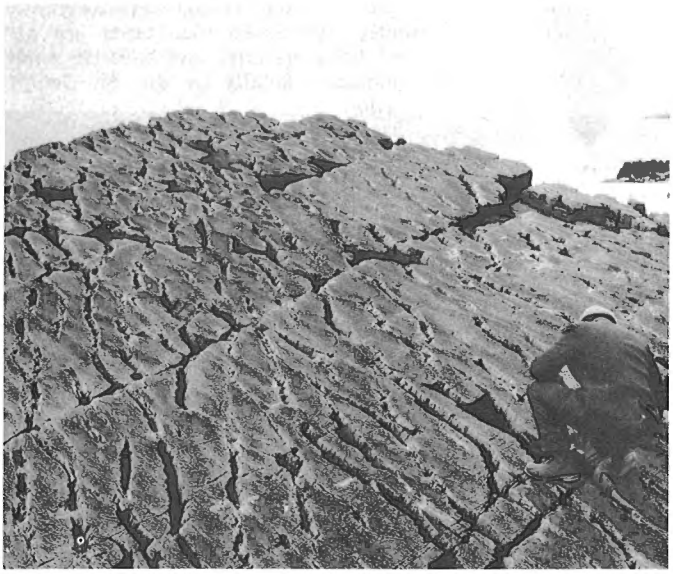


Figure 13. Asymmetrical wave ripples on bedding surface of Mistaken Point Formation, Mistaken Point. (GSC 203104-J)

resemble **Charnia masoni** Ford (1958), are in places joined by a stalk to the disc-like forms (**Charniodiscus**), and thus may represent one organism (Fig. 14E). The disc presumably represents a circular anchorage for the once-upright frond-like form. Pectinate forms (Fig. 14D) are rare.

Fossils can be found toward the top of the Mistaken Point Formation in most places where suitable bedding plane surfaces are exposed. At least three fossiliferous horizons occur to the northeast of the type section at Watern Cove. Poorly preserved forms also occur west of St. Shotts. North of the map-area, disc-, frond- and spindle-like impressions occur at Aquaforte, Calvert, and Cape Broyle.

The profusely fossiliferous Mistaken Point strata define a biostratigraphic zone as well as a lithologic formation. The concentration of thin tuff horizons in the formation indicate that it is an actual chronologic unit as well. This easily recognized formation is therefore chosen to define the top of the Conception Group. The Hibbs Hole Formation (Hutchinson, 1953; McCartney, 1967) and Torbay slate (Rose, 1952) at Conception Bay are probably Mistaken Point correlatives.

In Charnwood Forest of Leicester, England, the fossiliferous Woodhouse Beds and overlying purple to greenish grey argillites (Swithland Slate) are possible correlatives of the Mistaken Point Formation. Furthermore, white-weathering siliceous siltstones and tuffs (Beacon Beds), which occur beneath the fossiliferous Woodhouse, are comparable with the Drook Formation of the Avalon succession.

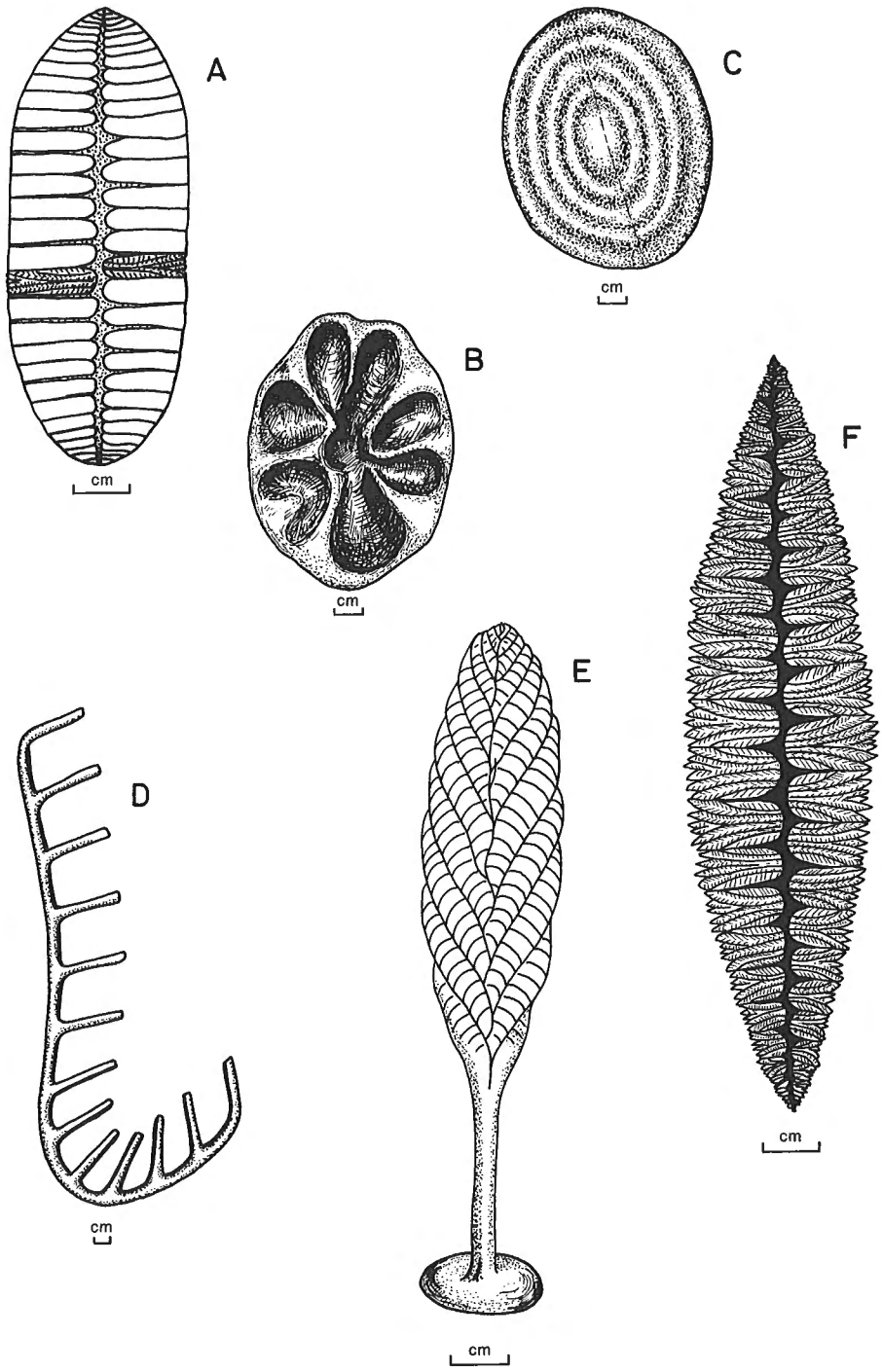


Figure 14

Precambrian fossils of Mistaken Point Formation (bar scale represents 1 cm). A, B, D, and F after Anderson (in King et al., 1974); E after Ford (1958).

A. Spindle-shaped form showing alternate lobes and depressions.

B. Disc-like form with radial depressions.

C. Disc-like form with numerous concentric annulations.

D. Pectinate Form.

E. ***Charniodiscus concentricus*** *with* ***Charnia masoni*** *Ford (1958).*

F. Spindle-shaped form showing alternate lobes and depressions (possible rimless variety of A).

St. John's Group

The St. John's Group in the map area consists of three lithic units of formational status, which from bottom to top are here defined as the Trepassey, Fermeuse, and Renews Head formations. The Fermeuse and Renews Head formations were mapped traditionally as the St. John's Slates (Jukes, 1842), Aspidella Slates (Murray and Howley, 1881) and the St. John's Formation (Rose, 1952; Hsu, 1972) where they occur north of the map area. In the map area, the Fermeuse Formation was recorded as St. John's Slate (Jukes, 1843) and mapped as the St. John's Formation at Cape Race and Trepassey Bay (Misra, 1969a, 1971; Koh, 1969). The Trepassey Formation has been assigned to either the St. John's Formation (Rose, 1952; Hsu, 1972) or the Conception Group (Misra, 1969a, 1971; Koh, 1969). Misra (1971) emphasized a colour change from purple at the top of the Conception Group (Cape Cove Formation) to grey at the base of the St. John's Formation. This colour change coincides with the present Mistaken Point – Trepassey boundary, although Misra (1971) placed grey rocks of the Trepassey Formation in his Conception Group (see Fig. 4 in Misra, 1971).

The Trepassey, Fermeuse and Renews Head formations constitute a continuous, conformable sequence of grey to black cleaved shales and grey to buff sandstones with gradational contacts. The St. John's is redefined and elevated to group status because these presently delineated map units are all related lithologically, and because each was included locally in the St. John's Formation.

The St. John's Group conformably overlies the Conception Group with a gradational and conformable contact between the Mistaken Point and Trepassey formations. The top of the St. John's Group is marked by an abrupt contact and local erosional disconformity between the Renews Head formation and the Cappahayden Formation at the base of the Signal Hill Group.

The lithic subdivisions of the St. John's Group in the map area are all recognizable at the type area of the St. John's Formation of earlier authors. The type area is at the city of St. John's, 60 km northeast of the map area. Elevation of the St. John's to group status is valid therefore throughout the eastern Avalon Peninsula.

Trepassey Formation

The name Trepassey Formation is proposed for thin- to medium-bedded grey sandstones and shales that overlie the Mistaken Point Formation (Fig. 15). It is approximately 250 m thick throughout the map area and is well exposed in the St. Shotts, Biscay Bay, Cape Race, and Kingman's synclines. As well, it forms a long, continuous band within the Chance Cove Monocline. Trepassey Harbour is designated as the type section.

The formation is locally most coarse and most thickly bedded at its base, grading upward into light grey, thin bedded shales of the Fermeuse Formation. Most of the beds are from 10 to 30 cm thick and are graded with sandy bottoms and shaly tops. Bedding is everywhere parallel. Locally at Mistaken Point, a thin, continuous horizon that parallels the graded beds consists of buff weathering sandstone lenses of Fermeuse type. West of St. Shotts, Trepassey lithologies in places alternate with reddish rocks typical of the Mistaken Point Formation over about 100 m and the Mistaken Point-Trepassey contact is difficult to define. Elsewhere, the contact is gradational over a few metres.

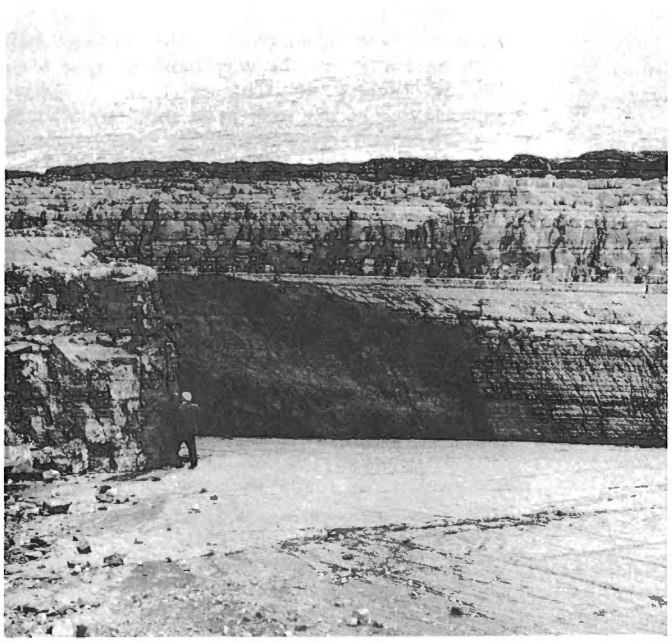
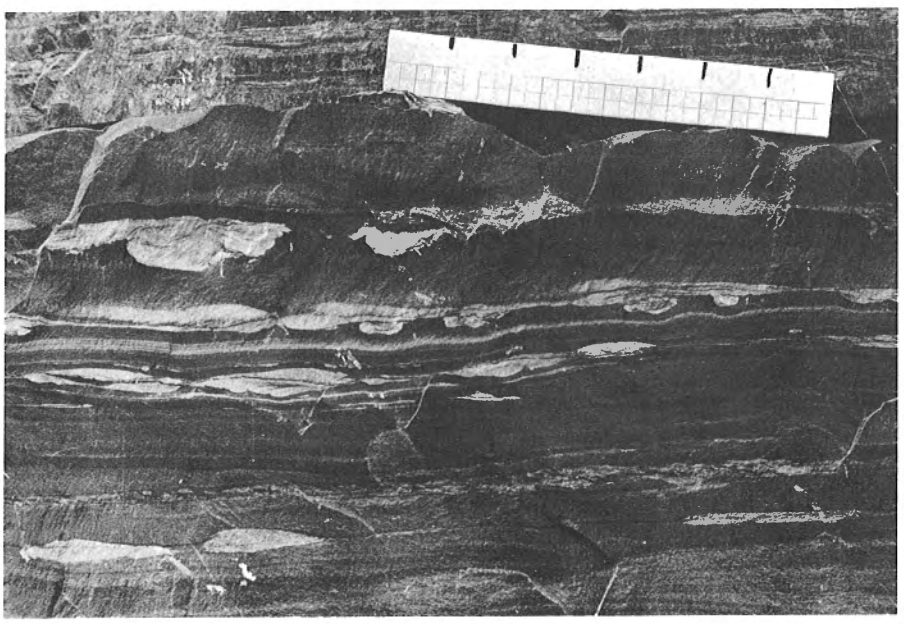


Figure 15. Thin- to medium-bedded sandstone and shale of Trepassey Formation, Mistaken Point. (GSC 203104-K)



Fermeuse Formation

The name Fermeuse Formation is proposed for the light to dark grey shales and minor buff sandstones that comprise the middle unit of the St. John's Group. It is the uppermost exposed formation in the St. Shotts, Biscay Bay, and Cape Race synclines and forms a broad band within the Chance Cove Monocline. The formation is about 1400 m thick in the Chance Cove Monocline with continuous sections exposed at Fermeuse, the type section, and Renews Harbours. It is conformable above the Trepassey Formation with a gradational contact. The base of the formation has thin bedded, light grey shales that commonly display large-scale slump folds. Its upper part consists of dark grey shale with thin lenticular interbeds of buff weathering sandstones that commonly display ripple lamination. Circular structures on bedding surfaces, from 1 to 10 cm diameter, were previously interpreted as the trace fossil **Aspidella terranovica** Billings, 1872. These occur toward the top of the formation with the best examples in the map area at Clear Cove on the north side of Fermeuse Harbour.

The Fermeuse Formation is the dominant lithology of the St. John's Group and it is the unit that is most characteristic of the former St. John's Formation. It can be traced from the map area for 60 km northward to St. John's and Middle Cove. A probable westward correlative is the Carbonear Formation (Hutchinson, 1953) of the Hodgewater Group on the western side of Conception Bay.

The orientation of ripple lamination at Biscay Bay and Cape Cove agrees with current direction determinations north of the map area, and all indicate derivation from the northeast.

Renews Head Formation

The Renews Head Formation consists of thin, lenticular-bedded sandstones with thin, dark shale laminae (Fig. 16). These are gradational above the dominant shales of the Fermeuse Formation. The formation is about 300 m thick in its type section at Renews Head and occurs as a uniform horizon in the Chance Cove Monocline.

The Renews Head Formation is distinguished from the Fermeuse Formation by its sandy character and details of bedding. Many of the beds are highly indurated and difficult to fracture and thus contrast with the shaly Fermeuse. Slumped beds and transposition structures resulting from injection (e.g. sand dykes), ejection (e.g., sand and mud volcanoes) and deformation (e.g. convolute laminae and load structures) are also common. North of the map-area, the formation occurs at Ferryland and Calvert and equivalents are also known at Bauline South, Bay Bulls, St. John's and Outer Cove.

Figure 16

Lenticular sandstones of Renews Head Formation. Scale marked in inches. Tops up. (GSC 203104-L)

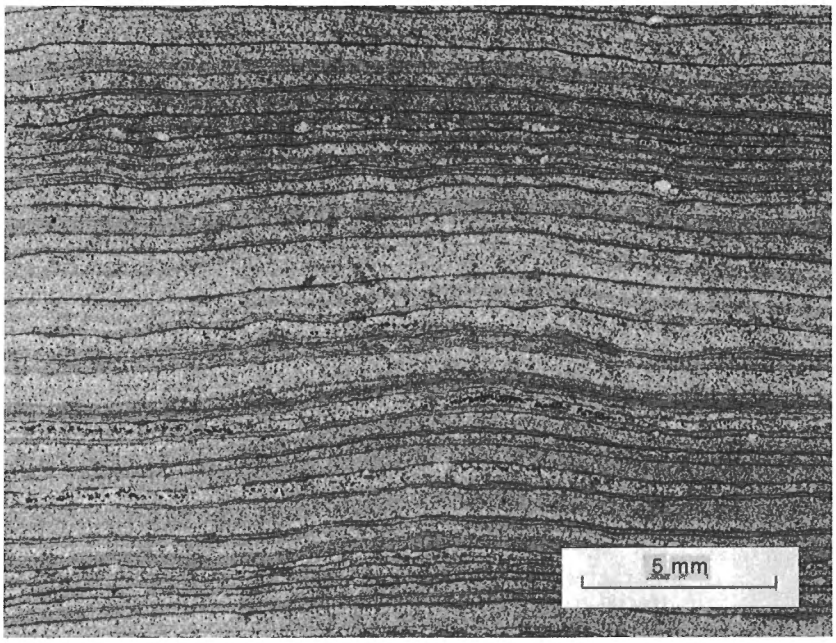


Figure 17. Thin-laminated siltstone of Cappahayden Formation. Cappahayden. Tops up. (GSC 203104-M)

Signal Hill Group

The term Signal Hill Group is introduced in the map area in accord with imminent nomenclature changes for similar rocks in their type area of Signal Hill at St. John's (A.F. King, in prep.). The former Signal Hill Formation (Rose, 1952), with its type section at Signal Hill, is now known to include three distinct mappable units of formational status. The Signal Hill is therefore elevated to group status. In the map area, it consists of four formations, which from bottom to top are the Cappahayden, Gibbett Hill, Ferryland Head, and Cape Ballard formations. All are confined to the Chance Cove Monocline. The Gibbett Hill can be traced all the way from its type area at St. John's to Chance Cove. Other formations in the map area show significant variation with respect to lithic subdivisions of the group farther north.

In the type area, the St. John's and Signal Hill were defined as two of three formations of the Cabot Group (Rose, 1952). Because both formations are now elevated to group status, the name Cabot is dropped.

The Signal Hill Group in the map area is dominated by thick bedded, light grey sandstones with local red sandstone. These contrast with the mainly dark shaly rocks of the St. John's Group. The base of the Signal

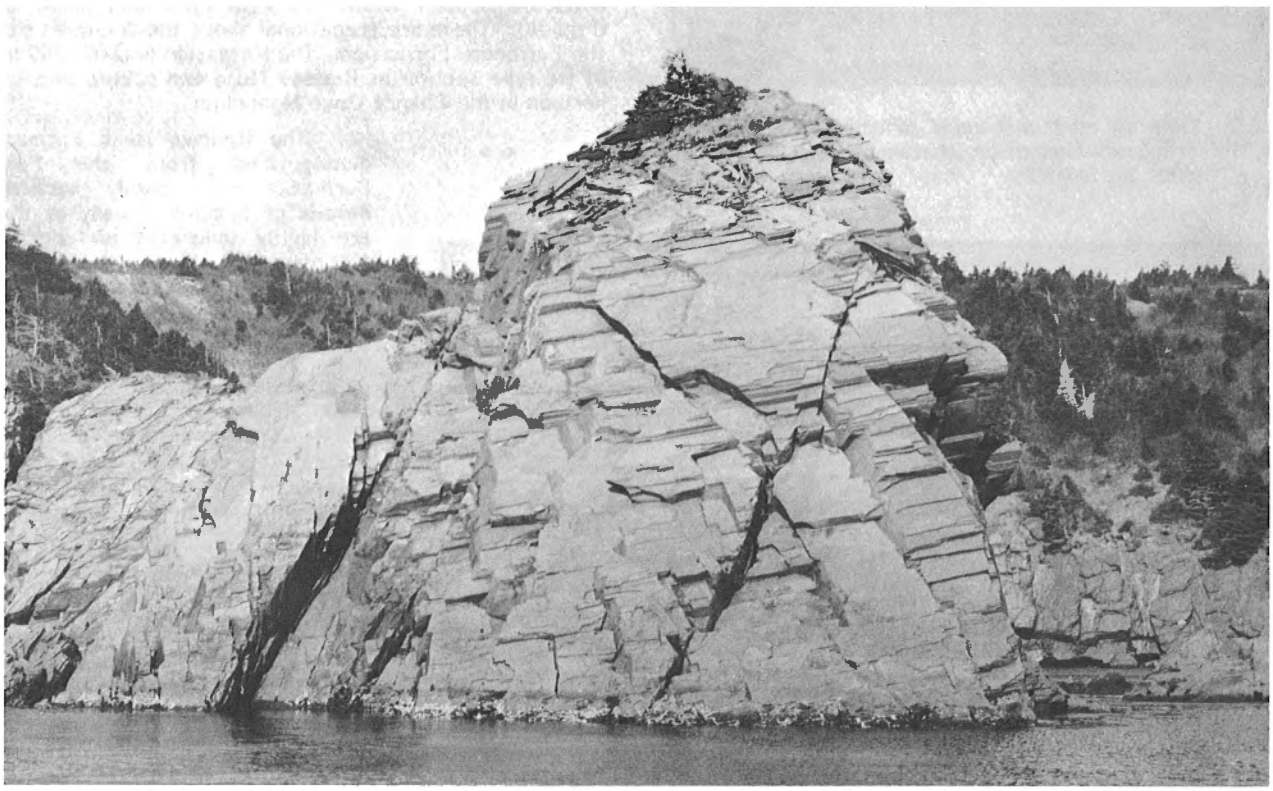


Figure 18. Fissile siltstones of Cappahayden Formation, Bear Cove Point. (GSC 203104-N)

Hill Group is drawn at the Renews Head-Cappahayden contact. At most places there is local erosional disconformity at the contact so that it is abrupt and therefore easily defined in the field. All other formations within both the Signal Hill and St. John's groups are characterized by conformable and gradational boundaries.

Cappahayden Formation

The Cappahayden Formation consists of light grey, fissile, finely laminated siltstone. Although only about 175 m thick, it is a distinctive unit and easily defined in exposed sections at Bear Cove Point, west of Renews Island, and its type section at Burnt Point and Cappahayden. Its southward extension to Chance Cove is inferred, but it extends northward to the isthmus of Ferryland Head. The very thin laminae, 10 or more per cm (Fig. 17), and bedding fissility (Fig. 18) are the most diagnostic features of the formation. Its contact with the underlying Renews Head Formation is abrupt and in most places the irregularly bedded Renews Head sandstones are erosionally truncated where they occur beneath the finely parallel-laminated Cappahayden siltstones. The Cappahayden Formation is lighter coloured than the Renews Head, except at the immediate contact where the upper 20 cm of the Renews Head is abnormally light grey.

Gibbett Hill Formation

The name Gibbett Hill Formation, formerly Gibbett Hill Member (King, 1972a), is applied to the grey sandstones at the base of the Signal Hill Group in its type area at St. John's (King, 1972a). These can be traced in virtually continuous outcrop from there to the map area, as indicated by Jukes (1843) and Murray and Howley (1881). In the map area, the formation is approximately 760 m thick and it can be traced from Bear Cove Point to Renews Island, Cappahayden and Chance Cove. The base of the formation is drawn at the first appearance of coarse sandstone beds above the Cappahayden Formation.

The Gibbett Hill Formation consists of buff weathering, thick bedded grey sandstones. Some display crossbedding, internal slumps, and ripple marks. Spherical sandstone balls are common locally, and bluish grey weathering mud flakes, lithologically similar to Conception beds at Holyrood Pond, occur in most outcrops. Thin limestone lenses and tuff interlayers are also prominent in some places.

Grey sandstone beds are from 1 to 2 m thick in most exposures and at Renews Island single massive beds reach thicknesses of 10 to 15 m. At Seal Cove, the formation has hard, whitish, siliceous, fine grained units up to 2 m thick and a local white quartzite bed that is 3 m thick. At Chance Cove Head, hard ellipsoidal carbonate-rich sandstone lenses up to a metre across have thin bedding that is continuous with bedding in surrounding sandstones (Fig. 19). The ellipsoidal limy sandstones are the result of diagenesis, and where slumped and disrupted, they produce sand balls in the formation.

The Gibbett Hill sandstones were deposited by currents coming from the northeast. At Bear Cove Point, asymmetric ripples, primary current lineations and a few irregular trough crossbeds all indicate currents from the northeast toward the southwest. Similarly at Burnt Point and Chance Cove Head, sedimentary features indicate currents toward the southwest

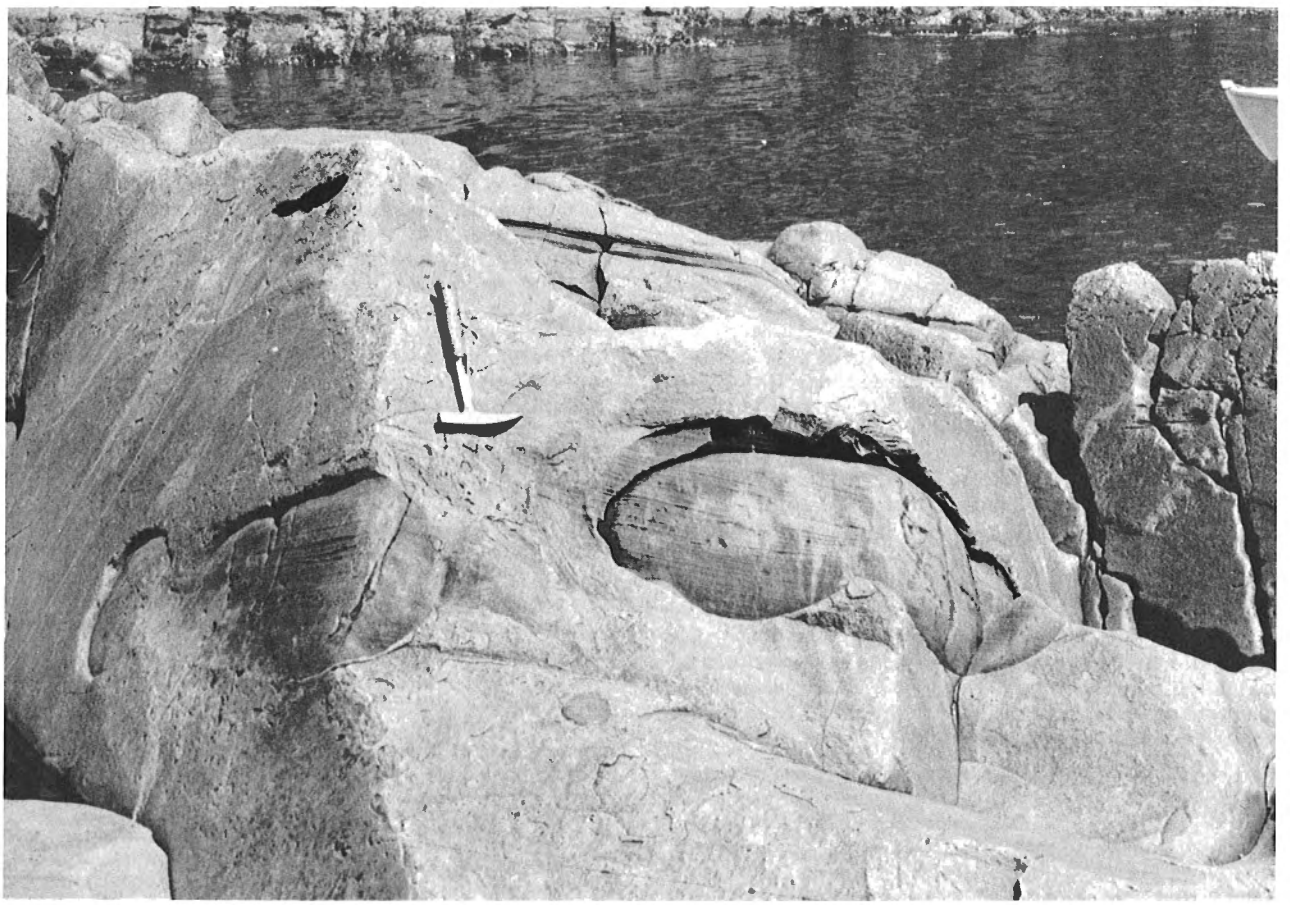


Figure 19. Limy concretionary sandstone ellipsoids in Gibbett Hill Formation, Chance Cove Head. (GSC 203104-O)

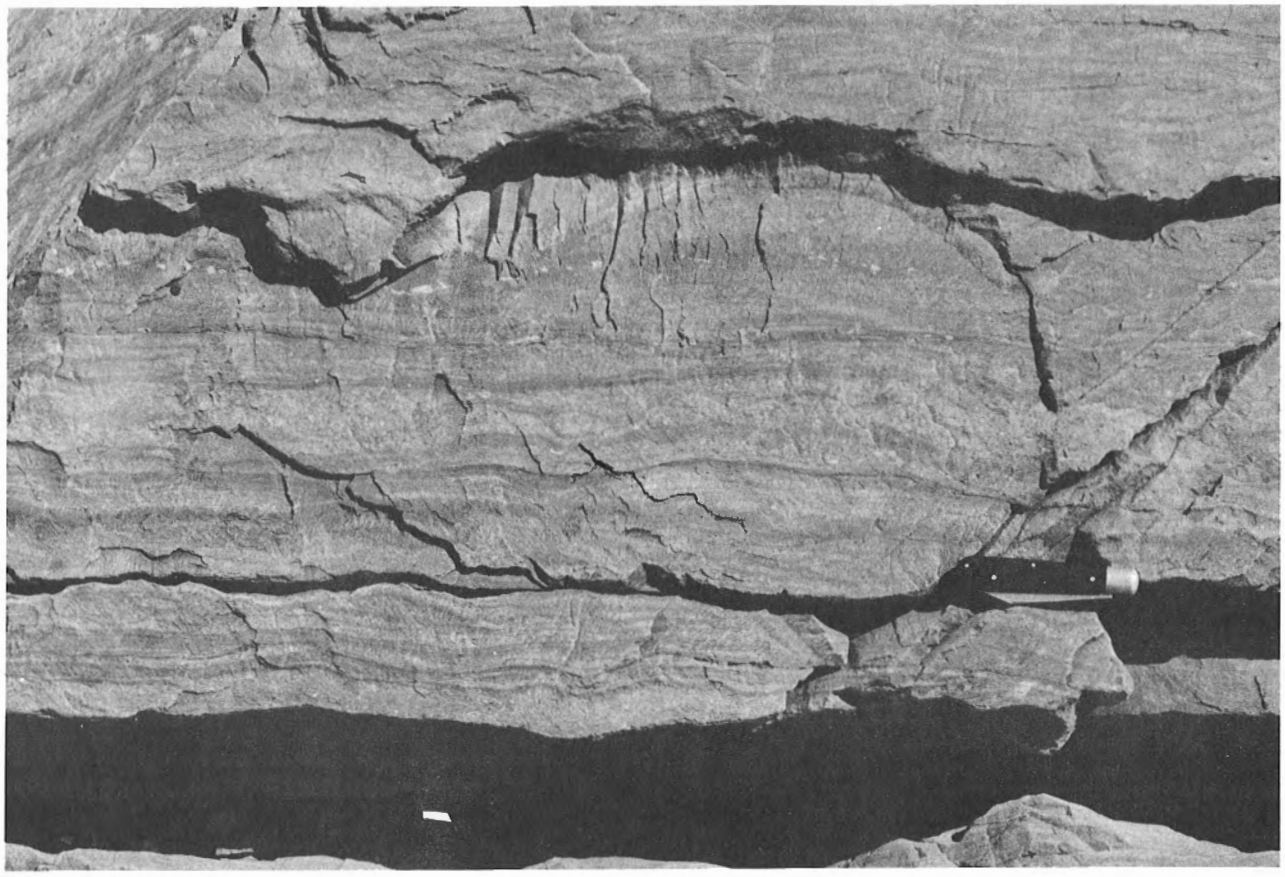


Figure 20. *Wavy-bedded sandstones of High Rocks Member, Ferryland Head Formation, south shore of Seal Cove. Tops up. (GSC 203104-P)*

and south. A northerly provenance is also supported by the predominance of thick sandstone beds in the north and the appearance of dark, thin bedded sandstone units at Chance Cove in the south.

Ferryland Head Formation

The Ferryland Head Formation consists of grey and red sandstone that conformably overlies the Gibbett Hill. This formation is better developed and thicker at Ferryland Head, 2.5 km north of the map area and along strike with the formation as exposed in the Chance Cove Monocline. Ferryland Head is designated therefore as the type locality. The formation is about 250 m thick in the map area.

The boundary between the Ferryland Head and Gibbett Hill formations is drawn at the first appearance of red sandstones at High Rocks south of Seal Cove. These red beds define the High Rocks Member of the Ferryland Head Formation. Six km southwest along strike to Shoe Cove, the High Rocks Member is absent and there is no sharp distinction between the Gibbett Hill and Ferryland Head formations. The boundary there is located by projecting the base of the High Rocks Member southwestward.

Red sandstones of the High Rocks Member are identical to grey varieties higher in the section except for their red coloration (Fig. 20). They display wavy bedding, ripple marks, crossbedding, and mud cracks. Toward the top of the Ferryland Head Formation there are coarse irregular beds up to 3 m thick that appear to be channel sand deposits.

The red and grey sandstone beds of the Ferryland Head Formation are probably equivalent to red conglomerates and sandstones of the Quidi Vidi (King, 1972a) and Blackhead (Rose, 1952) formations respectively, of the Signal Hill Group at its type locality. Southward from the type locality at Signal Hill, the Quidi Vidi conglomerates wedge out by passing into a red sandy facies near Bay Bulls that resembles the overlying Blackhead Formation. It is therefore desirable to propose a new name for these combined units where indistinguishable farther south, i.e. Ferryland Head Formation.

Cape Ballard Formation

The Cape Ballard Formation contains the stratigraphically highest beds of the Signal Hill Group in the map area. The type section is at Cape Ballard where the formation is approximately 260 m thick with top unexposed. The basal part of the formation consists of 50 m of grey to purple shale and siltstone (Fig. 21) that can be traced from Cape Ballard to Black Head. It is overlain by thick beds of buff weathering sandstone and grey quartz granule conglomerate (Fig. 22). Bedding surfaces of the arenaceous beds display megaripples at Cape Ballard (Fig. 23). These indicate variable currents that appear to be from a general northerly direction.

Renews Rocks consist of grey sandstones that are directly along strike and correlated with the Cape Ballard Formation.

Lithic correlatives of the Cape Ballard Formation are not represented in the type area of the Signal Hill Group at

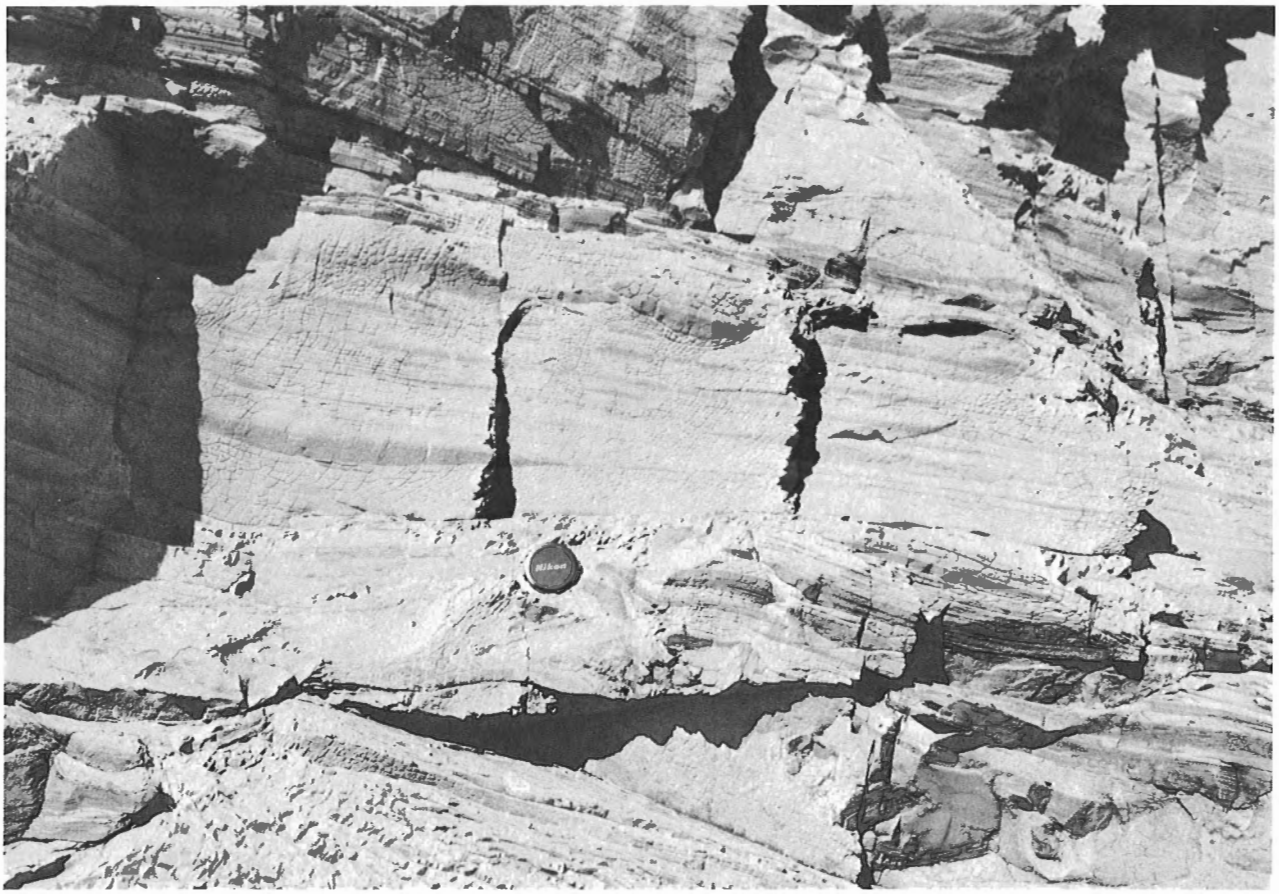


Figure 21. Argillite and siltstone of Cape Ballard Formation, Cape Ballard. Tops up. (GSC 203104-Q)

St. John's. However, quartz granule conglomerates and coarse sandstones like those at Cape Ballard occur within a sequence that unconformably overlies Conception beds at Red Head (Anderson et al., 1975), approximately 80 km north of the map area and 17 km north of St. John's. The aspect of bedding and colour variations in argillites at the base of the Cape Ballard Formation suggest correlation with the Blackhead Formation (Rose, 1952) at Maddox Cove, Petty Harbour.

Intrusive Rocks

Holyrood Granite

A small body of granite north of Butter Pot is a southward continuation of the Holyrood Plutonic Series (McCartney, 1967). The granite is medium grained, equigranular, massive and pink, and it is similar to granite at Holyrood north of the map area. North of Butter Pot, the granite is bounded by faults. Elsewhere north of the map area, it is intrusive into the Harbour Main Group. Pebbles and cobbles of granite, like that north of Butter Pot are common in the Gaskiers Formation.

Whalesback Gabbro

Numerous bodies of gabbro cut the Drook Formation immediately west of the Red Hills Anticline. Some of the smaller bodies are exposed sills with planar contact, and several aligned large outcrops west of Red Hill indicate a sill about 8 km long. The equidimensional bodies, such as the one near Butter Pot, are defined only by widely spaced outcrops. Possibly these outcrops are individual small sills so that the rocks may be misrepresented on the map as large equidimensional bodies.

The Whalesback Gabbro is a uniform, medium- to coarse-grained massive pyroxene-plagioclase rock. It was not observed to cut the Harbour Main Group and it appears to be stratigraphically restricted to the base of the Drook Formation. No other formations of the Conception Group or younger groups are cut by similar gabbro, and the only other mafic intrusions in the map area are small dykes less than 0.3 m wide that locally cut the Drook Formation along Crossing Place River.

Possibly the Whalesback Gabbro is an intrusive equivalent of the local pillow lavas of the Biscay Member of the Drook Formation. Like the gabbro, the pillow lavas are localized toward the base of the Drook Formation.

STRUCTURAL GEOLOGY

The upper Precambrian rocks of the map area are folded about northeast axes that plunge gently to the southwest, and locally to the northeast. The folds are open with steep axial surfaces and regional axial planar cleavage that varies from vertical to steeply southeast- to northwest-dipping. Major faults parallel fold axes.

Distinctive lithic units of the Conception and St. John's groups clearly delineate the form of the major folds. The Colinet Passage Syncline, La Haye Point Anticline, St. Mary's Syncline and Crossing Place Anticline are clearly defined in the map-area as gently southwest-plunging structures by their bedding attitudes, numerous top determinations and the

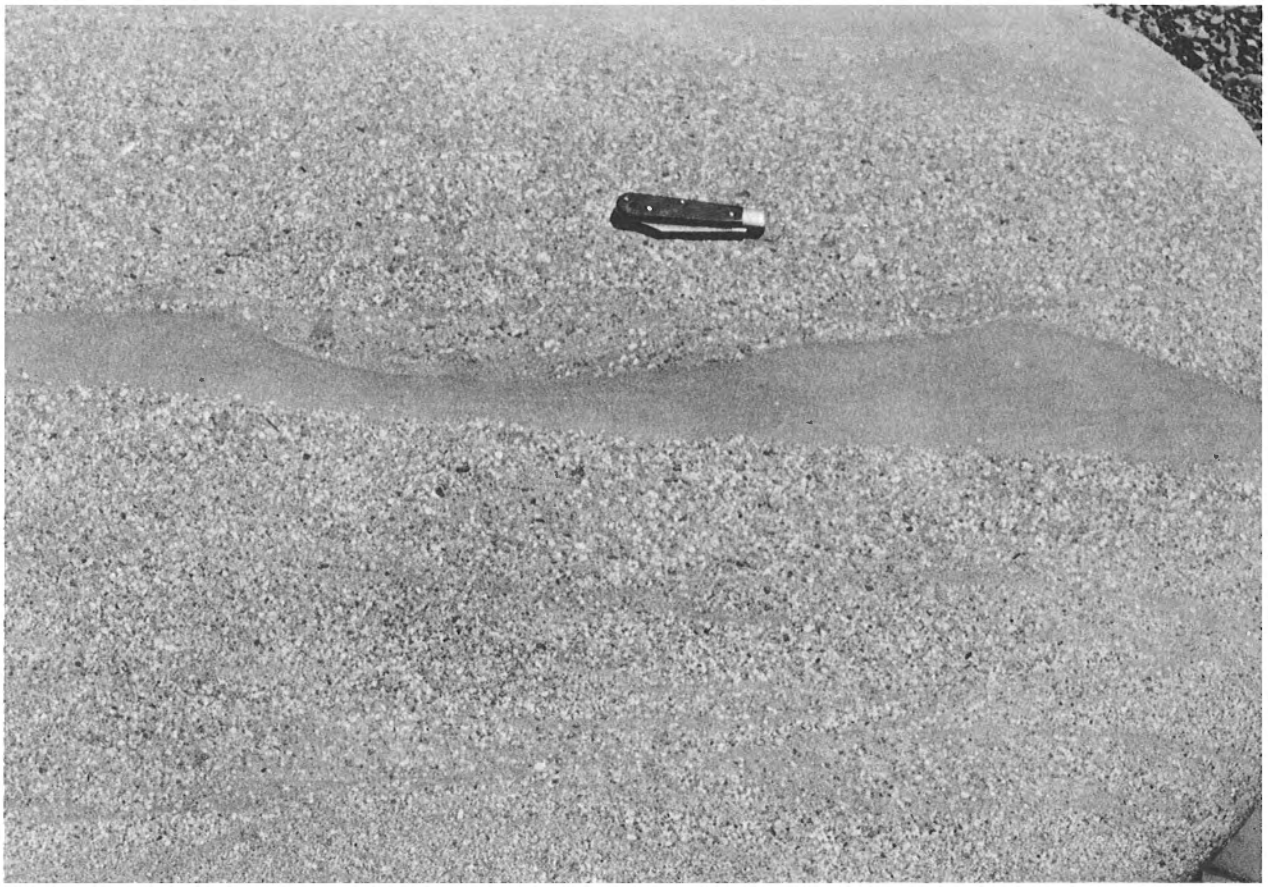


Figure 22. Coarse sandstone of Cape Ballard Formation, Cape Ballard. (GSC 203104-R)

distribution of the Gaskiers Formation. A few minor folds are associated with the major structures. These complicate the pattern of bedding attitudes so that the form of the major structures is most easily ascertained by tracing a sharp marker horizon.

The Gull Island Syncline, St. Shotts Syncline, Biscay Bay Syncline, Freshwater Anticline and Cape Race Syncline are all gently southwest-plunging structures as indicated by the distribution of the Briscal, Mistaken Point, Trepassey and Fermeuse formations. Minor folds related to these structures have wavelengths of a few metres to a hundred metres and they also plunge southwest, except for a few that plunge gently northeast. Minor folds are conspicuous in the Mistaken Point and Trepassey formations on the west limb of the St. Shotts Syncline, and in the Drook, Briscal and Mistaken Point formations on the west limb of the Cape Race Syncline. Spectacular minor folds with wavelengths up to 100 m are exhibited between Cape Pine and Trepassey Harbour on the west limb of the Biscay Bay Syncline, and north of Cape Cove on the east limb of the Cape Race Syncline.

The Kingman's Syncline and Aquaforte Anticline are clearly defined by the distribution and local attitudes of the Mistaken Point and Trepassey formations. The Aquaforte Anticline is exposed in continuous coastal sections on both sides of Aquaforte Harbour and the axis of this structure can be traced northward to Cape Broyle.

The beds that define the Chance Cove Monocline continue north of the map area to Cape Broyle where they are involved in northeast-plunging open folds.

A northeast-trending cleavage is related to the formation of the St. Shotts and Biscay Bay synclines in the central part of the map area and is best developed in the less competent Mistaken Point, Trepassey and Fermeuse formations. Cleavage is weak or absent in the underlying Harbour Main Group and is not strongly developed in Conception beds in the western part of the map area.

Cleavage is evident in most of the Drook Formation in the central part of the area. Between Peter's River and Trepassey, and from Biscay Bay to Cape Race, cleavage in the Drook parallels fold axes. North of the Biscay Bay Syncline, the Drook Formation is disposed in a variety of open folds. There, cleavage trends northeast and it is not geometrically related to the folds, suggesting that these are earlier than the development of the regional northeast-trending cleavage. Possibly the open folds are precursors of tighter structures and result from warping and décollement detachment above a resistant substratum, as might be provided by the Harbour Main volcanics. Continued compression would produce tighter folds with coplanar cleavage about consistent northeast-trending axes. Slaty cleavage that is noncoplanar with the axial surfaces of folds is probably more widespread throughout the Avalon Peninsula than has heretofore been recognized. The phenomenon is also common in other parts of the northern Appalachians (Stringer, 1975).

Two steeply dipping major faults cross the map area. Both are interpreted as high angle dip-slip faults without significant strike-slip displacement. The Peter's River Fault trends northeast from Peter's River to the north edge of the

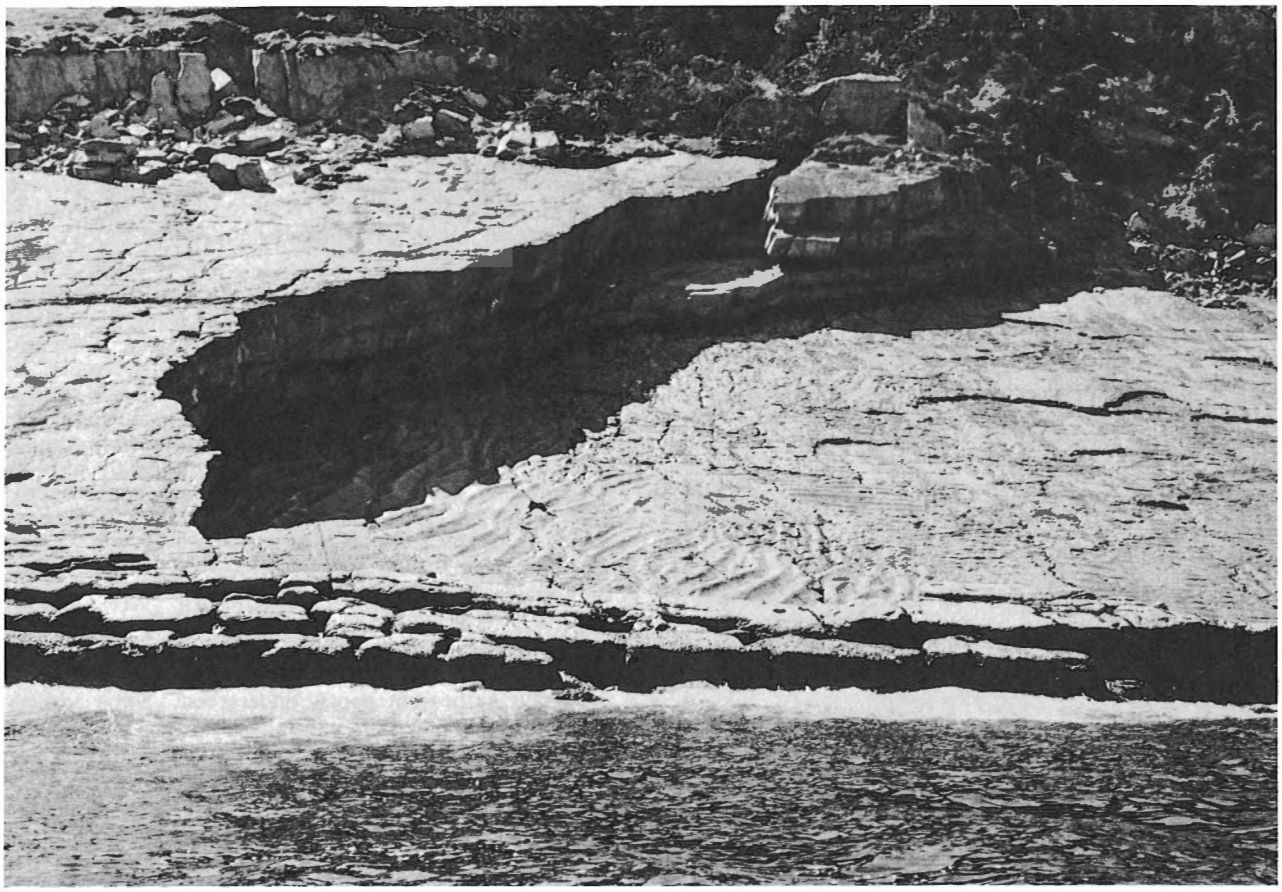


Figure 23. Megaripples on sandstone beds of Cape Ballard Formation, Cape Ballard. (GSC 203104-S)

map area and possibly continues for an additional 50 km to Holyrood on Conception Bay. It is not thought to be coincident with a major fault that bounds the Harbour Main Group to the west, as shown by McCartney (1967), and it is interpreted to lie slightly east of that fault. In the map area, the Conception beds are crushed and broken where cut by the Peter's River Fault in roadside exposures near Peter's River. The fault is not exposed elsewhere but its trace is marked by structural discontinuity throughout its length. Because similar rocks are exposed on opposite sides of the fault, it is not thought to be a zone of major strike-slip movement.

The Frenchman's Cove Fault trends northerly from Frenchman's Cove and it is interpreted to splay into two or more northwest-trending faults west of Fermeuse. This fault is unexposed, except for its easterly bifurcation in a stream bed near the highway at Fermeuse. It is interpreted as a high angle fault with its eastern side downthrown. This movement pattern also explains the presence of the small inlier of Harbour Main volcanics near Fermeuse.

North of the western part of the map area, the distribution and facing direction of isolated outcrops of Gaskiers tillite indicate that the La Haye Point and Crossing Place anticlines close northward and are periclinal structures (Fig. 24). The distribution of tillite on Little Colinet Island, to the north of the map area, also indicates that the Great Colinet Island tillites are on the east limb of an anticline that closes to the north. Additional exposures of tillite north of Crossing Place River indicate another anticline toward the east of the Crossing Place Anticline. This total distribution of the Gaskiers Formation, both within and immediately north of the map area, is interpreted to form the structures depicted in Figure 24.

The age of deformation in the map area is unknown except that it postdates the youngest Precambrian rocks. North of the map area, both Cambrian and Ordovician strata are involved in the same deformation. The steep upright fold style is rather typical of Acadian (Devonian) deformation in the northern Appalachians (Williams et al., 1972) and suggests that the rocks were deformed at that time. Within the map area, there is no evidence of a penetrative deformation during any part of the Precambrian that might correlate with Precambrian Avalonian movements (Rodgers, 1967).

A major positive aeromagnetic anomaly that crosses the entire Avalon Peninsula from Gaskiers Bay to Tors Cove, and extends offshore to the east (Papezik et al., 1975), has no expression in the surface geology of the map area. Possibly it relates to a basement feature in rocks beneath the Conception Group. Other positive anomalies coincide with Harbour Main volcanic rocks or with the Gaskiers Formation.

TECTONIC EVOLUTION

The geological history of the map area suggests mainly terrestrial silicic volcanism during initial stages of development (Harbour Main) that was locally accompanied, but mainly followed by, marine deposition of the Conception Group. A proximal volcanic terrane during deposition of the lower Conception Group is indicated by the presence of agglomerate and tuff associated with the Gaskiers Formation and numerous volcanic clasts within its mixtites. Pillow basalts and mafic dykes within the Drook Formation also indicate continuing igneous activity. Local tuff beds in the Mistaken Point Formation and overlying formations of the St. John's Group diminish upward in the stratigraphic section and

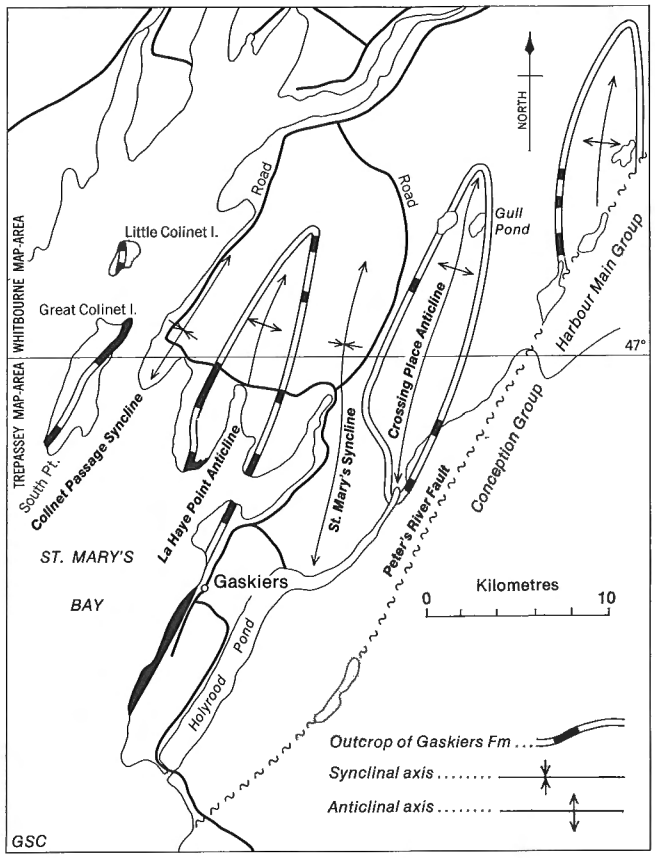


Figure 24. Distribution of Gaskiers Formation and major fold structures in the St. Mary's Bay area.

record waning volcanic activity during encroachment of the earlier volcanic centres by thick Precambrian sedimentary deposits. Arkosic beds toward the south and southwest (Cape English and Peter's River members of the Drook Formation, and Briscal Formation) imply unroofing of a granitic terrane to the southwest that was possibly associated with Harbour Main volcanism. The St. John's Group records a shoaling of the Conception marine basin and the Signal Hill indicates deltaic terrigenous environments.

Geological models for the Avalon Peninsula have stressed either a sequential development for the rock groups (Rose, 1952; McCartney, 1967) or else the continuous evolution of a volcanic island complex (Harbour Main), with parallel accumulation of marine tuffs and volcaniclastic rocks (Conception) and also terrestrial Signal Hill-type sandstones (Hughes and Brückner, 1971). Relationships in the map area indicate that the Harbour Main volcanic rocks are overlain by at least the middle and upper parts of the Conception Group. Also the fold style of the Drook Formation throughout the central part of the map area suggests a near-surface resistant substratum that might be furnished by a competent foundation such as the Harbour Main Group.

Provenance directions and the distribution of coarse clastic facies in the Drook and Briscal formations indicate transport from the south and southwest in the southern part of the map area. This is contrasted with northeast provenance directions in Conception and younger rocks north of the map area in the eastern Avalon Peninsula (King, 1972b). The total picture therefore appears to be one of southwest and northeast convergence toward the presently exposed Harbour Main Group. This indicates that the bulk of the Conception Group must overlie the Harbour Main Group and that middle and upper Conception rocks could not have been derived from a volcanic centre coincident with the presently exposed volcanic core of the Avalon Peninsula. The present concentric arrangement of late Precambrian sedimentary rocks around a volcanic core in the eastern Avalon therefore appears to be the result of Precambrian structural doming, as Lower Cambrian strata overstep the Conception Group to lie directly upon the Holyrood granite and Harbour Main volcanics at Conception Bay (McCartney, 1967).

A review of the age of the Avalon Precambrian rocks (Anderson, 1972) and recent $^{40}Ar/^{39}Ar$ isotopic studies (Peter Reynolds and Vidas Stukas, pers. comm., 1975) suggest that the rocks date back almost 800 million years. Their accumulation took place therefore over a period of about 230 million years. It is probable that the Conception Group with its tillite and Precambrian fossils is related in time to the Vendian of northern Eurasia. The Vendian also records Precambrian glaciation and the earliest appearance of an Ediacaran-type fauna (Sokolov, 1973). According to this comparison, the Gaskiers Formation would relate in time to the Varangian Period and the Mistaken Point Formation to the Ediacaran Period of the Vendian Era, on the chronostratigraphic scale proposed by Harland (1975).

The tectonic significance of the Avalon Zone and its extensions in any plate tectonic model for the Appalachian Orogen is at present poorly understood. Some authors have suggested that its Precambrian rocks represent an ancient North American island arc (Hatcher, 1972), others suggest a distended basin and range regime (e.g. Papezik, 1972) that possibly formed above an east-dipping subduction zone on the eastern side of the proto-Atlantic (Wilson, 1966; Dewey, 1969; Strong, 1977). The antiquity of the Avalon rocks, compared to the most recent proposals of about 600 to 700 Ma for the time of rifting and initiation of a proto-Atlantic Ocean (Stukas and Reynolds, 1974; Williams and Stevens, 1974) is difficult to reconcile in an island arc or subduction model that relates to an Appalachian cycle. Nor do the Avalon rocks resemble the products of island arc development, if the Ordovician of central Newfoundland is any indicator of standard arc sequences. The simple structural history of much of the Avalon Zone in Newfoundland is also difficult to reconcile in a dynamic arc model, if most of the Precambrian rocks were virtually undisturbed and were without penetrative deformation until the Devonian Acadian Orogeny.

The upper Precambrian rocks of the Avalon Zone are more akin to the terrestrial Siluro-Devonian or Carboniferous rocks of the Northern Appalachians, than to the Cambrian or Ordovician products of an open ocean. They may relate therefore to the last compressional movements of a Precambrian cycle that preceded, and was unrelated to, the opening and evolution of the Early Paleozoic proto-Atlantic (Rast et al., 1976; Blackwood, 1976). Alternatively, the Avalon Zone may represent a wide distentional belt and partly marine basin and range domain, which developed as a precursor to the actual opening of the Early Paleozoic proto-Atlantic.

ECONOMIC GEOLOGY

No economic mineral deposits have ever been mined in the map area and there are very few, if any, promising prospects. Gold has been reported in late Precambrian rocks of the eastern Avalon Peninsula (Fogwill, 1965) but there are no known occurrences in the map area. The volcanic rocks of the map area are low in accessory base metals.

Gravel deposits suitable for road metal abound throughout the map area (Henderson, 1972).

REFERENCES

Allen, P.
1959: The Wealden Environment; Anglo-Paris Basin; Royal Society of London, Philosophical Transactions, Ser. B, v. 242, p. 238-346.

Anderson, M.M.
1972: A possible time span for the late Precambrian of the Avalon Peninsula, Southeastern Newfoundland in the light of worldwide correlation of fossils, tillites, and rock units within the succession; Canadian Journal of Earth Sciences, v. 9, p. 1710-1726.

Anderson, M.M. and Misra, S.B.
1968: Fossils found in the Precambrian Conception Group in Southeastern Newfoundland; Nature, v. 220, p. 680-681.

Anderson, M.M., Brückner, W.D., King, A.F., and Maher, J.B.
1975: The Late Proterozoic "H.D. Lilly Unconformity" at Red Head, Northeastern Avalon Peninsula, Newfoundland; American Journal of Science, v. 27, p. 1012-1027.

Blackwood, R.F.
1976: The southeastern margin of the Canadian Appalachians: Some major elements; Geological Society of America, Abstracts with Program, v. 8, no. 2, p. 138.

Boulton, G.S.
1972: Modern Arctic glaciers as depositional models for former ice sheets; Geological Society of London, Journal, v. 128, pt. 4, p. 361-393.

Brückner, W.D. and Anderson, M.M.
1971: Late Precambrian glacial deposits in Southeastern Newfoundland – a preliminary note; Geological Association of Canada, proceedings, A Newfoundland Decade, v. 24, no. 1, p. 95-102.

Carey, S.W. and Ahmad, N.
1961: Glacial marine sedimentation; in Raasch, G.O. (ed.), Geology of the Arctic, v. 2, University of Toronto Press, p. 865-894.

Chriss, T. and Frakes, L.A.
1972: Glacial marine sedimentation in the Ross Sea; in Adie, R.J. (ed.), Antarctic Geology and Geophysics, v. 4, Oslo, Universitetsforlaget, p. 747-762.

Dewey, J.F.
1969: Evolution of the Appalachian/Caledonian Orogen; Nature, v. 222, no. 5189, p. 124-129.

Fogwill, W.D.
1965: Mines and Mineral Occurrences map of the Island of Newfoundland; Newfoundland Department of Mines and Agricultural Resources, Information Circular no. 11.

Ford, T.D.
1958: Precambrian fossils from Charnwood Forest; Yorkshire Geological Society Proceedings, v. 31, p. 211-217.

1968: The Precambrian paleontology at Charnwood Forest; in Sylvester-Bradley, P.C. and Ford, T.D. (eds.), The Geology of the East Midlands; Leicester Univ. Press, p. 12-14.

Harland, W.B.
1964: Evidence of late Precambrian glaciation and its significance; in Nairn, A.E.M. (ed.), Problems in Palaeoclimatology; Nato Paleoclimates Conference, Newcastle, January, 1963, London, Interscience, p. 119-149.

Harland, W.B. (cont'd.)
1975: The two geological time scales; Nature, v. 253, no. 5492, p. 505-507.

Hatcher, R.D., Jr.
1972: Developmental model for the Southern Appalachians; Geological Society of America Bulletin, v. 83, no. 9, p. 2735-2760.

Henderson, E.P.
1972: Surficial geology of Avalon Peninsula, Newfoundland; Geological Survey of Canada, Memoir 368, 121 p.

Hsu, E.Y.C.
1972: The stratigraphy and sedimentology of the Late Precambrian St. John's and Gibbett Hill Formations and the upper part of the Conception Group in the Torbay map-area, Avalon Peninsula, Newfoundland; unpublished M.Sc. thesis, Memorial University of Newfoundland.

Hughes, C.J. and Brückner, W.D.
1971: Late Precambrian rocks of Eastern Avalon Peninsula, Newfoundland – a volcanic island complex; Canadian Journal of Earth Sciences, v. 8, no. 8, p. 899-915.

Hutchinson, R.D.
1953: Geology of Harbour Grace map-area, Newfoundland; Geological Survey of Canada, Memoir 275, 43 p.

Jukes, J.B.
1842: Excursions in and about Newfoundland during the years 1839 and 1840; vols. 1 and 2, London, John Murray, 322 p. and 354 p.

1843: General Report of the Geological Survey of Newfoundland, John Murray, London, 160 p.

King, A.F.
1972a: History of the rocks and scenery in and near Signal Hill National Historic Park; Memorial University of Newfoundland, Geology Department, Report 6, 15 p.

1972b: Late Precambrian molasse of the Avalon Platform; Geological Society of America, Abstracts with Program, v. 4, no. 1, p. 26.

King, A.F., Brückner, W.D., Anderson, M.M., and Fletcher, T.
1974: Field Trip Manual B-6; Geological Association of Canada – Mineralogical Association of Canada, St. John's, Newfoundland, 59 p.

Koh, I.S.
1969: Geology of the Trepassey area, Avalon Peninsula, Newfoundland; unpublished M.Sc. thesis, Memorial University of Newfoundland, 143 p.

McCartney, W.D.
1967: Whitbourne map-area, Newfoundland; Geological Survey of Canada, Memoir 341, 133 p.

Misra, S.B.
1969a: Geology of the Biscay Bay-Cape Race area, Avalon Peninsula, Newfoundland; unpublished M.Sc. thesis, Memorial University of Newfoundland, 139 p.

1969b: Late Precambrian(?) fossils from Southeastern Newfoundland; Geological Society of America Bulletin, v. 82, p. 979-988.

1971: Stratigraphy and depositional history of late Precambrian Coelenterate-bearing rocks, Southeastern Newfoundland; Geological Society of America Bulletin, v. 82, no. 4, p. 979-987.

Mullins, W.J.
1970: Geology of St. Catherine's (east half) map-area (1N/3, E 1/2); Newfoundland Department of Mines and Agricultural Resources, Geological Report no. 15, 13 p.

Murray, A. and Howley, J.P.
1881: Peninsula of Avalon; Geological Survey of Newfoundland Map.

Papezik, V.S.
1972: Late Precambrian ignimbrites in Eastern Newfoundland and their tectonic significance; 24th International Geological Congress, Montreal, Proceedings, section 1, p. 147-152.

1974: Prehnite-pumpellyite facies metamorphism of late Precambrian rocks of the Avalon Peninsula, Newfoundland; Canadian Mineralogist, v. 12, Part 7, p. 463-468.

Papezik, V.S., Hodych, J.P., and Goodacre, A.K.
1975: The Avalon magnetic lineament: A possible continuation of the Triassic dike system of New Brunswick and Nova Scotia; Canadian Journal of Earth Sciences, v. 12, no. 2, p. 332-335.

Rast, N., O'Brien, B.H., and Wardle, R.J.
1976: Relationships between Precambrian and Lower Paleozoic rocks of the 'Avalon Platform' in New Brunswick, the northeast Appalachians and the British Isles; Tectonophysics, v. 30, p. 315-338.

Reading, H.G. and Walker, R.G.
1966: Sedimentation of Eocambrian tillites and associated sediments in Finmark, Northern Norway; Palaeogeography, Palaeoclimatology and Palaeoecology, v. 2, p. 177-212.

Reineck, H.E. and Singh, I.B.
1973: Depositional sedimentary environments; New York, Springer-Verlag, 439 p.

Rodgers, John
1967: Chronology of tectonic movements in the Appalachian region of Eastern North America; American Journal of Science, v. 265, p. 408-427.

Rose, E.R.
1952: Torbay map-area, Newfoundland; Geological Survey of Canada, Memoir 265, 64 p.

Schermerhorn, L.J.G.
1966: Terminology of mixed coarse-fine sediments; Journal of Sedimentary Petrology, v. 36, no. 3, p. 831-835.

Sokolov, B.S.
1973: Vendian of Northern Eurasia; in Pitcher, M.G. (ed.), Arctic Geology, p. 204-218. (Published by American Association of Petroleum Geologists, Memoir 19).

Spencer, A.M.
1971: Late Precambrian glaciation in Scotland; Geological Society of London Memoir no. 6, 98 p.

Stringer, P.
1975: Acadian slaty cleavage noncoplanar with fold axial surfaces in the Northern Appalachians; Canadian Journal of Earth Sciences, v. 12, no. 6, p. 949-961.

Strong, D.F.
1977: Volcanic regimes of the Newfoundland Appalachians; in Geological Association of Canada, Special Paper 16, p. 61-90.

Stukas, V. and Reynolds, P.H.
1974: $^{40}Ar/^{39}Ar$ dating of the Long Range dikes, Newfoundland; Earth and Planetary Science Letters, v. 22, no. 3, p. 256-266.

Williams, A.F. and Lilly, H.D.
1965: The nature and origin of the high shoal topography of the Grand Banks of Newfoundland; Memorial University of Newfoundland, Report no. 3, 29 p.

Williams, G.E.
1975: Late Precambrian glacial climate and the Earth's obliquity; Geological Magazine, v. 112, no. 5, p. 441-465.

Williams, H., Kennedy, M.J., and Neale, E.R.W.
1972: The Appalachian Structural Province; in Price, R.A. and Douglas, R.J.W. (eds.), Variations in Tectonic Styles in Canada; Geological Association of Canada, Special Paper no. 11, p. 183-261.

1974: The northeastward termination of the Appalachian Orogen; in Nairn, A.E.M. (ed.), Ocean Basins and Margins, v. 2, New York, Plenum, p. 79-123.

Williams, H. and Stevens, R.K.
1974: The ancient continental margin of Eastern North America; in Burk, C.A. and Drake, C.L. (eds.), The Geology of Continental Margins: New York, Springer-Verlag, p. 781-796.

Wilson, J.T.
1966: Did the Atlantic close and then reopen?; Nature, v. 211, no. 5050, p. 676-681.

Wright, A.E. and Moseley, F. (eds.)
1975: Ice Ages; Ancient and Modern; Geological Journal Special Issue no. 6, Liverpool, Seel House Press, 320 p.