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GEOLOGY OF SUNNYSIDE MAP-AREA NEWFOUNDLAND

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(Report and Map 18-1958)

By

W. D. McCartney

OTTAWA
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INTRODUCTION

Field work on which this report is based was done during three weeks in 1955. Final publication, as part of a larger project, is intended on a scale of 1 inch to 4 miles, but some features of the area warrant preliminary publication on a 1 inch to 1 mile scale, particularly as there are exceptionally good exposures of the late Precambrian Musgravetown group (2-8).

Competent and willing field assistance was rendered by C. Roy McLeod, Henry E. Gebhardt, William D. Smith, Thomas H. Scantlebury and Frank Benoit. The area was mapped earlier by Hayes and Rose (1948), and adjoins the Bonavista and Dildo map-areas to the north and south respectively (Christie, 1950; McCartney, 1957).

The southern part of the area comprises the isthmus of Avalon Peninsula separating Placentia and Trinity Bays. Transportation routes are thus funnelled through the Peninsula, and are restricted by topography to much their present course. The principal highway as yet unpaved and the railway connects with St. John's, and, to the north, with Clarenville. At Goobies, a branch highway leads west to the Burin Peninsula. A new secondary road extends from the highway north of the map-area to Long Beach, and continues easterly to Southport, Trinity Bay. Fishing, small-scale farming, and wood cutting for domestic use remain the principal occupations, although facilities for travellers are of importance at Goobies. The fishing village of St. Jones Without, lacking access by land, has recently been abandoned.

TOPOGRAPHY AND GLACIAL GEOLOGY

Resistant volcanic rocks of the Bull Arm formation (2,3), form numerous knobs and hills and underlie most of the irregular topographic land forms in the area. Representatives of this type of topography are: Centre Hill (elevation 1,133 feet), the highest point in the area; massive wooded hills west of Come By Chance River (elevations to 1,050 feet); and the area south and west of Bull Arm. The sedimentary rocks of the Musgravetown group (4-8) exposed in the east underlie a moderately rugged area characterized by bare elongate strike-ridges. The Crown Hill conglomerate member (7) is particularly resistant and, on the flanks of the Deer Harbour syncline, underlies an elongate, knobby highland up to 850 feet in elevation. Granite (12),

Cambrian beds (10), and rocks of the Connecting Point group (1), with a mantle of glacial till, underlie gently rolling slopes mainly west of the Long Beach fault, the hills underlain by the Powder Horn Diorite Complex (A) excepted. Elevations in this section gradually attain a maximum of 500 feet in the northwest corner of the area.

In the areas of subdued relief outlined above, glacial till contributes to the regularity of the topography and masks many bedrock relations. Till cover is minor in the east where bare rock is exposed on much of the high ground. Ice movement during Pleistocene time was easterly in the fiord of Deer Harbour and was probably southerly or southeasterly near the mouth of Come By Chance River. The last-mentioned directions are deduced from the presence of porphyritic gabbro erratics northwest of Arnold's Cove which were probably derived from the Powder Horn Diorite Complex (A) either in Sunnyside area or from its continuation to the west.

Elevated sand and gravel deposits were observed about a mile west of the area some 6 miles southwest of Sunnyside, and at Long Beach on the north border of the area. The former deposit extends to about 20 feet above high-tide level. Bedding is essentially horizontal and the deposit is, in the upper 12 feet now exposed, mainly sandy gravel. Below the organic soil and shallow leach zone, the upper 14 inches of stratified sand and gravel are cemented with dark, rich-brown oxides. This is underlain by 4 feet of clean stratified sandy gravel which rest on 3 to 6 feet of the same material partly cemented with dark brown oxides. The lowermost beds exposed comprise about a foot of alternating 2-inch beds of clean and oxide-coated, pebbly sand.

The deposit at Long Beach is notably crossbedded and comprises clean sand and coarse gravel. E. P. Henderson, currently engaged in Pleistocene studies in Avalon Peninsula, found that the top of this deposit measured 48 feet above high-tide level.

Other sand and gravel deposits about 25 feet above sea-level, marked by conspicuous crossbedding and channelling, were observed on the shore of Placentia Bay, about 40 miles south of the map-area. Coarse gravel also occurs slightly above sea-level at Broad Lake, Trinity Bay. No such stratified deposits were found in southeastern Trinity Bay, St. Mary's Bay, or Conception Bay.

GENERAL GEOLOGY

Sunnyside map-area is mainly underlain by unmetamorphosed Precambrian sedimentary rocks and lesser amounts of volcanic rocks, all related to similar rocks elsewhere in southeastern Newfoundland. In general, facies changes along the strike of the later Proterozoic beds (Musgravetown and Hodgewater groups) are drastic, but less so parallel with the regional north-northeasterly structural trend than contrary to it. Cambrian shales, slates, and limestone in isolated patches maintain a remarkably uniform lithology and fauna over southeastern Newfoundland and, except in the Conception Bay area, are underlain by white quartzite of the Random formation. Small areas of granite in the map-area and on some islands in Placentia Bay are probably related to more extensive Palaeozoic granite to the west and northwest. The oldest rocks known in the region, the Harbour Main group, are not exposed in the map-area on western Avalon Peninsula, but are presumed to underlie the Connecting Point group.

CONNECTING POINT GROUP

The sediments of this group, named by Hayes (1948), outcrop in a fault block in the western part of the area, and extend both north (Christie, 1950) and south (McCartney, 1957) of Sunnyside map-area. Green and grey siltstone, slate, argillite, and greywacke, with minor black cherty argillite beds only were found, although rare conglomerate beds to the north are reported by Christie (p. 11), and one or more red tuffaceous beds were observed to the south, near Southern Harbour, Placentia Bay.

Features of the group that distinguish it from most younger rocks include the regular, commonly laminated and in part graded types of bedding, the dull earthy-white weathered coating normally developed on inland outcrops, the lack of major red beds, the great predominance of fine-grained sediments, and the abundant basic dykes. The basic dykes are believed to be related to the succeeding Bull Arm formation, and only rare dykes of unusual lithology (11) have been found in the Musgravetown group.

The base of the group is not exposed, although a thickness of more than 8,000 feet is indicated. Relations to younger rocks are masked in this area by major faults. Limited evidence to the south suggests that they are conformable with the Bull Arm volcanic rocks (McCartney, 1957). Seventeen miles north of the area the Musgravetown group rests on them with angular unconformity, although 6 miles north, the evidence is less clear and suggests a gradational, conformable contact (Christie, p. 17).

MUSGRAVETOWN GROUP

The Musgravetown group, named by Hayes (1948), is an arkosic and volcanic assemblage of rocks overlying the Connecting Point group and underlying conformably the Random formation. It is correlated with some part of the Hodgewater group of central Avalon Peninsula (Hutchinson, 1953; McCartney, 1954, 1956, 1957). The group is here divided into the Bull Arm and Deer Harbour formations.

On the Bay de Verde peninsula, 20 miles east of the area, rocks of the Hodgewater group have been traced as far north as lat. 48°, and there meet lithologic units referred by Christie to the Musgravetown group. In particular, grey arkose and siltstone along lat. 48° east of long. 53°02' belong to the Halls Town formation; red arkose and siltstone from 53°02' to about 53°04' represent the rapidly thickening Whiteway formation; and wavy-bedded green, grey, and minor red siltstone and arkose west of long. 53°04' are typical of the Snows Pond formation, all in the Hodgewater group. The conglomerate mapped by Christie near Bay de Verde appears to represent a much thicker and coarser facies than is typical of the Whiteway formation, and, from work to the south, is tentatively correlated in a lithostratigraphic sense with the Signal Hill conglomerate near St. John's (Rose, 1948). Apart from these observations the distribution of the Musgravetown group is in reasonable agreement with Christie's map of 1950.

Bull Arm Formation

The name Bull Arm Felsites was given by Hayes (1948) to the volcanic rocks of this area. These volcanic rocks were shown as a lithologic unit by Christie, and were mapped tentatively as the Bull Arm "group" to the south (McCartney, 1956, 1957). This elevation to group status, adopted for preliminary publications while working towards the type area, now does not seem justified. It exaggerates the importance of the cessation of volcanism during sedimentation of the Musgravetown type, and it changes the lower boundary and concept of the Musgravetown group contrary to the way in which it was defined and accepted in the type area. It is here proposed that the term Bull Arm formation be used in a lithostratigraphic sense to designate the dominantly volcanic assemblage of rocks in the lower part of the Musgravetown group, resting on rocks of the Connecting Point group and underlying conformably the Deer Harbour formation. The original type area of southwest Bull Arm is recognized. South of the map-area, a representative, structurally simple, and complete cross-section of the formation, showing a southward decrease in felsite members, is exposed on the Placentia Bay shore northwest from Fairhaven (McCartney, 1957).

The formation, by definition, is markedly volcanic in origin, although it includes tuffaceous arkose, red and green arkose, siltstone, and conglomerate. Green slate and siltstone similar to Connecting Point sediments are found intercalated with the flows, breccias, tuffs, and minor intrusive rocks.

Rhyolitic members (3) are deep red to light orange and grey, and are mainly breccias and flow-banded lavas, with, perhaps, some welded tuffs. Welded tuffs resembling flow-banded rhyolite are present in the older Harbour Main group and may be present in this formation also. The greatest development of these rhyolitic rocks is near Bull Arm, but they thin and form a minor part of the formation 8 to 16 miles to the south (McCartney, 1957). Still farther, 20 to 50 miles, to the south they are insignificant in the upper, exposed part of the formation (McCartney, 1956, and in preparation).

Basalts and andesites with related breccias, tuffs, and dykes are most abundant in the southwest part of the formation in this area. Some lavas are amygdaloidal, with carbonate or epidote fillings. Intercalated sediments and tuffs are thought to be more abundant below the rhyolitic members in the southern part of the area. The peculiar cherty, pale green to mauve and purple laminated rocks associated with pink grit in the northeast (2a) are tentatively included with the Bull Arm formation despite the lack of direct evidence of volcanism. This is done because they are undoubtedly low in the Musgravetown group and because they underlie a rare massive arkose member having streaky, buff-coloured beds very much like a member at the top of the Bull Arm formation at Great Mosquito Cove. No rocks similar to the brightly coloured sediments of 2a were observed in the Deer Harbour formation.

Near the south border of the map-area green siltstones and slates, very like sediments of the Connecting Point group, are intercalated with flows in the lowermost part of the Bull Arm formation. These rocks seriously complicate the interpretation of basal contact relations.

The Bull Arm formation is in fault contact with the older Connecting Point group in Sunnyside map-area. The contact with overlying sediments of the Musgravetown group is transitional and conformable.

The maximum thickness of the Bull Arm formation in the area is not known, but the proportion of volcanic rocks to intercalated sediments appears to decrease rapidly towards the northeast edge of the map-area. To the north, near Bonavista Bay, Christie (1950) showed volcanic rocks in the Musgravetown group which are probably part of the Bull Arm formation. To the south

the thickness of dominantly volcanic members is maintained or increased to an observed thickness of about 8,000 feet (McCartney, 1957). The formation is not represented by volcanic rocks in the Hodgewater or Cabot groups to the southeast, although the time interval of Bull Arm volcanism should be within the time interval of the sedimentation that formed those groups. The Precambrian volcanic rocks of the Burin Peninsula west of Placentia Bay have been tentatively correlated with the older Harbour Main group by Weeks (1957, p. 143), but their place in the Precambrian is not yet fully understood. Until further evidence is presented it is suggested that they may just as probably be correlated with the Bull Arm formation because:

(a) Connecting Point rocks are not exposed on the Burin Peninsula and may underlie the volcanic rocks there.

(b) Unusual piedmontite rhyolite is present in both the Burin rocks and the Bull Arm formation, but is absent in the Harbour Main group in its type locality (McCartney, 1954).

(c) The Bull Arm formation on the east shore of Placentia Bay attains an impressive thickness and greatly resembles the Harbour Main group, hence correlation with similar rocks in, and west of, Placentia Bay appears reasonable.

(d) Rocks overlying the Burin Peninsula Precambrian volcanic rocks are in part similar to the Deer Harbour and Random formations and are overlain by fossiliferous Lower Cambrian sediments.

Deer Harbour Formation

The name Deer Harbour formation is here proposed in a lithostratigraphic sense for those sediments of the Musgravetown group overlying the Bull Arm formation and underlying the Random formation. Although a rather thin section of Musgravetown sediments is present, the shores of Deer Harbour afford good exposures typical of the sediments. The relationship of the formation to the underlying Bull Arm formation, near the mouth of the westerly flowing stream at the west end of the harbour, and to the overlying white quartzite of the Random formation, in the Deer Harbour syncline, is clear and definite. A locality near the type locality of the Bull Arm formation is selected because the volcanic rocks there are well developed and are known to be in the lower part of the group.

Owing to the rapid changes in lithology and thickness in the area, except for the Crown Hill conglomerate member (7), no formal lithostratigraphic subdivisions of this formation are now proposed. The informal members selected here (4,5,6) are of lithostratigraphic significance, but rocks separating these members are undivided. The units mapped show some useful structural trends and facies variations, but appear less persistent than some broad lithostratigraphic divisions traced over appreciable distances south of the area (McCartney, 1956, 1957).

Lower Green Siltstone and Conglomerate Member

This member is seen west of the Deer Harbour syncline, in scattered outcrops, and 2 miles south of Long Beach. It is represented 1,000 feet north of Great Mosquito Cove, but the Deer Harbour formation is not typical at this locality and is largely undivided.

Basal beds normally are red conglomerate and very coarse- to medium-grained red arkose, up to 350 feet thick. The upper part, about 500 feet thick, is greyish green and grey slate, argillite, siltstone, arkose, and pea- to walnut-sized conglomerate, with siltstone dominant in the upper part. Conspicuous features include very abrupt changes in grain size and rather irregular bedding, with rust-weathering, calcareous lenses and nodules in some beds. The matrix of some conglomerates is, in places, a calcareous arkose. Rounded to sub-rounded pebbles are dominantly greyish green siliceous argillite and chert which are thought to be derived from the Connecting Point group.

Massive Red Arkose Member

Distribution of this member seems virtually restricted to the east limb of the Deer Harbour syncline. About 25 feet of red arkose are present north of Great Mosquito Cove and about the same thickness of massive arkose occurs near the head of Deer Harbour, but these beds seem to be too thin to be equivalent to the entire thickness of the type lithological unit. The unit is marked by unusually massive red arkose, and is commonly underlain by red arkose, commonly crossbedded, with rather vague streaky and irregular bedding defined mainly by shades of red rather than by variations in grain size. The member is about 800 feet thick where mapped and is presumed to thin drastically west of the Deer Harbour syncline. It is lithologically like the central massive part of rock units in about the same stratigraphic position south of the area: namely, unit 3, Argentia map-area, and unit 5, Dildo map-area (McCartney 1956, 1957).

Grey Siltstone Member

This member is best exposed on the shores of Deer Harbour, but is insignificant and not mapped separately on the west limb of the Deer Harbour syncline. It probably extends to the north and resembles grey beds seen near Gooseberry Cove, Trinity Bay, although these beds contain pea-sized conglomerate which was not observed in the member in Sunnyside map-area. No equivalent lithologic member is recognized south of the area. It consists of dark grey siltstone, slate, and arkose, for the most part in regular beds. The basal and upper contacts are transitional, and are drawn where red beds become interbedded with the grey. An average thickness, where the unit is separated, is about 1,200 feet.

Crown Hill Conglomerate Member

The name Crown Hill conglomerate member is here proposed for the red conglomerate that lies at the top of the Deer Harbour formation, and is overlain by the white quartzites of the Random formation. This conglomerate underlies prominent ridges adjacent to the Deer Harbour syncline, including Crown Hill, and is well exposed opposite Sunnyside in Bull Arm and on the shores of Deer Harbour.

The characteristic lithology and persistent thickness of the member make it a useful map-unit in this area. Although some unusually bright red siltstone and normal, dull red arkose are included in the lower 200 to 500 feet of the member, the overlying 700 to 1,300 feet are dominantly red conglomerate. These contain pea- to walnut-sized pebbles, with coarse, sub-rounded pebbles up to 4 inches in diameter at some localities. Pebbles are of red rhyolite and some of argillite, basic lava, and quartz. This is the same conglomerate as the one that underlies the Random formation at the latter's type locality at Hickmans Harbour (Walcott, 1900, pp. 3-5). Walcott called this member the "Signal Hill conglomerate" in his description, but the writer is in agreement with Christie's (1950, p. 20) view that the Signal Hill conglomerate represents a lower part of the late Precambrian succession. A name seems justified in order to distinguish this member from various older rocks of similar lithology. It is easily recognized as it is everywhere overlain by the unique and widely distributed Random formation. Where present in the area, the member is conformable or possibly disconformable with the underlying beds and with the base of the Random quartzites.

The lithology is much the same throughout the area except that the conglomerate is sheared and green in the southwest, near Come By Chance River. The uppermost beds of the Deer

Harbour formation are not exposed in Dildo area (McCartney, 1957), but they are at Brine Islands, Placentia Bay, where they are mapped as unit 4d (McCartney, 1956) and are probably equivalent to the Crown Hill member. The Random formation is thought to overlie this Brine Islands conglomerate (unit 4d) because of the lithostratigraphic succession below the conglomerate, but, as the Random quartzite is not preserved, the proposed correlation remains uncertain. Current work in southwest Avalon Peninsula shows that thin Random quartzite overlies red arkose and pea-sized conglomerate there, but the lithology is not sufficiently similar to that of the Crown Hill member to warrant correlation (McCartney, in preparation). No conglomerate of this type underlies the Random quartzite in central Avalon Peninsula.

To the north, this member is correlated with the conglomerates underlying Random quartzite at Hickmans Harbour and with conglomerates on the north shore of Smith Sound as mapped by Christie (1950), but is apparently lacking at Keels some 16 miles north of Smith Sound. Thus the member maintains its lithostratigraphic identity for at least 30 miles but for less than 46 miles north-northeast of Sunnyside, and is probably represented 20 miles to the south. It is not present below the Random quartzite 19 miles south-southeast of Sunnyside, nor on the east shore of Trinity Bay 12 miles east of the Deer Harbour outcrops. This distribution is typical of the Precambrian sedimentary and volcanic facies of Avalon Peninsula, where lithostratigraphic units tend to maintain their identity for long distances along the regional north-northeast trend, but in places vary rapidly across this trend. This is believed to reflect the trends of the original basins of deposition and of the Bull Arm and Middle Cambrian zones of volcanism.

Undivided Deer Harbour Formation

In this catagory are placed arkosic sediments identical in lithology to parts of the members already described but which cannot be satisfactorily subdivided. Locally these sediments are broadly subdivided into dominantly red (8a) or dominantly green (8b) types but both the ratio of red to grey to green beds and their thickness vary so markedly that in many places even this subdivision cannot be made.

Contact Relations

Exceptionally good exposures of the basal conformable and transitional contact of the Deer Harbour formation with the Bull Arm formation are visible on the shore and cliffs near Great Mosquito Cove. A simplified stratigraphic section is presented below that illustrates the increase in the ratio of sediments to

volcanic rocks near the top of the Bull Arm formation; the late, minor lava flows that represent the uppermost members of the Bull Arm formation; and the virtually complete but thinnest known section of the Deer Harbour formation.

Simplified Stratigraphic Section,
Upper Part of the Musgravetown Group,
Near Great Mosquito Cove, Bull Arm

Thickness (feet)	Lithology (top)	Location and Remarks
1,000	Red, pea to walnut conglomerate with some red arkose	Crown Hill conglomerate member (7), on shore opposite Sunnyside
200	Bright red siltstone and red arkose with minor red conglomerate	Lower beds of the Crown Hill conglomerate member (7), 4,000 feet north of Great Mosquito Cove
50	Unexposed	Conformity or possible disconformity
300	Grey and green slate and siltstone with minor conglomerate	Deer Harbour formation possibly a thin representative of the grey siltstone member (6)
25	Red laminated siltstone, arkose, and red conglomerate with pebbles up to 4 inches in diameter	Deer Harbour formation possibly equivalent to the red arkose (5)
500	Greyish green and grey slate, siltstone, arkose, grit, and pea to walnut conglomerate	Deer Harbour formation, possibly representing the upper beds of member (4)
330	Red conglomerate and red coarse- to medium-grained arkose	Deer Harbour formation, probably the lower beds of member (4)
60	Andesite flow with brecciated upper part	Bull Arm formation (2), 1,000 feet north of Great Mosquito Cove

Thickness (feet)	Lithology (top)	Location and Remarks
600	Red arkose with unusual lenticular, discontinuous buff interbeds	Bull Arm formation (2)
60	Andesite flow	Bull Arm formation (2)
70	Unusually bright red conglomerate with volcanic pebbles loosely locked in an arkose matrix, associated with dull red subangular conglomerate and red pea conglomerate	Bull Arm formation (2) North shore of Great Mosquito Cove
40	Buff-weathering, green, subangular conglomerate and overlying coarse, green arkose	Bull Arm formation (2)
200	Coarse, red angular conglomerate or agglomerate with fragments up to 4 inches in diameter	Bull Arm formation (2)
15	Light pink, dense rhyolite, crystal tuff, or welded tuff	Bull Arm formation (2)
20	Dull red, bedded agglomerate	Bull Arm formation (2)
150	Grey, coarse arkose	Bull Arm formation (2)
15	Massive, fine-grained rhyolite	Bull Arm formation (2)
40	Maroon andesitic breccia and agglomerate	Bull Arm formation (2)
?	Rhyolitic and andesitic crystal tuffs, fragmental crystal tuffs, and lapilli tuffs	Bull Arm formation (2), south shore of Great Mosquito Cove

Underlying rocks of the Bull Arm formation exposed on the shore for 6 miles to the south of it are massive flows and tuffs, with negligible bedded sediments.

The foregoing stratigraphic section is not typical, inasmuch as the Deer Harbour formation is unusually thin and the basal contact is more clearly transitional than in equivalent exposures elsewhere in the map-area or to the south.

As the Bull Arm formation, by its definition, contains all volcanic rocks in the lower Musgravetown group the contact between it and the Deer Harbour formation is placed in this section at the top of the upper 60-foot andesite flow. Below this flow are almost 1,000 feet of sediments before the bulk of the lavas is reached. Minor flows in the upper Musgravetown group well above the bulk of the lavas are rare or lacking elsewhere in the western Avalon Peninsula. It is uncertain if the 1,000 feet of sediments in this section were deposited while volcanism was more intense in adjacent areas or if such areas were above sea-level, or, alternatively, if these sediments are equivalent to those of the lower Deer Harbour formation in adjacent areas, with minor and local volcanism. In mapping, the last alternative was disregarded. It is clear therefore that the boundary between the Bull Arm and Deer Harbour formations as mapped may locally cross both time and stratigraphic horizons, yet the restriction of lavas to the lower Musgravetown group is widespread and probably represents the most practical basis for group division for these rocks. South of Sunnyside map-area, the Deer Harbour sedimentary units are more persistent and the lower boundary is probably more constant in stratigraphic position and time than the boundary within this area.

In summary, although the contact is transitional and conformable at Great Mosquito Cove, in most places it is more abrupt and between massive Bull Arm volcanic rocks and Deer Harbour sediments. All Precambrian lithostratigraphic contacts may transgress time boundaries to some extent, but this contact is probably more erratic in a time sense than, for example, the upper contact of the Deer Harbour formation with the Random quartzite.

That this is a conformable or disconformable contact is shown by the distribution of the two formations as they appear on the map.

Thickness and Correlation

Thickness of the Deer Harbour formation varies in this area from about 2,200 feet near Great Mosquito Cove to about 9,500 feet in the northeast part of the area. Farther south, a thickness of 7,000 to 8,000 feet is maintained (McCartney, 1956, 1957).

The name as proposed applies to rock units 4 to 8 in this area where the formation is unusually well exposed, to rock units 4 to 6 (Lower, Middle, and Upper Divisions of the Musgravetown group) of Dildo map-area (McCartney, 1957), and to units 2, 3, 4c, 4d, and 4e in the west half of Argentia map-area (McCartney, 1956). It will apply to rocks marked by similar limits in southwest Avalon Peninsula (McCartney, work in progress). To the north, the name would seem to be applicable and useful in some cases where underlying volcanic rocks can be correlated with the Bull Arm formation. Although probably equivalent in age to some strata in the upper part of the Hodgewater group to the east and southeast, the name cannot be used where the underlying Bull Arm formation is not represented and where the lithology is different.

RANDOM FORMATION

The Random formation comprises white quartzite beds with interbedded arkose and siltstone that underlie fossiliferous shales and limestones of Lower Cambrian age. They overlie Precambrian rocks that are mainly arkosic or conglomeratic sediments and lack white quartzite. As mapped in Avalon Peninsula and by Hayes (1948) and Christie (1950), the beds thus defined agree with those of Walcott's (1900) original type locality (see also Hutchinson, 1953 and McCartney, 1956, 1957). Along Smith Sound to the north, Hayes (1948, p. 19), appears to have included the underlying Crown Hill conglomerate member in his Random formation at one locality. Rose (1948, pp. 42, 43, 44) combined the Crown Hill member, the Random formation, and the overlying fossiliferous shales and limestones near Come By Chance River in his Lower Cambrian Brigus formation. In this he followed the usage of Van Alstine (1948, p. 9) in earlier work on the Burin Peninsula. It is suggested that for the sake of uniformity these widespread rocks should be subdivided according to Walcott's type section and the lithostratigraphic definition used above[1].

[1] Walcott observed the conglomerate, here called the Crown Hill member, below his Random type section and concluded that this was equivalent to the older Signal Hill conglomerate and should underlie the Random formation on the east shore of Trinity Bay at Hearts Delight. In fact, the conglomerate member does not exist there (Hutchinson,1953; McCartney, 1956). Walcott's section of "Random formation" measured there is topped by 45 feet of true Random white quartzite, but he misleadingly included some 900 feet of non-conglomeratic beds of the upper Snows Pond formation with his measured section. This illustrates the need for defining the base of the Random formation as the base of the lowest white quartzite member which rests on various rock types.

Diagnostic of this formation are the one or more white quartzite beds. These are commonly crossbedded and may show both torrential and normal bottom-set types of crossbedding in some beds. In a very few outcrops a series of shallow, smooth, undulating channels were observed having a depth of about 4 inches and a width from crest to crest of about 2 feet. Interbedded with the quartzite and quartz pebble conglomerate members are siltstone, argillite, and arkose. The outcrop width of the Random formation is increased by isoclinal, incompletely exposed folds in the Deer Harbour syncline, but a thickness of about 600 feet is suggested. The formation south of Come By Chance River on the east shore of Placentia Bay is incomplete due to faulting, but the 60 feet of Random formation preserved included an upper 6-foot bed and a lower 12-foot bed of white quartzite, separated by 40 feet of grey slaty siltstone. The formation there is faulted against sheared, green conglomerate thought to be part of the underlying Crown Hill member and is in contact with younger overturned Lower Cambrian sediments, now dipping steeply to the east.

Beds between white quartzite members are most commonly like beds of the Deer Harbour formation but, in partial exposures west of Sunnyside, a grey silty shale contains grey limestone nodules and resembles nodular beds of the Lower Cambrian sediments. Similarly, near Gooseberry Cove, Placentia Bay, bright red shale lithologically like Lower Cambrian beds and not typical of the Deer Harbour formation was recently found below white quartzite. In central Avalon Peninsula, the beds intercalated with white quartzite are unlike Cambrian rocks.

No actual contacts were observed in the area, but the distribution shows complete absence of angular unconformity between the Crown Hill member, Random formation, and Cambrian beds. The upper contact with the basal fossiliferous Lower Cambrian sediments is well exposed in southeast Trinity Bay and elsewhere, and the Random formation is normally overlain by a thin, dark red, rounded-pebble conglomerate with a calcareous arkose matrix. This conglomerate generally rests on a slightly irregular surface of white quartzite or Random pea-sized conglomerate, but shoreline weathering attacks the matrix of the Cambrian conglomerate more readily than the quartzose matrix of the Random conglomerate, and the two types can generally be distinguished, even in isolated outcrops.

Age and Correlation

No fossils other than the annelid trails described by Walcott have been found, and there is a slight disconformity at the base of the overlying fossiliferous Lower Cambrian sediments. The writer currently favours a lowermost Cambrian age, but believes

the formation is more significant in a lithostratigraphic sense than in a time sense. The principal point in favour of a lowermost Cambrian age is the concept that the white quartzite beds represent shoreline deposits of a gradually transgressing Cambrian sea over an area of unconsolidated or poorly consolidated sediments of low relief. Hence the quartzites are thought to form a logical basal unit for the overlying widespread shale-limestone facies of the Lower Cambrian. No white quartzite and virtually no limestone are present in the clastic older rocks of southeast Newfoundland. The quartzite rests on various facies of the Deer Harbour and Snows Pond formations. The variety of underlying rocks was best shown by mapping in the upper Snows Pond formation on the southeast shore of Trinity Bay, where a slight angular unconformity is strongly suspected at the base of the Random formation (McCartney, 1956). These relations, in terms of sedimentary environment, tend to group the stable facies of the Random-Lower Cambrian together, as opposed to the variable clastic facies of the underlying rocks. On the other hand, Random quartzites are lacking to the east around Conception Bay (Rose; Hutchinson; McCartney, 1954) where fossiliferous Lower Cambrian beds rest with marked angular unconformity on the Precambrian Harbour Main and Conception groups. The fact that rocks equivalent to the Musgravetown-Hodgewater groups are there missing as well as the Random formation is not readily compatible with the previous reasoning. It is tentatively suggested that transgression of the Cambrian sea in the structurally unstable Conception Bay area may have been more rapid, and only the basal Cambrian conglomerate, up to 18 feet thick at Manuels Brook, was laid down by the advancing sea. Other factors that may have prevented quartzite deposition include the harder, deformed rocks that must have formed the Cambrian shore and probably a more irregular shore configuration.

Correlation in a lithostratigraphic sense is possible over southeast Newfoundland, Cape Breton, and New Brunswick, although the formation is very probably time-transgressive and may be Precambrian in age in some areas and Lower Cambrian in others. Although not always clear from the literature, typical Random formation was observed southwest of Sunnyside area on the French island of Miquelon (Weeks and McCartney, field observation) and in the southern Burin Peninsula. North of the area it is preserved at intervals at least as far as Keels and possibly to Deer Island, Bonavista Bay (Christie, 1950, p. 18). It extends south to the extreme southwest of Avalon Peninsula (Hutchinson, personal communication; McCartney, 1956, 1957) and east to the east shore of Trinity Bay. It is not found below Lower Cambrian beds farther east in Conception Bay. Weeks (1954, p. 146) proposed to correlate the Random formation with the white quartzite of the upper Morrison River formation of Cape Breton and although the ages may be slightly different, this is in full agreement with the use of the term as defined here. Similarly the Random formation may be correlated

with the Glen Falls formation (Hayes and Howell, 1937, p. 64) near Saint John, N. B. Because fossil evidence suggests that some at least of the Cambrian beds in Newfoundland represent older zones than those of the Cape Breton and Saint John localities, it is suggested that the underlying quartzites of the last-mentioned localities are probably younger.

LOWER AND MIDDLE CAMBRIAN SEDIMENTS

Lower and Middle Cambrian beds were not mapped separately as only one outcrop that might be Middle Cambrian was found. This is an outcrop of manganiferous slate recently exposed at the rear of the Cabot Hotel, Goobies, and probably belongs near the base of the Paradoxides bennetti zone of the lower Middle Cambrian. Outcrops are particularly rare in this western part of the map-area. Only Lower Cambrian beds are exposed along the shore where outcrops are fairly continuous, but Middle Cambrian beds may be present north of Sunnyside. The outcrops found there were mainly Lower Cambrian and did not include beds with Middle Cambrian fossils or lithologically like Middle Cambrian beds. All Lower Cambrian shore exposures are of characteristically bright red or green slates, commonly with pink or grey limestone nodules, or of pink algal or massive pink limestone. No siltstone or sandstone is known in the Lower Cambrian sediments of the region above the basal beds.

No lava flows or intrusive rocks were found in Cambrian beds in this area, to the north, or to the west; hence such rocks, mainly Middle Cambrian in age, are restricted to a narrow northerly trending belt in southwestern Avalon Peninsula (Hutchinson, 1953; McCartney, 1956, 1957, and in preparation).

The thickness of the Lower Cambrian sediments is thought to be more than 500 feet, but as, exposures of the overlying Middle Cambrian beds are inadequate, the true thickness cannot be determined in the area. A preliminary description and the thickness of the Lower Cambrian beds, and of the Paradoxides bennetti, P. hicksi, and P. davidus zones of the Middle Cambrian, east and southeast of this area have been published by Hutchinson (1953) and McCartney (1956). Furthermore, studies made immediately north of the area by Walcott, by Van Ingen, and by Hayes are reviewed and amplified by Christie (1950).

INTRUSIVE ROCKS

Northern Bight Granite

The granite in the northwest corner of Sunnyside area was named Northern Bight granite by Rose (1948, p.46). This granite extends west and north of the area. It is pink, equigranular, medium grained, with minor biotite, and may be related to the pink granite on islands in eastern Placentia Bay (McCartney, 1956). No exposed contacts are known in the area, but the granite is thought to intrude rocks of the Deer Harbour formation, and is probably post-Cambrian in age.

Powder Horn Diorite Complex

The rocks of this map-unit are not well exposed, but most are fine-grained gabbro and porphyritic gabbro intimately associated with medium-grained granodiorite, hornfels, minor rhyolite porphyry dykes, and some dark grey, well-bedded siltstone. The complex seems to comprise rocks equivalent to the rocks of the Bull Arm formation, particularly to its hypabyssal intrusions, and granodiorite and hybrid granite that intrude the older rocks and may be related to the Northern Bight granite.

Dyke Rocks

Rocks of the Connecting Point group are cut by numerous fine-grained andesitic dykes. These dykes are absent in the sediments younger than the Bull Arm formation and are probably related to Bull Arm volcanism. They are not shown on the map.

Younger dykes (11) are rare, but intrude sediments of the Deer Harbour formation on and near Bull Island. The rock is an unusual diabase with pink plagioclase. Rare dykes lithologically identical with the above intrude late Proterozoic beds in the Rocky River, 30 miles south-southeast of Bull Island, and are there thought to be Middle Cambrian in age (McCartney, 1956).

STRUCTURAL GEOLOGY

Open folds of regional significance are restricted to the east half of the map-area, whereas major faults control rock distribution in the west. Folds within the Connecting Point group could not be mapped owing to insufficient outcrops and lack of marker horizons.

FOLDS

All major folds have an essentially vertical axial plane and limbs of mainly moderate dips. The Deer Harbour syncline and the anticline near Centre Hill control the distribution of the Musgravetown group in the east part of the area but there are also broad, open, drag-folds southeast and east of the Deer Harbour syncline. Some increase in outcrop width of the Deer Harbour formation northwest of Bull Island is caused by these minor folds, but equally important is a rapid increase in the thickness of the formation itself.

Fold axes strike in a north-northeast direction and plunge gently north or south with reversals common as is characteristic of the Avalon Peninsula fold pattern. This is best illustrated by the canoe-shaped body of the Crown Hill conglomerate in the Deer Harbour syncline and by the fairly typical, rather erratic outcrop pattern of the red arkose member (5) caused by reversals of gentle plunge along open fold axes.

The Random formation and overlying Cambrian beds here and in several localities in western Avalon Peninsula have behaved as an incompetent structural unit. This has resulted in repeated isoclinal folds in white quartzite in the core of the Deer Harbour syncline. Isoclinal folds accompanied by slight overturning of beds are also present in a very similar syncline in Central Argentia map-area (McCartney, 1956) and also in Middle Cambrian beds at the head of Trinity Bay (McCartney, 1957). Crumpling of white quartzite into open folds was observed above uniformly dipping beds of the Deer Harbour formation on the west shore of St. Mary's Bay. This effect undoubtedly complicates contact relations at some localities and, together with faulting, may contribute to the overturning of Random and Lower Cambrian beds south of the mouth of Come By Chance River, immediately west of the map-area.

FAULTS

Faults in the area are thought to be steeply dipping, but satisfactory sequence of, and solution to fault movements have not yet been developed. Southeast-trending faults and joints appear to be tensional in origin as they are commonly occupied by Palaeozoic dykes in southwest Avalon Peninsula and many show negligible stratigraphic displacement.

The horst-block of Connecting Point rocks in the western part of the area is bounded by the Long Beach fault on the east and by the Come By Chance fault on the west. A third major fault, believed to lie in Bull Arm, forms the eastern boundary of the Cambrian rocks at Sunnyside. Largely horizontal movement is

probable on the fault at Bull Arm, but the presence of the Crown Hill conglomerate on both sides of the fault restricts the amount or displacement, probably to less than 10 miles. Supporting evidence of the limited but important amount of relative displacement is the unusual thinness of the Deer Harbour formation on both the south shore of Bull Arm and, to a lesser extent, on the west limb of the Deer Harbour syncline. This suggests that these sediments at both places shared a somewhat similar depositional site. In this and similar fault problems in southeast Newfoundland late Proterozoic facies changes should be considered and, in general, these changes are less abrupt along the present north-northeast trends than they are across this trend, reflecting the original trends of depositional sites and volcanic activity.

The fault extending north from Bull Arm is older than the Long Beach fault, but is post-Cambrian in age. Cambrian beds appear to be truncated by the fault and retain their shale-limestone facies up to it.

The Come By Chance and Long Beach faults may have essentially vertical movements, and the common appearance of Cambrian beds along these faults, both in this area and along their extension to the north (Christie, 1950), seems best explained as minor graben adjacent to the major horst of Connecting Point rocks. The absence of exposed Deer Harbour formation within or adjacent to some blocks of Cambrian sediments is probably due to fault movements, but the Deer Harbour formation could be very thin or lacking in some localities. The Come By Chance fault may prove to be of regional significance in marking facies changes or a metamorphic boundary. Rocks in the map-area west of the fault, other than Cambrian and Random beds, do not appear typical of those east of it, but are too poorly exposed to be subdivided into lithostratigraphic units that could be compared with the units east of the fault.

ECONOMIC GEOLOGY

There is little indication of the presence of economic mineral deposits in Sunnyside map-area. A thin, Lower Cambrian limestone bed, 2,000 feet southeast of the church at Sunnyside, contains a few specks of the copper-bearing mineral covellite. It seems plausible that such a limestone near or adjacent to the granite northwest of Goobies might be mineralized, but no float or outcrops of mineralized rock were found.

Lower Cambrian limestone is exposed at a few places on the south shore of Bull Arm southwest of Sunnyside, on the east shore of Placentia Bay south of Come By Chance River, and 2,000 feet north of the church at Sunnyside. This limestone might be

crushed and used locally for agriculture or road metal, although better quarry sites and probably thicker beds outcrop at Thornlea, Trinity Bay (McCartney, 1957), and Colliers Bay, Conception Bay (McCartney, 1954). Agricultural lime is needed in soils of the area, and is especially required in bog reclamation projects of current interest.

Gravel and sand of variable quality are available at Come By Chance tidal flats, Arnold Cove tidal flats, at stratified deposits above sea-level on Placentia Bay 6 miles southeast of Sunnyside, and at Long Beach. These deposits would require testing for quality and volume, but might provide material for local road construction. Unsorted glacial till is abundant along present road routes, and should facilitate new highway construction.

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