GEOLOGY OF THE FORTUNE BAY AREA, NEWFOUNDLAND

Daniel A. Bradley

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GEOLOGY OF THE FORTUNE BAY AREA, NEWFOUNDLAND

Purpose and Acknowledgements

The purpose of this report, a Master's Thesis, is to present a summation of the geologic knowledge of the Fortune Bay area, Newfoundland. This report includes the conclusions of the present author from field work (summer, 1947) in the Terrenceville area. Acknowledgement is made to Dr. E. W. Heinrich, Dr. K. K. Landes, and Dr. M. W. Senstius for their guidance and constructive criticism. The author is also indebted to Dr. A. K. Snelgrove of the Michigan College of Mining and Technology who visited the party in the field, Mr. C. K. Howse and E. Rose of the Newfoundland Geological Survey, and to K. Widmer, a doctoral candidate at Princeton University, for their active interest in discussing field problems.

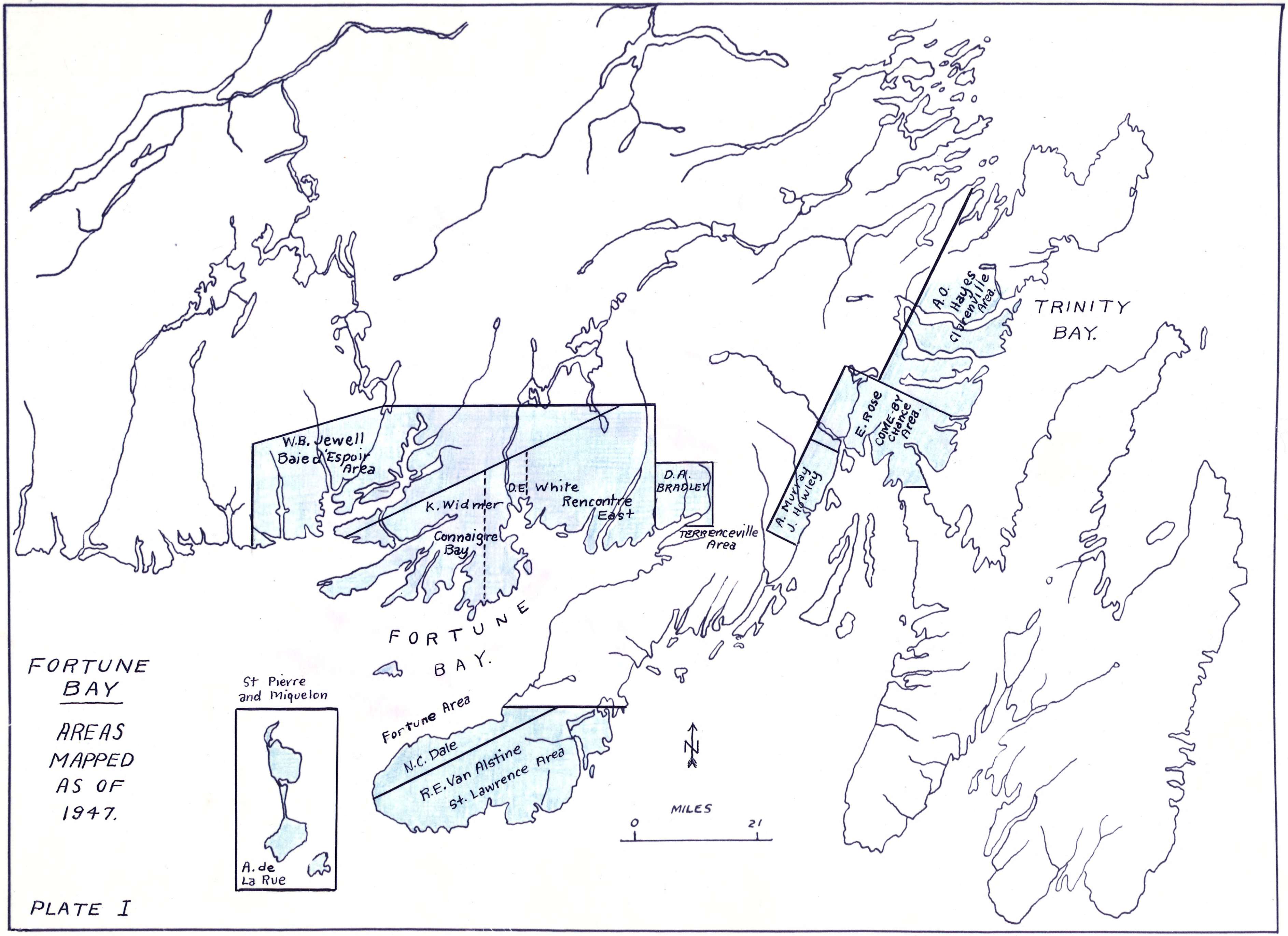
Location of the area

Fortune Bay is located on the central part of the south coast of Newfoundland. The area covered by this report includes a northeasterly belt from St. Pierre and Miquelon bordering north and south on Fortune Bay extending to the north shore of Trinity Bay. The length of the area is 190 miles and the width of the mapped area varies from 95 miles where the bay is 35 miles wide to 16 miles on the Trinity Bay shore. Fortune Bay is reached from Come-By-Chance (on Trinity Bay) by the Terrenceville Road; this road is being continued on the Burin peninsula and will open the inaccessable parts of the peninsula to exploration.

Previous Workers

The areas mapped in Fortune Bay as recently as 1947 are shown in Plate I. There are Summary Reports (Newfoundland Geological Survey) and sketch maps available for these areas.

This paper was written using as background the information contained in D. E. White's report on the Rencontre East area and K. Widmer's report on the Hermitage Bay area. In order to prevent repeated duplication of reference it has been the policy of the writer to give reference to these men by name only except in special instances when they quoted from papers unavailable in the University of Michigan library.



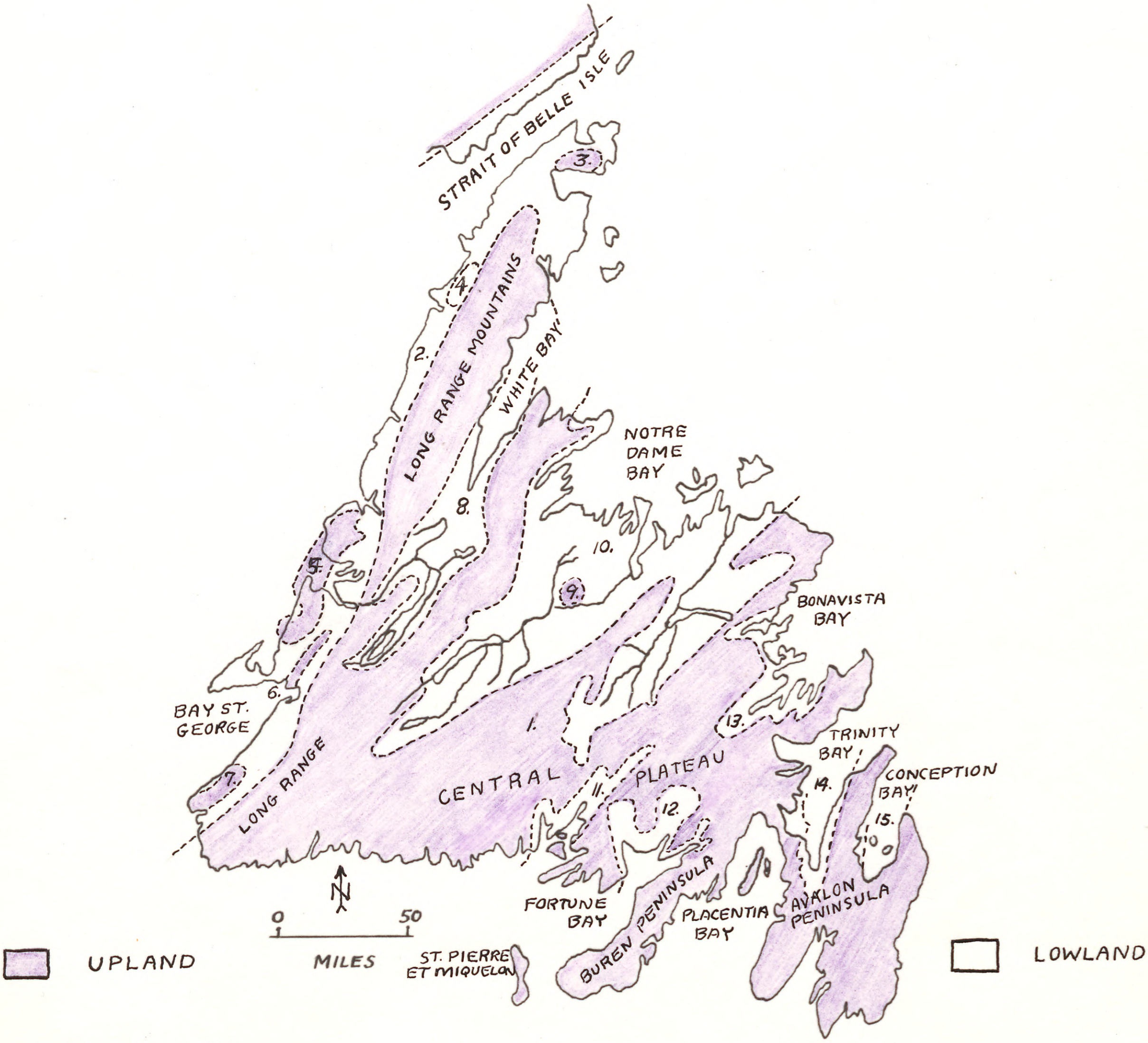
FORTUNE BAY

AREAS MAPPED AS OF 1947.

PLATE I

PHYSIOGRAPHIC DIVISIONS OF NEWFOUNDLAND.

INDICATED BY ARABIC NUMERALS (MODIFIED FROM DR. A.K. SNELGROVE.)



1. ATLANTIC UPLAND
2. WEST COAST LOWLAND
3. HARE BAY "SERPENTINE HILLS"
4. HIGHLANDS OF SAINT JOHN
5. BAY OF ISLANDS "SERPENTINE RANGE"
6. INDIAN HEAD RANGE
7. ANGUILLE MOUNTAINS
8. GRAND LAKE - WHITE BAY BASIN
9. HODGES HILL MONADNOCK
10. NOTRE DAME BASIN
11. BAIE D'ESPOIR BASIN
12. FORTUNE BAY BASIN
13. BONAVISTA BAY BASIN
14. TRINITY BAY BASIN
15. CONCEPTION BAY BASIN.

PHYSIOGRAPHY

General Statement

The physiographic divisions of Newfoundland and their nomenclature have been established by Dr. A. K. Snelgrove (Twenhofel, 1940, p. 1670) and are shown on the accompanying modified version of his index map. The Fortune Bay area is shown as a topographic low in the Atlantic Highlands province.

Topography

Structural control of topographic features is evident in every detail of Newfoundland; there is a marked linear parallelism of most of the land forms with the prevailing north-easterly strike of the fold axis, fault planes, and axes of intrusion. The excepted land forms are oriented normal to the regional strike. The structure defined the drainage systems. The drainage guided the glaciers. The fluvio-glacial valleys, upon emergence of 100-200 feet from a pre-Pleistocene submergence of 600 feet, have provided space for the island terrace fringe. However, notwithstanding the structural emphasis, peneplanation has given rise to three surfaces which are physiographic features of regional magnitude.

Peneplanation

The island of Newfoundland may be thought of as a part of the mainland separated only by a shallow epicontinental sea. Peneplain surfaces of the island are probably related to those of Labrador and Eastern Canada and to the more distant Appalachian surfaces.

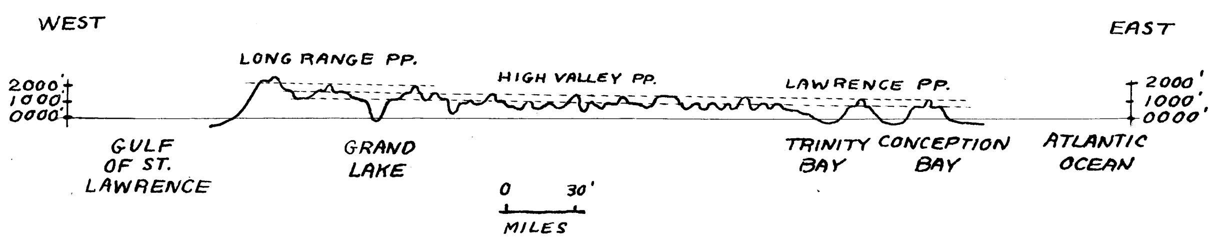
In terms of the areal concept of the Appalachian surface, the island of Newfoundland is unique because here is found an isolated remnant of an extensive erosion surface surrounded by the ultimate base level of erosion. The drainage divide farthest from the sea is the Annieopsquoch mountains 150 miles from tidewater by the Exploits River drainage flowing northeast, and only 20 miles to Bay St. George due west, or 20 miles to La Poile Bay due south. Downcutting pursuant to uplift has an exaggerated effect in the dissection of a peneplain where an increase in elevation must effect its change in a relatively short stream length.

The tilting of the Newfoundland peneplanes is such that a 1700 foot surface in the northwest has extension in the southeast on monadnock summits at 800 feet. Projecting this surface to the northwest across the Straits of Belle Isle, one finds that there is a continuation of the surface in northeastern Canada and Labrador with a continued rise to the northwest. All three Newfoundland surfaces, according to Twenhofel, (1940, p. 1724) slope to the east and were developed by fluvial erosion; they are definitely not plains of marine origin.

Twenhofel (1940, p. 1924) believes that the peneplanation took place after the Permian and before the Ice Age; the degree of preservation suggests that the action was Cretaceous. In the Fortune Bay area the extension of the High Valley surface is broad and remarkable in its slight relief over large areas. The upland surface averaging 1000 feet or the "High Barrens," as it has been

NEWFOUNDLAND PENEPLAINS: NOMENCLATURE
FROM W.H. TWENHOFEL AND P. MAC CLINTOCK
(B.G.S.A.; VOL 51, pp. 1665-1728, 1940.)

PROFILE FROM GULF OF ST LAWRENCE, SOUTH OF BONNE BAY, TO THE ATLANTIC OCEAN AT ST. JOHNS.



EROSION SURFACES OF NEWFOUNDLAND.			
SURFACE: / AREA:	LONG RANGE PENEPLAIN	HIGH VALLEY PENEPLAIN	LAWRENCE PENEPLAIN
WEST COAST	LONG RANGE MOUNTAINS 2000' - 2600'	HIGH LEVEL VALLEYS 1300' - 1700'	DISSECTED UPLAND 1000'-1100' WIDE MATURE VALLEYS 500'-1000'
CENTRAL BELT	MONADNOCKS 1900'	HIGH CENTRAL PLATEAU 1200'-1600'	BROAD MATURE VALLEYS 500'-1000'
SOUTH COAST	SURFACE COMPLETELY REMOVED	AVALON MONADNOCKS 700'-800'	AVALON PLATEAU 400'

called locally by the baymen, is most extensively developed on the Long Harbour volcanics which form resistant and level summits. The Garrison Hills granite and the Bay du Nord granite also are resistant to erosion and form level uplands. As elsewhere on the island the steep slopes that lead to the lowlands are fault scarps. The lowlands are developed on the less resistant rocks.

Drainage

General Statement

Rigid northeast structural control with minor and auxiliary northwest control characterizes Newfoundland drainage. Extensive continental glaciation with associated local effects has caused wide-spread disarrangement of drainage patterns, so all that remains of some of the pre-glacial rivers is a chain of ponds.

A typical stream of the Fortune Bay area consists of three parts; the upper reaches, purely dependent upon the effects of glaciation; the lower reaches dependent upon structure and glaciation; and the lowest reaches are fjords.

Upper Reaches

The upper environ of the ideal stream is primarily a peneplain surface which extends over most of the land bordering the bay and secondly it is a glaciated area with a consequent drainage. Each stream has its principal nick point where the stream crosses the sharp dividing line between peneplain surface and wall facing the bay.

Glacial movement was guided by the auxiliary or southeast structural trends. The scouring action formed upland depressions that were subsequently filled by meltwater to form innumerable small ponds. The task of integrating and connecting all these bodies of water to establish a system of drainage has progressed little; scattered, short, rock-walled streams connect the larger bodies of water. These short streams have been given impetus by the uplift, a springboard action caused by the loss of weight due to the melting of the ice. The larger streams fed by these many higher and smaller lakes, ponds, and streams have a substantial erosive power and under favorable structural conditions have cut through to the sea.

Nick points

Jewell (1939, p. 4) has made a generalization that holds well for all of the Fortune Bay area, namely that there is a much steeper gradient below 450 feet than there is above this height. The elevation of 450 feet in an axial stream profile would thus be a nick point as defined by Bryan (1946, lecture). These nick points have been accentuated and the stream profiles oversharpened by the glacially oversteepened U-shaped valleys.

Lower reaches

The lower reaches of streams have a far steeper gradient. The nick point is commonly marked by a waterfall of several tens of feet, and the remainder of the stream consists of rapids and cascades, with a leveling of the profile as the stream enters the sea.

Some of the larger streams flow in mature valleys established in pre-glacial times. Here we find a more rigorous adjustment to the structure with the course controlled by the strike of the beds over which the stream flows.

Long Harbour River

This river presents an individual case in that its upper reaches are developed solely in the Ackley City granite which is characteristically nonresistant to erosion. An extensive and complete dendritic drainage pattern has been developed into the batholith where the Long Harbour river becomes the dominant control and carries the water out. At some time in the geologic past, the Long Harbour volcanics must have presented a resistant barrier to drainage much as the volcanics form a structural dam at the southern end of Gisburn Lake at the present time. At a later time, due to accelerated erosion following uplift, the course of the present lower Long Harbour river and fjord was established.

Vegetation Affinities to Rock Types

General Statement

Previous workers, notably Jewell, White, and Widmer, have made generalizations regarding the distribution of vegetation. These remarks have been carefully noted and summarized with the idea that they may be of use in future reconaissance works.

There is a heavy growth of vegetation on the soil product overlying the Bay du Nord batholith, the meta-sedimentary rocks of the Baie d'Espoir series, and the volcanic rocks of the Long Harbour series.

Vegetation has negligible growth in the soil product of the Ackley City batholith, the Garrison Hills granite, and the shales and slates of the Baie d'Espoir series.

GLACIATION

Regional Glaciation

MacClintock and Twenhofel (1940, p. 1775) summarize the results of their study of the glaciation of Newfoundland; the points pertinent to the Fortune Bay area are as follows:

(1) No drift older than Wisconsin was found.

(2) Fresh erratics and roches mountonnees are in abundance on the critical uplands and summits indicating that the Wisconsin ice completely glaciated the island.

(3) Newfoundland supported a local ice cap which moved outward beyond the present shore line rounding and scraping the bedrocks and hills and gouging the valleys to fjords. A subsidiary ice cap occupied the Avalon peninsula during some phase of the deglaciation and produced the outward striae of that area.

(4) Slight deglaciation resulted in recession of the land ice in many places within the present shore line with the accompanying deposition of a suite of drift, consisting of till, plain gravel, and kame gravel.

(5) Immediately following this episode, sea level was high enough to deposit extensive deltaic marine deposits. These terraces are now found above present sea level rising progressively toward the north.

(6) Post Wisconsin frost splitting has blanketed the uplands with felsenmeer, while weathering under a vegetal cover on flanks and lowlands has produced the podsol soil, characteristic

of the region.

(7) Newfoundland may have been glaciated by Labrador ice during an early phase of glaciation which is suggested by the warped surface of the wave-cut benches (Flint, 1939, p. 1909) and by the striae at Port au Port.

Local Features of Glaciation

In the Fortune Bay area below the level of the Atlantic Highlands province, the glacial features follow the direction (approximately south) of the structural valleys normal to regional strike. On the upland peneplain surface the direction of movement is seen to be consistent with the hypothesis that the ice moved radially from the center of the island.

U-shaped valleys are very common, the striking examples are the valleys of the Baie d'Espoir, Bay du Nord, Long Harbour, and Grand le Pierre rivers. Along the base of the steep valley walls there are many talus slopes containing large blocks of slide material. The hanging valleys, waterfalls, short rock-walled streams, potholes, and innumerable ponds in rock scoured depressions are evidence of glaciation. Features of deposition are rare, which indicates that Newfoundland was a gathering ground for the ice and the englacial load which has been deposited chiefly beyond the limits of the island. The bay wall east of Grand le Pierre has planation parallel with and down to the waters edge, which is in keeping with the idea that an ice mass may scour to great depths in a fjord.

FIGURE 1. PERCHED GLACIAL ERRATIC ON BELLE BAY VOLCANICS. THREE MILES NORTH OF BAY DE L'EAU.

FIGURE 2. POTHOLE IN BELLE BAY VOLCANICS. FIVE MILES EAST OF GRAND LE PIERRE.

FIGURE 3. U-SHAPED VALLEY CUT IN BELLE BAY VOLCANICS. VIEW SOUTHWEST TO TERRENCEVILLE.

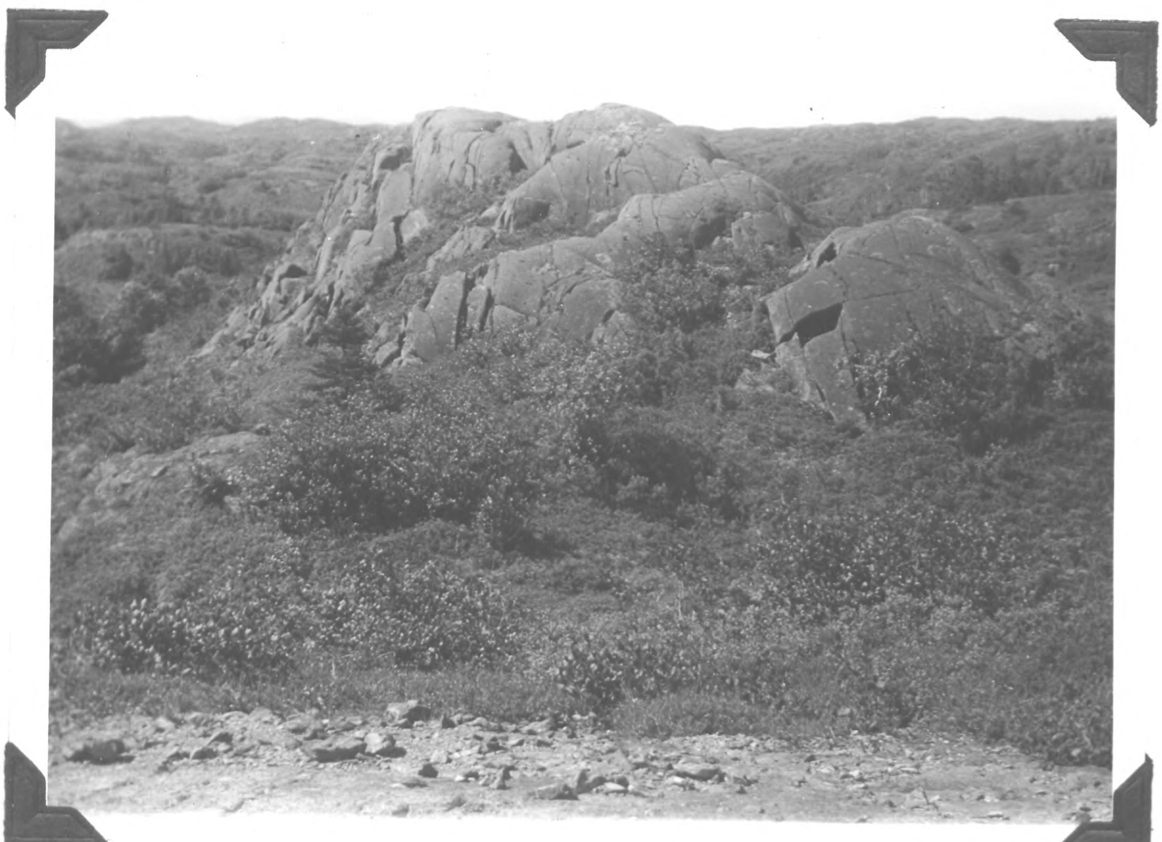


FIGURE 4. ROCHES MOUTONNÉES IN BELLE BAY VOLCANICS. THREE MILES NORTHWEST OF PAYS COVE.

FIGURE 5. BAY-HEAD BAR AT TERRENCEVILE.
FORTUNE BAY FAULT AND GLACIO-FLUVIAL TERRACE.

FIGURE 6. GLACIO-FLUVIAL TERRACE AT GRAND LE PIERRE.

Terraces

General Statement of the Terrace Problem

There are post-glacial terraces along the Atlantic coast from Hamilton Inlet, Labrador as far south as Nova Scotia. They are found on the shores which nearly surround the Gulf of St. Lawrence and they are recognized also to form a terrace fringe around the island of Newfoundland. The questions arising from field observations to date (1948) are these:

What is the origin of these fluvio-glacio terraces?

Where is the hinge line of post-glacial uplift?

What is the amount and direction of the regional tilting?

Terraces of the Fortune Bay area

The Fortune Bay area is an ideal location to work on the answers to these questions because: (1) there are at least 100 known terraces (2) terrace data may be obtained for a distance of 60 miles along the strike of the bay and across the bay for a distance of 40 miles and (3) the Fortune Bay area is on the continental side of the island so that direct comparisons may be made with the terraces on the Gulf of St. Lawrence.

Widmer (1948, personal communication) believes that there are four general levels of terraces on the northern shore of Fortune Bay: 12'-15', 25', 65', and 85' with a few at 100'-110' and that there is no evidence of tilt from the west to the east. In the Terrenceville area there are terraces at Terrenceville, Grand le Pierre, Spudgells Cove, Pays Cove, Bombards Cove, English Harbour

East, Little Bay de L'Eau, and Bay l'Argent on the south shore; no elevations were determined.

The terraces are plainly related to meltwater streams which deposited their load upon entrance into the sea. There are no cases of terraces being found on the shores of the lakes.

What lakes? Do terraces occur in coves?

The terraces were built during periods of stillstand in the uplift of the island according to the springboard action theory. The force of uplift would arise from the unloading of the ice. There is a positive correlation between area of a terrace and its own respective amount of uplift so that size is an indication of the progress of uplift. Terraces are consistently found at the heads of coves, harbours, and bays and rarely on an unprotected coastline. Wave-cut benches are common but they are small and inconspicuous; rarely have they been recognized at any great height comparable to that of the terraces.

Fjords

The Fortune Bay area is part of an extensive plateau developed by peneplanation which has been partially submerged as evidenced, according to N. C. Dale (1927, p. 415), by the indented configuration of the shore lines, the dismembered character of the streams and the distribution of the coastal islands. The principal erosive effect of the glacial ice, in a regional sense, has been to enlarge and gouge out those valleys parallel to glacial movement, deepening the lower ends so they become narrow bays or fjords with the melting of the ice and return of the sea.

Under one school of thought, opposed by Von Engeln

(1942, p. 468), fjords are believed to be due to a sinking of the land. In the Fortune Bay area there was a pre-glacial submergence of 600 feet, but since the close of the glacial period the land has emerged 100 feet. The more logical explanation is that fjords are developed by glacial processes. This theory is demonstrated by the use of the longitudinal fjord profile. A barrier sill is present at the mouth of each fjord; this is the place in the bay bottom where the glacial ice ceased its grooving action because of the increased and opposing force of buoyancy. The presence of the barrier sills is noted by a seaward decrease of depth on the soundings chart; for example, the Bottom of Fortune Bay is a typical Newfoundland fjord that has a maximum depth of 209 meters and a barrier sill at a depth of 126 meters.

Von Engeln also points out that in fjord regions, adjoining fjords differ greatly in depth, a circumstance incompatible with the land sinking theory of origin. This difference of depths is shown by the following compilation of the principal Fortune Bay fjords; the figures were taken from British Admiralty Chart #893, Burin Harbour to Devil Bay, Newfoundland:

Fjord	Maximum depth	Depth of Barrier Sill
Facheau Bay	206 m.	77 m.
Baie d'Espoir	390 m.	164 m.
Hermitage Bay	226 m.	150 m.
Harbour Breton	96 m.	50 m.
Great Bay de L'Eau	150 m.	120 m.

Fjord	Maximum depth	Depth of Barrier Sill
Mal Bay	135 m.	100 m.
Long Harbour	93 m.	34 m.
Fortune Bay	209 m.	126 m.

PLATE IV

STRATIGRAPHIC
CORRELATION CHART
OF FORTUNE BAY
NEWFOUNDLAND.

LA POILE – CINQ CERF AREA
COOPER, J.R. DORF, E.

TIME UNIT	LITHOLOGIC UNIT	THICKNESS	DESCRIPTION
PLEISTOCENE			
CARBONIFEROUS			
DEVONIAN	? LA POILE SERIES	13,000	Rhyolite and trachyte lava flows and tuffs with subordinate shale arkose and conglomerate.
	UNCLASSIFIED SCHIST AND GNEISS	?	Paraschist and para gneiss with conglomerate and some volcanic rocks. Includes many dikes along the south coast.
SILURIAN	BAY DUNORD SERIES (LOWER DEVONIAN)	10,000	Slate with argillaceous quartzite, graywacke, grit, conglomerate and a few thin limestone beds. Slate locally has fossil land plants: DREPANOPHYCUS SPINAEFORMIS, TAENIOCRADA DECHENIANA
ORDIVICIAN			
CAMBRIAN			
PRE-CAMBRIAN	KEEPING GNEISS (PRE-DEVONIAN)	?	Granite gneiss hornblende gneiss amphibolite, banded paragneiss.

BAIE D'ESPOIR AREA
JEWELL, W.B.

LITHOLOGIC UNIT	THICKNESS	DESCRIPTION
LAMPROPHYRE		
PEGMATITE AND APLITE DIKES		
GARRISON HILLS GRANITE (More reddish and more inclusions)		Medium-grained binary granite consisting essentially of potash feldspar, quartz, biotite, and muscovite.
NORTH BAY GRANITE		
BAIE D'ESPOIR SERIES	15,000'	METAMORPHOSED BAIE D'ESPOIR: Quartz, biotite, garnet, and staurolite schists with pegmatite and granite sills and knots. UPPER - Black, pyritic, graphitic slates, and phyllites; greenish micaceous, chloritic slates and phyllites with thin beds of sandstone and quartzite. LOWER - mostly quartzite argillite, graywacke, and amphibolite

HERMITAGE BAY AREA
WIDMER, K.

LITHOLOGIC UNIT	THICKNESS	DESCRIPTION
BAY de L'EAU CONGLOMERATE (UPPER DEVONIAN)	3000'	Red, yellow and in part greenish grey coarse conglomerates with fossil tree stumps and fragmental ferns of PROTOLEPIDODENDRON SP. and EOSPERMATOPTERIS SP.
RENCONTRE		Middle member coarse grained cross bedded light purple beds of arkosic greywacke interstratified with darker thin beds (occurs on the East border of the contact with the Long Harbour volcanics only)
CONNAIGRE BAY PHASE OF THE LONG HARBOUR VOLCANICS	5000'	Green andesitic to basic porphyritic lava flows with occasional thinner yellow rhyolite flows and intrusions; some tuffs, slates, and cross bedded sandstone and at least 2000' of coarse green volcanic conglomerates with included boulders up to 3' in diameter and a dense green glassy groundmass.
LONG HARBOUR VOLCANICS		Acid volcanics - brown to chocolate brown porphyritic rhyolites.
POOL'S COVE CONGLOMERATE	5000'	Red coarse terrential conglomerate (different lithology than the Bay de L'Eau Cg.
BAY D'EST	1000'	Red and yellow sandstones, grey limestones and mixed red sandstones, limestone sequence with several thick limestone beds; local phases at the base whose principal constituents are the underlying Cambrian formations.
YOUNG'S COVE (UPPER-MIDDLE CAMBRIAN "FRANCONIAN")	3000'	Black and green fossiliferous slates and slatey shales and other unfossiliferous sandstones and quartzites. Conglomeratic and cross bedded sediments varying from fine grained micaceous to red medium grained cream, and coarse grained cream and red cross bedded sandstones.
SAGONA ISLAND SANDSTONE MEMBER	1000'	Grey coarse grained rusty red weathering quartzitic sandstones capped by black shale with fragmental fossils. Uncertain lithologic relations.
DOTEN COVE SS		Same as D.E. White
BAY D'ESPOIR SERIES		Black shales and grey quartzites. Gneissic and schistose metasediments.

RENCONTRE EAST
WHITE, D.E.

LITHOLOGIC UNIT	THICKNESS	DESCRIPTION
SMITH HOLE CONGLOMERATE	200±	Base is a fine-grained light greenish or reddish gray arkosic wellcemented limey conglomerate. Gray and green-gray quartzitic sandstone above. Most of section consists of poorly indurated coarse to medium red conglomerate of local derivation with red micaceous sandstone from the Doten, limestone from the Bay du Nord and arkose from Pools Cove. Unconformable on Belle Bay volcanics and Doten Cove Fm.
RENCONTRE	3400	Dark gray impure quartzites. Coarse hard silica-cemented light purple arkosic greywacke. Basic greenstone flows interstratified with red and purple shales and grey wackes.
	± 100	Red clastics
	15±	Coarse basal conglomerate
LONG HARBOUR SERIES: MOORING COVE VOLCANICS	1,500	Massive tan rhyolite felsite flows. Complete absence of basic and intermediate flows, agglomerates and clastic seds.
LONG HARBOUR SERIES: ANDERSON COVE SLATES	1,500	Fine-grained olive-green tuffaceous slates. Weathers cream colored. Shows varving and diagenetic disturbance.
LONG HARBOUR SERIES: BELLE BAY VOLCANICS	13,000	Acid felsite flows, less prominent volcanic agglomerate; tuffs and basic greenstone flows. Local clastics unimportant.
YOUNG'S COVE GROUP (UPPER-MIDDLE CAMB.)	2,000	Thinly bedded green gray slates and gray fine grained green-gray micaceous quartzite. Two faunal zones in Middle-Upper C.
DOTEN COVE SS.	2,000	Flaggy, well stratified red arkosic, micaceous sandstone with thin beds of deep red micaceous fine-grained sandstone or silts.
BAY DU NORD GROUP: SPYGLASS COVE QUARTZITE	350±	Light greenish-gray and light gray quartzite with some fine grained quartz conglomerate.
BAY DU NORD GROUP: TILT POINT LIMESTONE	300	Pure gray limestone with quartz grains and pebbles.
BAY DU NORD GROUP: POOL'S COVE CONGLOMERATE	5000	Pink to reddish gray homogeneous conglomerate with granite boulders in an arkosic matrix.
BAY DU NORD GROUP: BAY D'EST LIMESTONE	650±	Nodular limestone, limestone as a matrix to conglomerate and sandstone, and pure limestone.
BAY DU NORD GROUP: SPOON COVE ARKOSE	500 +	Well indurated red and purple arkosic sandstones.
GNEISSIC GRANITES (Proterozoic)		Also granodiorite. These intrude older gneisses.
GNEISSES (Archean)		Coarse grained augengneiss

PETROLOGY

Sedimentary Rocks

Pre-Cambrian Sequence

General statement

The pre-Cambrian rocks have been considered in entirety because they are terminated as a unit by the Bay du Nord fault. The oldest rocks, Archean gneisses, and the Baie d'Espoir series are considered here and Proterozoic gneissic granite is discussed in the section on igneous rocks under their more rigorous name "Garrison Hills granite."

Archean gneiss

This term has been used by White to designate a body of gneiss that trends east-west north of the Bay du Nord fault that probably represents greatly metamorphosed, stratigraphically lower horizons of Jewell's Baie d'Espoir series. This formation consists of coarse-grained and medium-grained gneisses, some of which are paragneisses, with coarse-grained augen gneisses predominating. Most abundant of the augen gneiss is a biotite, surrounded by finer grained aggregates of strained quartz and biotite showing marked parallel orientation. These rocks may be orthogneisses but the large porphyroblasts of microcline are suggestive, according to White, of a migmatite origin. The paragneisses are fine-grained and probably originated from impure quartzites. The Garrison Hills granite intrudes the gneisses.

The metasediments characteristically form topographic depressions.

Baie d'Espoir series

The Baie d'Espoir series was named by W. B. Jewell (1939, p. 6) and includes all sedimentary rocks of the Baie d'Espoir area. This formation is separated from Paleozoic rocks to the south, along a northeasterly strike by the Bay du Nord fault. This series according to Jewell (1936, p. 6) originated as sediments of mechanical origin which were lithified and metamorphosed to differing degrees during Proterozoic and later orogenies.

The great bulk of the series, according to Jewell (1939, p. 6), consists of black, pyritic, graphitic slates, and phyllites, and grey micaceous, chloritic slates and phyllites, and with smaller amounts of sandstone, quartzite, argillite, greywackes, and amphibolite. The major part of the quartzite, argillite, greywacke, and amphibolite are characteristic of occurs in the lower part of the Baie d'Espoir series, which is exposed in the lower reaches of the Baie d'Espoir river. The upper part of the series, is mainly slate and phyllite with thin beds of sandstone and quartzite, exposed in the upper reaches of the river. All beds are conformable.

Jewell (1939, p. 6) states that it is not at all unlikely that the total thickness of the series is 15,000 feet or more. The prevailing dip is to the northwest, with the oldest beds lying to the southeast. Northeast of the Garrison Hills, the Baie d'Espoir series is in intrusive contact with the Late Proterozoic Garrison Hills granite.

A marine origin is postulated for the Baie d'Espoir series on the basis of such a characteristically marine assemblage of fine-grained rocks, their great thickness of possibly 15,000 feet and because they consist in large part of pyritic slate (formerly black mud). The question of age is moot as the beds are entirely nonfossiliferous and there are no limestone beds. Nevertheless, it is surprising that such a promising assemblage of rocks has yielded no fossils. In absence of contrary stratigraphical or paleontological evidence and on the basis of the degree of metamorphism the investigators succeeding Jewell, who have had more of the geologic picture at their disposal, have assigned the rocks to the pre-Cambrian. An Archeozoic (?) assignment has been given because these sedimentary rocks and metasediments have been intruded by a granite, now seen as a gneiss, which is suggested to be of a Proterozoic age.

Jewell, (1939, p. 7) however, as the first worker on the north shore of the Fortune Bay, designated these rocks as Silurian (?) or possibly pre-Cambrian following the primary reconaissance of Murray and Howley (1887). Snelgrove (Jewell, 1937, p. 7) too has suggested a Silurian age, in that these rocks resemble fossiliferous Silurian rocks in the Gander area on the north coast. W. H. Twenhofel, (1947, p. 65) with this theme in mind, started from the fossiliferous beds in the northeastern part of the island and traversed across Newfoundland along the regional strike of the beds. His stratigraphic column (1947, p. 90) includes the Baie d'Espoir series as Silurian, but it seems questionable that one may extend correlations for 150 miles, traversing essentially parallel to strike without fossils, and including a 50 mile expanse, where stratigraphic evidence is lacking, across a batholith.

The Baie d'Espoir sediments in no way resemble the late pre-Cambrian rocks of the Fortune area described by N. C. Dale (1927, p. 424) as pointed out by Jewell (1937, p. 7). However, from Jewell's descriptions it seems that the slates and phyllites are similar to those observed in reconaissance by Widmer (1948, personal communication) and the author, along the Terrenceville Road. These metamorphics are believed to continue in an uninterrupted southeasterly trending belt from the Clarenville area to the tip of the Burin peninsula.

Relationship to Paleozoic Rocks

The Archean gneisses, the Baie d'Espoir series, and the Proterozoic gneissic granite are in fault contact with Paleozoic rocks to the southeast. The Paleozoic rocks show negligible metamorphism when compared to the coarse-grained orthogneisses of Archean age and to the recrystallized younger Proterozoic gneissic granites. White sums up the evidence for the age distinction as follows: the gneissic granites are characterized by: (1) a varying degree of metamorphism, with stained quartz characteristic even of the unfoliated central portion of the mass; (2) the presence of biotite and muscovite; (3) oligoclase as the plagioclase; and (4) a finer-grained texture. The granite and the alaskite phases of the Paleozoic intrusive rocks are characterized by: (1) an almost complete absense of metamorphic texture; (2) miarolitic (shallow-depth intrusion) phase; (3) low calcium, magnesium and iron content; (4) absense of muscovite and rarity of biotite as primary minerals; and (5) albite as the plagioclase of the granitic and later phases. Field evidence in Widmer's area shows the pre-Cambrian Garrison Hills granite cut by the Devonian intrusives. Also it is seen that structurally weak early Paleozoic sedimentary rocks are less disturbed and less metamorphosed than the pre-Cambrian sedimentary rocks indicating that the assignment of the orogeny causing the metamorphism, faulting, and folding is best made to post Early Paleozoic time.

Cambrian System

General Statement

The Cambrian system is represented in the Fortune Bay area by the Lower Cambrian Doten Cove formation and the overlying Youngs Cove group of Middle or Upper Cambrian age.

Doten Cove sandstone

The Doten Cove formation name was proposed by White for a thinly-bedded, flaggy, red micaceous sandstone typically exposed in Doten Cove on the northwest shore of Corbin Bay. The greatest thickness is on the east limb of the Youngs Cove syncline, northeast of Youngs Cove and the total thickness, according to White is probably of the order of 2000 feet.

The sequence consists of well stratified red arkosic micaceous sandstone commonly in beds of one foot or less in thickness separated by thinner beds of a deeper red, micaceous, fine-grained sandstone and siltstone. Mica is always oriented parallel to the stratification, giving rise to the flaggy appearance. Locally cross-bedding may be found in the coarser-grained sandstones.

The Doten Cove formation is believed to be of terrestrial origin because of the characteristic red color, the abundance of clastic mica, and the presence of relatively fresh angular grains of feldspar.

The lower limit of the Doten Cove formation is unknown but it is conformably overlain by fossiliferous lower Upper Cambrian. Thus the Doten Cove formation may be assumed to be of Lower Cambrian age even though the formation, in itself, has yielded no fossils. White has pointed out that de La Rue's work (White 1939, p. 33) on the island of Little Miquelon has shown similar formation described and dated as pre-Cambrian underlying a fossiliferous Cambrian slaty shale equivalent to the Youngs Cove Group.

Youngs Cove Group

This group was named by White, but it is here presented as redefined by Widmer. The Youngs Cove group exposures lie in a diagonally faulted southwesterly trending belt extending from northeast of Youngs Cove across Bay du Nord to the shore southwest of Cinq Isles Bay and Corbin Head. They are terminated there by the unconformably overlying Belle Bay volcanics formation.

This group is the most incompetent structural unit in the Fortune Bay area and several intense orogenies have resulted in regionally metamorphosed thicknesses of slates and quartzites. The actual thickness is unknown, due to the complication by very highly faulted zones and metamorphism, but the thickness is conservatively estimated to be 2000 feet.

The group is described as homogeneous, consisting of interbedded dark quartzites and slates in which the individual beds have a thickness of usually less than a foot with interbedded thicker massive beds of quartzite. The quartzite is generally fine-grained grey, greenish grey or dark purple grey with clastic mica oriented parallel to the stratification particularly near the top of the section. The interbedded slates are black, dark grey and dark greenish-grey.

The slates contain no fossils but well preserved fossils were collected from the unstratified highly jointed grey siltstones that occur near the base of the group. Howell (White 1939, p. 35) reports that the fossils are characteristic of two faunal zones, one of early Middle Cambrian and the other zone of Late Cambrian age. The presence of brachiopods and trilobites in such a thickness of homogeneous slates and quartzites is definite proof of a marine origin for the Youngs Cove group.

The Youngs Cove group conformably overlies the Doten Cove formation. The upper limit is nowhere exposed because of the unconformably overlying Long Harbor volcanic series. The angle of unconformity as seen west of Belle Bay is as much as 45°.

Correlations on the basis of paleontological evidence have been made with known stratigraphic sections of Newfoundland, Nova Scotia, and New Brunswick. However, this report will here be concerned only with those of the Fortune Bay area, namely on the Island of Little Miquelon from work done by de La Rue (White, 1939, p. 33) and at West Pinion Cove, on the north shore of the mouth of Fortune Bay, where N. C. Dale (1927, p. 426) previously found fossils of this age.

Description of the unconformity

The Cambrian and pre-Cambrian rocks were folded along a northeast axis, faulted and eroded before the extrusion of the Long Harbour volcanic series, which is unfossiliferous and of terrestrial origin. The Belle Bay volcanics may be observed unconformably overlying the Youngs Cove group on the south shore of Corbin Bay, east of Youngs Cove, as well as east of Belle Bay. Additional evidence of an age younger than the Cambrian for the volcanics is supplied by felsites intrusive into the Doten Cove formation west of Corbin Bay and east of Youngs Cove.

Ordovician System

General Statement

The Ordovician is here divisible into two distinct states; an earlier one of sedimentation and a later stage of volcanology. The Bay d'Est limestone and the Pools Cove conglomerate were deposited in the earlier epoch. Marine deposition was interrupted by regional movement which produced a block fault structure. An upfaulted granite mass was exposed to accelerated erosion resulting in accumulation of a thick deposit in a downthrown terrestrial basin. The Middle and Upper Ordovician are represented by the Long Harbour series consisting mainly of volcanic rocks, at least 16,000 feet in thickness, divisible into three conformable formations. The Belle Bay volcanics, of terrestrial origin, are succeeded by the Anderson Cove slates, a fine-grained tuffaceous material possibly of marine origin which, in turn, are overlain locally by the Mooring Cove volcanics. Van Alstyne in the St. Lawrence area (Widmer, 1948, personal communication) has an Ordovician system that matches this Long Harbour series in thickness, lithology, and stratigraphic position [in the column.] Briefly the nomenclature of the system is: Burin volcanic series, Little Lawn slates, and Mount Margaret volcanics. The Long Harbour series with the exception of the Andersons Cove slates is discussed under Igneous Petrology.

not so on the legend of the map; pl. VII

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?

Bay d'Est limestone

The name Bay d'Est limestone was originally used by White [as a formation name] for one unit of his Bay du Nord series. Cooper (Widmer, 1947, personal communication) on the west coast /has pre-emptive right to The name ? [the] Bay du Nord and White's usage has been abandoned following a redefinition by Widmer of several of White's formations. Widmer reinvestigated White's field sections of Bay d'Est and came to the conclusion that there was a definite repetition by faulting. This later was substantiated by the writer on a reconaissance trip across the disputed section. Following Widmer's usage (1946, p. 21) all concerned agree to the redefinition of White's Bay du Nord series, namely that the Bay d'Est formation includes the peculiar lithology of White's Bay d'Est, Spoon Cove, Tilt Point and Spyglass Cove formations.

/of what?

The Bay d'Est type section crops out at Bay d'Est and also on the eastern shore of Great Bay de L'Eau and on the eastern

? East Bay on map?

shore of Little Bay West.

The lithology as described by Widmer consists of a basal thickness of some hundred feet of grey conglomeratic sandstone conformably capping Cambrian, overlain by a typically mixed sandstone - limestone sequence, and this by thick grey limestone beds. In the mixed sandstone - limestone sequence there occurs a grey limestone with white quartz pebbles that exhibit cross-bedding similar to that of White's Tilt Point lithology. By adding the largest thickness of each particular phase of the sequence, Widmer arrived at a figure of 1000 feet for the thickness.

The Bay d'Est formation, unfossiliferous in itself, overlies unconformably the fossiliferous Cambrian with a basal conglomerate that contains Cambrian pebbles, so it is considered to be Ordovician. In White's area the Bay d'Est formation is conformably overlain by the Pools Cove conglomerate. In two localities in Widmer's area the Bay d'Est is capped unconformably by the Devonian Great Bay de L'Eau conglomerate.

The diversity of lithology included within this formation argues for a terrestrial origin. Most predominent are limestone, nodular limestone, red and purple arkose, and quartzite. The criteria used are the red color, the fresh nature of the feldspars and the presence of clastic mica in association with carbonate. Such coarse clastics are a feature of the present day fresh-water marls of the playa lakes.

Pools Cove Conglomerate

This formation was named by White for a wide southwesterly map shows East of Bay du Nord

striking belt of conglomerate west of Bay du Nerd and Cinq Isles Bay. The beds are exposed on the southern tips of the heads into Bay d'Est and continue along strike into Widmer's area north of Old Bay.

Where on map?

The Pools Cove formation, as White suggests, is possibly the most unique formation within the Fortune Bay area. A postulated thickness of 5000 feet is conservative and, even at this figure, exceeds the relative thickness geologists ascribe to most types of conglomerate. There is a marked lithologic homogeneity throughout and the variation is limited simply to coarse-grained sandstone and fine conglomerates. There is, too, a homogeneity of composition, for the formation consists of 90% granite boulders, pebbles, and coarse arkose derived from similar granite masses. White reports good stratification withoug cross-bedding, local channeling, and that the attitude of bedding is usually consistent in any one section. Lastly, singularity is shown by the relatively unindurated condition of most of the formation.

The rounded boulders of the conglomerate may have originated from a porphyritic granite mass. The matrix of the conglomerate is arkosic with angular quartz and angular pink feldspar grains as much as 1/4 inch in diameter. White found the feldspars were mainly cloudy orthoclase and perthite. Boulders with diameters as large as four feet have been observed. These granite boulders may be of significance when we know more of the regional distribution of igneous bodies. At this point it might be well to suggest that these porphyritic granite boulders be compared with specimens of the Gaultois porphyry of Widmer's area which is described as a coarsely porphyritic phase of the Garrison Hills granite exhibiting large orthoclase phenocrysts. Also reconaissance work has shown that there is another coarsely porphyritic intrusive body cropping out north of the Terrenceville Road about 15 miles from Terrenceville.

The great thickness, homogeneity in the formation itself, homogeneity of derived materials, and good stratification with local channeling and the relatively unindurated condition of the arkosic conglomerate imply a terrestrial origin. A block fault structure that exposed an elevated granite mass to rapid erosion forming a thick sequence in a terrestrial downthrown basin is suggested.

The age of this formation is uncertain for there are no localities known where the upper thicknesses are exposed. The Pools Cove conglomerate conformably overlies the Bay d'Est formation which is also post-Cambrian. It is pre-Devonian because it is intruded by the Ackley City granite from both Old Womans Cove and the Taylor Bay stocks. The most natural age designation is therefore Ordovician.

Anderson Cove slates

The Anderson Cove slates were named by White for the excellent exposures in Anderson Cove, just inside Long Harbour on the western shore. The slates extend northeast from here in a narrow belt for 10 miles where they are truncated, along with the Belle Bay volcanics, by the Ackley City batholith. The structurally symmetrical and southeast limb of the Long Harbour syncline may well be represented by sedimentary rocks striking north from Spudgells Cove.

The formation, as described by White, consists of an estimated thickness of over 1500 feet of fine-grained, olive-green, tuffaceous slates with a characteristic light, greenish-grey or cream colored, weathering surface. Slaty cleavage is characteristic of the formation. The formation is remarkably homogeneous throughout with the exception of the basal 100 feet which is characterized by a thin conglomerate or coarse greywacke and by several beds of purple slates.

North of Andersons Cove near the axis of the syncline one may view relatively undisturbed flat-lying beds. The rocks consist of finely-laminated banded layers appearing to represent varves. These layers vary in thickness from 1/16 to 1/2 inch with minor coarser, dark-green grains concentrated and stratified within the layers. These layers are separated by thin bands of very fine-grained light greenish materials. Diagenetic folds, evidence of slumpage of the material before lithification, may be seen both in outcrop and in the hand specimen.

The upper and lower contacts of the slates are esentially conformable. Below are the Belle Bay volcanics and above lie the Mooring Cove volcanics which are very similar and form a part of the same general period of vulcanism. The color, sorting, and thickness of the Anderson Cove slates are suggestive of a marine origin but the varved appearance with local diagenetic disturbance is suggestive of a lacustrine origin. However, in a subsiding volcanic trough, it is conceivable that there may have been a period of submergence followed by emergence and extrusion of more volcanic material. This formation is matched in Van Alstyne's area by his Little Lawn slate.

Silurian System

Rencontre formation

The Rencontre formation dips under the sea in all exposures thus far mapped. This formation was named by White from the type section on Rencontre Island and on all promontories on the north side of Fortune Bay. The sedimentary sequence in the downfaulted block of the actual Bottom of Fortune Bay may be also of the Rencontre type.

The Rencontre formation is 3500 feet in thickness and is divided into two members by White; the lower member consists of basic greenstone flows interstratified with red and purple shales or greywackes, and the upper consists predominantly of coarse, hard silica-cemented, light-purple quartzites which are present locally at the base and abundantly at the top of the known section. Volcanics are absent from the upper part of the formation.

The lower member shows considerable lateral variation; west of Lally Cove and northwest of Isle au Glu a coarse basal conglomerate of 20 feet in thickness is overlain by 100 feet of red clastics which in turn underlie the green volcanics. In contrast on the west shore of Mal Bay the section begins with 9 to 10 feet of basal conglomerate followed by 700 feet of massive greenstone flows. The number of flows also varies laterally; five flows series are interstratified with red and purple clastics along the west shore of Stone Cove, four series in Little Bay, west of Rencontre, and probably only two series near Lally Cove, and east of Corbin.

The basic lavas of the Rencontre formation, in contrast with those of the basic lavas of the Long Harbour series, generally show pillow structure. Notable features of the clastics, also of local occurence, include mudcracks and current ripple marks. The coarse greywackes are of such induration that they break across rather than around the individual grains. In the upper part of the formation, coarse light purple-grey greywackes, in beds averaging more than 6 feet thick, are interstratified with 1- to 2 - foot thick beds of finer red-purple greywackes; cross-bedding is commonly seen mainly in individual strata. White's thin sections show the material to be volcanic fragments, with angular quartz and fresh feldspar relatively common. The uppermost known section of the Rencontre is found on Belle Island and consists of a sequence of dark-grey, well-bedded, impure quartzite, interbedded with coarser-grained greywackes.

White suggests that the Rencontre formation may have resulted from fluviatile deposition, possibly on the piedmont slopes of a subsiding trough or basin. Local mudcracks and current ripple marks, the color of the arkosic nature of the clastics, abundant cross-bedding and the very local occurrence of pillow structure in the basic lavas (extrusion into small bodies of water) apparently favor such an origin. Another possibility of origin is that of a marine delta with the Rencontre strata as topset beds of a subsiding delta. The upper part of the series on Belle Island may be of marine origin. The attitude of current ripple marks indicate that the material probably came from the southeast.

The Rencontre has an unconformable lower contact on the

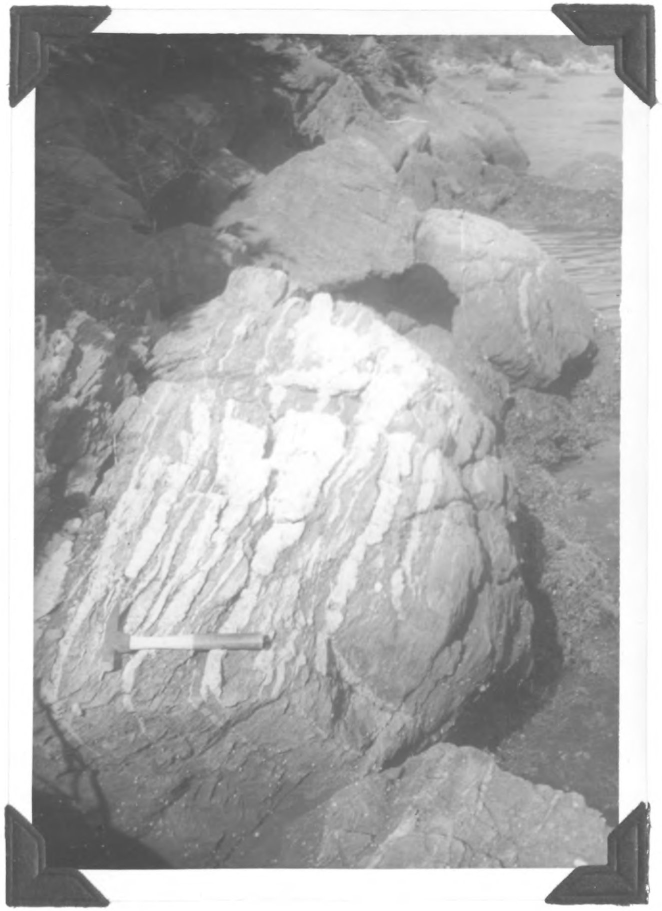


FIGURE 7. QUARTZ VEINS IN THE RENCONTRE FORMATION ON THE NORTH SIDE OF THE HEAD OF FORTUNE BAY.

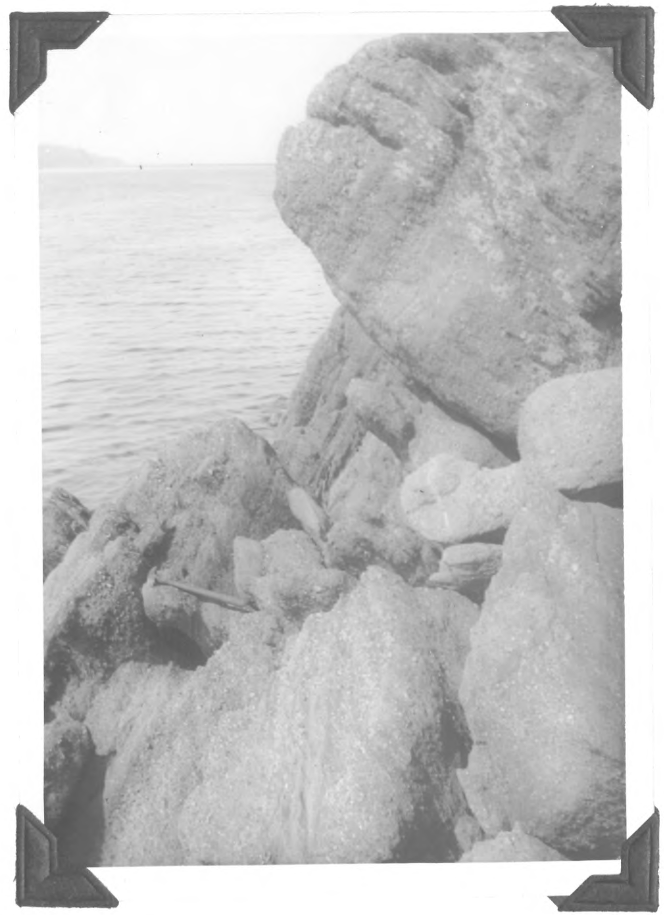


FIGURE 8. BEDDING AND FLOW CLEAVAGE IN THE RENCONTRE FORMATION.

Long Harbour series with an unknown upper limit since it is under the waters of the bay. This formation, unlike most of the others, has no equivalents in other parts of the region but there may be representation of it in the graben structure of the actual Bottom of the bay.

Description of the unconformity

The Rencontre formation and all the older formations were folded essentially along a northeast axis into their present positions forming the Fortune Bay synclinorium during the third and most intense Paleozoic orogeny.

This formation is very resistant and its compact aereal fold pattern reflects the intensity of the regional forces of deformation. There are five such local synclinal folds that have been so weathered that one could safely define the limits of the Silurian from the center of the Bay. The overlying unconformable Devonian Great Bay de L'Eau is relatively flay-lying and is believed to have been deposited after the older formations were folded and faulted and uplifted.

Devonian System

Great Bay de L'Eau conglomerate

This formation was named by Thomas A. Taylor, a Princeton student working on a Senior Thesis, who described the variation in a section near Great Bay de L'Eau which has come to be included in Widmer's area. White has variously called the formation Smith Hole conglomerate and Corbin Head conglomerate so that there are three names to date representing a formation that is exposed mainly in

Widmer's area on all the promontories adjacent to and making up Great Bay de L'Eau.

Widmer has most recently reconsidered part of the field work he did as White's assistant in 1938 and has designated a structural basin of sedimentary rocks just north of Femme Harbour, as being equivalent to the Great Bay de L'Eau conglomerate. The author has in reconaissance found that the Great Bay de L'Eau conglomerate has given rise to a topographic basin at the head of the bay on the Terrenceville side.

The Great Bay de L'Eau conglomerate has yielded plant fossils in Widmer's area at Coomb's Cove and in the Terrenceville area one mile west of twon. Thus from identifications by Dorf, (1948 personal communication) a Devonian age is affixed with certainty providing future workers with a dated formation that has aereal coverage and characteristic topographic expression as a basin where-ever exposed.

Taylor (Widmer, 1939, p. 29) divides the formation into three separate phases: the upper section is red; the middle greenish-yellow; and the basal section red with coarsest phase at the base. In very broad and general terms, the texture seems to change from coarse to fine where the color changes from red to greenish yellow. There are, of course, variations in each section. Silt layers which occur rather frequently throughout the formation are always red.

The lithology of the Great Bay de L'Eau is interesting because most of the components are locally derived. There are tabular blocks of the flaggy red Doten Cove sandstone, limestone from the Bay d'Est, and arkose derived in part from the Pools Cove formation. There are few boulders of intrusive or extrusive igneous rocks.

Texture seems to play a very definite part in the weathering of the conglomerate. In the coarse-grained sections, angular weathered surfaces generally prevail. In the finer-grained phases, more closely compacted, the weathered surface is invariably conchoidal, and the surfaces seem to be produced by a process similar to exfoliation.

The Great Bay de L'Eau conglomerate is highly arkosic, predominantly dark red in color and has a thickness of over 3000 feet. Marine conglomerates are seldom over 600 feet in thickness. This figure represents the greatest depth to which the effect of wave action is felt and, as suggested by Barrell, this same wave action controls the continental shelf and its deposits. The arkosic nature, the red color, and the great thickness are best explained by postulating a terrestrial environment similar to the intermontane deposits formed in the present day. The plant fossils substantiate this idea.

The Great Bay dè L'Eau conglomerate has not been found in contact with the Silurian formation, but on structural and physiographic evidence it seems best to assign the conglomerate to a younger period. The Rencontre is a very resistant formation and has been folded to form local synclines evidenced from the excellent topographical expressibn. On the other hand, the Great Bay dè L'Eau is not particularly resistant and it is flat-lying, or relatively so. Therefore if a more resistant formation is strongly folded it must be older than a nearby less resistant flat-lying series of beds. The Great Bay de L'Eau near Terrenceville characteristically is very non-resistant to erosion and has been partially removed to form a depression in an otherwise high barren country with steep cliffs bordering on the sea. This simple structure apparently has not participated in the previous orogeny (post Rencontre or post-Silurian) which formed the Fortune Bay synclinorium.

This formation overlies unconformably the Cambrian Doten Cove formation and the Ordovician Belle Bay volcanics and is itself cut by the Belleorum granite, considered Carboniferous because it intrudes not only the Devonian Great Bay de L'Eau conglomerate but the Ackley City granite as well.

Unconformity in Southwestern Newfoundland

In Cooper's La Poile-Cinq Cerf area southeast of the Bay St. George Carboniferous deposits, Cooper (1943, p. 264) has demonstrated: (1) his Bay du Nord series is lower Devonian in age, from plant fossil identifications and correlations with those of European and American localities; (2) this formation was folded, intruded, metamorphosed and eroded before the deposition of Mississippian and Pennsylvanian marine and terrestrial deposits: (3) the Mississippian and Pennsylvanian systems were folded and faulted probably in the Appalachian Revolution; and (4) the Devonian granites of Newfoundland intrude Lower Devonian formations, but not the Mississippian or Pennsylvanian systems. This last is very significant for up until 1943 this time designation for the granites has been made on analogy with granites of New England and Maritime Canada.

Extrusive Igneous Rocks

General Statement

The Middle and Upper Ordovician are represented by the Long Harbour series consisting mainly of volcanic rocks, at least 16,000 feet in thickness, divisible into three conformable formations. The Belle Bay volcanics, terrestrial flows, are succeeded by the Anderson Cove slates, fine-grained tuffaceous material possibly of marine origin which, in turn, are overlain locally by the Mooring Cove volcanics. Van Alstyne in the St. Lawrence area (Widmer, 1948, personal communication) has an Ordovician system that matches this Long Harbour series in thickness, lithology, and position in the column. Briefly the nomenclature of the system is: Burin volcanic series, Little Lawn slates, and Mount Margaret volcanics. The Andersons Cove slates are discussed under sedimentary petrology.

Belle Bay volcanics

The Belle Bay volcanics formation was named by White for the type area mapped/on both sides of Belle Bay; the large bay ?/ just east of Bay du Nord. The areal distribution of the Belle Bay volcanics may well turn out to be the largest of any of the igneous or sedimentary rock types in the Fortune Bay area. They extend in an east-west belt across the north shore of Fortune Bay from Bay du Nord entrance to Grand le Pierre. There is a problem here to be solved, for reconaissance by at least a dozen men has shown that there is a volcanic belt of 130 miles length and undetermined width southwest from the Clarenville area continuing through to Terrenceville and very probably on to the tip of the Burin peninsula where volcanics were dated by N. C. Dale (1927, p. 17) as pre-Cambrian.

The actual Bottom of Fortune Bay shows evidence of a graben fault structure. Thus the Ordovician volcanics may be bounded by a fault on the south with a sedimentary sequence of Silurian or Devonian downfaulted in the graben; the Burin upthrown block may consist of pre-Cambrian rocks.

The Belle Bay volcanics are thought by White to be at least 13,000 feet thick as measured on the northwest limb of the Long Harbour syncline where one may traverse for 5 miles over a section with a nearly constant 40° dip southeast. This estimated thickness is conservative in that material southeast of the Long Harbour fault is ruled out in order to prevent duplication. Belle Bay volcanics are very characteristically resistant due to the massive fine-grained nature of the volcanics and form the highest elevations in southwestern Newfoundland. The erosion surface preserved here is the southeastward extension of the High Valley peneplain of the Long Range Mountains and the Central Plateau.

In the Terrenceville area the author traversed the southeastern limb of the Long Harbour syncline and the thickness is conservatively estimated at 13,000 feet, which is the same figure that White arrives at. The Belle Bay volcanics, as described by White, consist mostly of felsitic flows and less prominent volcanic agglomerates, tuffs, and intermediate and possible basic greenstone flows. White states that clastic and sediments are local and of minor importance, but the author believes that these clastics are the key to the structure of the entire north side of the bay and thay they may be fossiliferous, possibly one might be able to prove them Ordovician in their own right.

The felsites, probably rhyolite and dacites, are thick, closely jointed flows in which individual units are rarely distinguishable enough to be useful in structural determination. They are colored red-brown, tan and purple, but weather to a light buff color.

As White states, prominent differences between top, bottom, and center of felsite flows are absent and the attitudes are very obscure. Individual flows of both acid and intermediate types are apparently quite local in extent although major units may be matched approximately. Flow structure is generally present as evidenced by orientation of phenocrysts. In particular, the rhyolites that crop out on the shores of the Bay de l'Eau west of English Harbour East, show a "breadcrust effect" so named by A. K. Snelgrove (1947, personal communication) which arises from a fracturing and breaking of upper flow levels so that fragments drop back into the "mush" to disturb the differentially colored flow band layers.

White and the author have found several localities where there has been abundant local development of spherulitic texture.

FIGURE 9. BOULDER (12' x 5' x ?) IN VOLCANIC AGGLOMERATE. ONE MILE WEST OF GRAND LE PIERRE. BELLE BAY VOLCANICS.

FIGURE 10. DARK BASIC FLOW OVERLYING A LIGHT ACIDIC FLOW. ONE MILE WEST OF ENGLISH HARBOUR EAST. BELLE BAY VOLCANICS.

This texture becomes accentuated upon exposure to air and water particularly along the shoreline. In field association, at several places, I have found rounded boulders of this spherulitic rhyolite in volcanic agglomerates. One angular block of it in an agglomerate measured twelve by five by (?) feet.

The greenstones are generally finer-grained than typical intermediate and mafic lavas, which White further describes as alteration to clinozoisite-epidote-chlorite-albite-actinolite mineral association usually so pronounded as to make the minerals indistinguishable megoscopically. Most of the greenstones are suggested to be alterations of andesites. Flows are thick, massive, and at places indistinguishable, but commonly one may distinguish separate flows. The flows consist of a narrow amygdular base, of massive structureless center, and a chilled amygdular top which may be reddened.

Pyroclastics are less common than flows but are abundant in places, particularly at Bettys Hole east of Bombards Island and east of Spudgels Cove. At both of these localities, spectacular cliffs of coarse agglomerate are seen. Both here and in White's area the lack of orientation of flow-banded fragments within agglomerates and breccias indicate that it was a primary structure rather than a secondary metamorphic effect.

The author agrees with White that the volcanics are terrestrial rather than of submarine origin. This statement is based on the following criterion: (1) the predominance of flows over agglomerates, tuffs and breccias, (2) the minor development of clastic sediments, (3) the red color and arkosic nature of clastics were formed, (4) the great thickness and predominant acid character, and (5) the absence of pillow lava structures.

The source vents of the volcanic eruptions are either rare or difficult to recognize. White has located several intrusive plugs or necks which may be the remnants of the cones of old volcanoes.

The five islands of Cinq Isles Bay form a line of diabase plugs. White lists as possible related intrusive bodies: dacite near Femme Harbour, trachysyenite near Tickle Beach in Long Harbour, felsite south of Spar Cove on the east shore of Mal Bay, and felsites south and west of Corbin. In the Terrenceville area there are two intrusive felsites, one on either side of English Harbour East. Widmer considers that a chocolate coloured porphyry of Salmonier Cove, Great Bay de l'Eau, may be related to the Ordovician volcanics.

The Belle Bay volcanics overlie the Cambrian Doten Cove formation and the Youngs Cove group at angles as much as 45°. They are conformably overlain by the Anderson Cove volcanics. These last are very similar to the Belle Bay volcanics and represent a continuation of volcanic activity following a period of submergence. Van Alstyne (1939, p. 3) recognizes a thick series of acidic volcanics, the Burin series, as Ordovician which are equivalent to the Belle Bay volcanics. The Belle Bay volcanics are not seen in contact with the Bay d'Est or Pools Cove formations.

Mooring Cove volcanics

The Mooring Cove volcanics were also named by White from local exposures in the cove of that name just west of the western head of Long Harbour. Here only, the plunge of the Long Harbour syncline brings these younger rocks into view. They have a very limited areal extent of less than 10 square miles, an estimated thickness of at least 1500 feet, and conformably overlie Anderson Cove slates.

The volcanics, also terrestrial, are similar to those of the Belle Bay formation in the abundance of felsite flows; they differ from the older volcanics in complete absence of mafic and intermediate flows, agglomerates and clastic sediments. This formation is unconformably overlain by the Silurian Rencontre formation. This unconformity is best observed at Stones Cove; there the volcanics have been removed by erosion and the Rencontre lies on the slates with a low angle unconformity. Van Alstyne considers his Mount Margaret volcanics equivalent to the Mooring Cove volcanics.

Connaigre Bay phase of the Long Harbour volcanics

The resistant volcanic complex forming the two south-westerly trending peninsulas north and south of Connaigre Bay were designated as the Connaigre Bay phase of the Long Harbour volcanics by Widmer because he believes that the two volcanic series are probably equivalent in age. The Connaigre Bay phase is bounded by intrusives or faults and is not in contact with any sedimentary formations. This phase is more basic and agglomeratic than the Long Harbour series and is believed to constitute the northwest limb of a geanticline, the southeast limb of which exposes Cambrian and Ordovician units in the Rachetty Hills.

Coarse green volcanic conglomerates make up 2000 feet of the formation and the total thickness is estimated to be 5000 feet. Typically, according to Widmer, the Connaigre Bay phase consists of dense, structureless, dark-green flows with some interbedded cream to brown rhyolite flows. The topographic expression of dark-green dense fine-grained lava in forming rugged, barren high ground is typical of the Long Harbour series to which the Connaigre Bay phase is considered equivalent. There are interbedded with the flows at several places, sections of red, purple, and green sandstones and tuffs.

Description of the Unconformity

The Long Harbour series was folded along a northeast axis and was extensively eroded before the Rencontre series was deposited. The greatest thickness of the Long Harbour volcanics is found at Long Harbour, which is thought to be the center and deepest part of the basin of deposition. Thus in the western area at Corbin there may never have been any great thickness deposited. East of Corbin as well as at the previously mentioned Stone Cove the Rencontre formation overlies truncated Belle Bay felsites and minor clastics.

Intrusive Igneous Rocks

General Statement

The intrusive igneous rocks are considered by discussing each body in chronological order outlining the characteristics, rock types represented, and its age and mode of entrance. The pre-Cambrian Garrison Hills batholith and the Carboniferous Belleorum batholith are of a simple type. The Bay du Nord batholith is coming to be recognized as an early phase of what is now regarded as the Devonian Ackley City batholith. In this report these two bodies are described individually. The composite batholith hypotheses is presented briefly with the idea that Devonian intrusives may be a part of the Devonian composite batholith system that extends along regional strike in the Northern Appalachians.

Garrison Hills batholith

Location

The Garrison Hills batholith named by Jewell (1939, p. 11) makes up half of the Baie d'Espoir area, or over 400 square miles. There are two belts bordering a northeasterly trending sedimentary wedge with 200 square miles of granite on either side. The Garrison Hills are typical exposures of this rock type. The Baie d'Espoir series is thus a roof pendant. The Gaultois porphyry phase makes up the southeastern boundary of the granite in a 40 mile wedge shaped exposure two miles wide, on the northwest side of the Hermitage Bay fault.

Characteristics

The Garrison Hills granite is a light grey, locally pinkish, binary granite with abundant pegmatite and aplite sills which extend for some distance beyond the granite contact into the Baie d'Espoir series parallel to the bedding and the developed schistosity. Widmer describes the granite as a white gneissic granite to granodiorite typically containing inclusions of sediments as hornblendites, pyroxenites, and metamorphosed quartzites and slates. Transgressive relationships are the exception and the granite contacts over the regional view are parallel to the strike of the sedimentary rocks. Contacts are nowhere sharp and in many places the rock is best described as an injection gneiss. As one approaches the contact from the Baie d'Espoir series the granite, pegmatite, and aplite sills and knots increase until one passes into a granite which has inclusions of schist of all sizes and in all stages of assimilation. The granite is characterized by a somewhat darker red color and a higher proportion of biotite near the assimilated schist fragments. The uniform reddish granite however contains a higher proportion of muscovite than biotite. Garnet is more common in the vicinity of inclusions.

This granite is believed to be Late Proterozoic in age because it intrudes Archeozoic (?) sediments. The batholith and the grain and foliation of the schist inclusions consistantly strike approximately N. 60° E. The granite, particularly in the northwest where there are fewer inclusions, is very massive and resistant resulting in steep bold cliffs. Where the granite is more gneissic it is less massive, more poorly jointed and less resistant to erosion.

Granite

The typical granite, relatively uncontaminated, is described by Jewell (1939, p. 11) as consisting of large quantities of orthoclase, microcline, micropegmatite, and quartz; smaller amounts of albite, biotite, and muscotite and small but variable amounts of garnet, magnetite, topaz, zircon, and apatite. Much of the microcline contains corroded remnants of both quartz and orthoclase. The biotite is usually partly bleached and altered to muscovite, chlorite, and magnetite and contains small zircons with pleochroic haloes. These observations according to Jewell (1939, p. 10) indicate that the late magmatic residues were fairly corrosive and much of the alteration in the granite was accomplished during the late magmatic stage.

Gaultois porphyry

This porphyry forms a narrow border phase of the granite and occurs for nearly 40 miles along the Hermitage fault which forms the southern boundary of the northeast-trending granite. The Gaultois type is a red to grey coarsely porphyritic potash granite which contains orthoclase phenocrysts commonly 3/4 inch in length; ferromagnesian minerals are almost completely absent. Possibly this is the source of the coarsely porphyritic orange granite boulders of the Ordovician Pools Cove conglomerate. This porphyry may be related to the coarsely porphyritic pink granite northeast of Dunns Pond along Terrenceville Road.

Pegmatite and aplite

These two rock types are found cutting both the Garrison Hills granite and the intruded Baie d'Espoir series. In the granites the structural control was the joint sets, but in the schist and sediments they occur irregularly as knots and lense-like invasions parallel to the schistosity or bedding. The aplites vary from feldspar and quartz to normal granite. They are light grey to red in color and consist of a fine-grained sugary aggregate of quartz, orthoclase, microcline, and muscovite. The pegmatites according to Jewell (1939, p. 12) consist essentially of potash feldspar, quartz, and muscovite. Locally they contain small amounts of garnet, tourmaline, biotite, chlorite, molybdenite, pyrite, chalcopyrite, arsenopyrite, and probably other minerals. The texture is quite coarse and irregular with individual crystals reported of sizes 4-5 inches for feldspar and 7-8 inches for mica.

Mode of intrusion

Jewell (1939, p. 11) considered the Baie d'Espoir belt of sedimentary and metamorphic rock as a huge roof pendant separating the batholith into two distinct areas. The batholith is believed to have emplaced itself largely by stoping and assimilation. As reasoned by Jewell, the gradational nature of the contacts, presence of inclusions in all stages of digestion, and the general parallel relationship of the contacts to the strike of the sedimentary rocks seem to demand such a process. Contacts are sharp in the few places where the granite and sediments meet along a fault.

Bay du Nord batholith

Location

The Bay du Nord batholith extends southwestward in a belt, three miles in width, from the area surrounding Bay du Nord back of Cinq Isles Bay and through to the east shore of Harbour Breton. The body is broken by faults and intruded by the Taylor Brook stock of Ackley City granite, but it is exposed for 35 miles along a strike of N. 45° E. The total exposed area is approximately 80 square miles. The Bay du Nord batholith has representation of 10 square miles northeast of Grand Le Pierre. ays ?

Characteristics

This batholith in White's area consists of a variety of rock types, the most abundant of which are granodiorite and alaskite. Intermediate phases as quartz-diorite are locally abundant; partially digested inclusions of femic composition with relict pryoxene suggest the existence of basic phases such as gabbro, although no outcrops of basic rocks were observed. There are a few pegmatite and aplite dikes representing late-stage products of the alaskite magma.

In the Rencontre East area this batholith was covered with rather heavy vegetation because of the relative ease of weathering of the femic components of the rocks. Outcrops were described as poor and discontinuous except along the shorelines and main stream valleys.

The Bay du Nord batholith is bounded on two sides largely by faults. The Hermitage Bay fault separates the intrusion from the Gaultois porphyry to the northwest. The southeastern contact of the granite is generally bounded by one of several smaller faults with Paleozoics downfaulted to the southeast. Intrusive contact is made with the Ordovician volcanics along 20 miles of the northwest boundary and to the southeast the granite is locally intrusive into the Cambrian formations. North of the Racketty Hills and in the Taylor Brook stock, the Ackley City granite is intrusive into and in gradational contact with the Bay du Nord granite.

Gabbro and diorite

The other authors have not mapped any phases more mafic than quartz-diorite, so the several bodies of gabbro and diorite lying north and northwest of Grand le Pierre, making up the earlier and border phases of the intrusive body, may be regarded as important evidence in reconstructing the intrusive history. All of these exposures include the rock types, gabbro and diorite found in embayments of the batholith into the Belle Bay volcanics. These separate bodies lie along an east-west line between Grand Le Pierre and Long Harbour. The largest single body is in the Taylor Mountain diorite stock, which has an area of several square miles and is located two miles north of Grand le Pierre.

The gabbro rock specimens are all of a dark green color and medium-grained to fine-grained, with a diabasic texture. Grain sizes range from slightly less than to slightly more than one millimeter. The olivine and hornblende both average 15% to 20%. The plagioclase, in lath-like crystals, varies from a light-green to a dark-green. Locally pyritization is important. The diorites vary in color from light to dark green and are medium-grained equigranular rocks in which the grain sizes range in average from one to two millimeters. Some specimens have a porphyrytic texture and in many of them there are conspicuous subhedral green lamellae of twinned plagioclases up to five millimeters. Megascopically the diorite has 80% to 85% feldspar.

Quartz-diorite

White describes this rock type as being a mottled light green in color, with dark green hornblende, greenish feldspar, and inconspicuous quartz. Typically it has a medium-grained texture with euhedral hornblende, saussuritized calcic oligoclase feldspar, quartz, minor microcline and orthoclase. Biotite, chlorite, apatite, sphene, and magnetite are minor constituents.

Oligoclase granodiorite

The granodiorite is generally lighter in color than the quartz-diorite because of a lower percentage of mafic minerals. They are light blue-green hornblende, brownish biotite from extensive replacement of hornblende, and green chlorite. The plagioclase is a cloudy sericitized albite or albite-oligoclase and is less abundant than in the quartz-diorite. The potash feldspar is generally interstitial perthitic plagioclase.

A composite description of quartz-monzonite specimens by the author is similar to White's modal analysis of this granodiorite. The quartz-monzonite, a medium-grained equigranular rock, is a mottled steel-grey color with an average grain size of one millimeter. The minerals differ in color so greatly that it emphasizes the interlocking granular texture. The most conspicuous mineral is a dark green hornblende in subhedral crystals as much as 2-5 millimeters in length and making up 15-20% of the rock. Quartz is present in quantities from 5-10%. There are two feldspars, microcline which is pink and comprises 25% of the rock, and pink to light green acid plagioclase estimated at 55%. The sequence of crystallization was determined by the author to be hornblende, acid plagioclase, microcline, and quartz.

Alaskite and granite

Representative alaskite, according to White, is a medium-grained to coarse-grained rock consisting of quartz and red potash-feldspar and plagioclase. Red colored albite-oligoclase is typical of the alaskite of this and the Ackley City batholith, but it is pinkish or white in the granodiorite and more basic phases.

The granite is gradational between granodiorite and alaskite and is generally a mottled purplish color, due to abundant patches of ferric oxide. The feldspars are a lighter pink color than in the normal alaskite.

Pegmatite and aplite

White states that the pegmatites and aplites are not common, but are found in places as definite, sharp-walled dykes. Both are probably similar in chemical and mineral composition to the alaskite, but differ mainly in texture. In general the feldspars of both types of dykes are of a lighter pink color than in the red alaskite; this color difference also distinguished the late-phase dykes of the Bay du Nord from the late phases of the Ackley batholith.

Mode of intrusion

In comparison with the Ackley City batholith, there is in the Bay du Nord late phases, an absence of miarolitic texture. The stronger alteration of the Bay du Nord batholith may be controlled by more abundant faulting and jointing than is characteristic of the Ackley batholith. This question of intrusion will be discussed to greater lengths after a treatment of the Ackley City batholith.

Ackley City batholith

Location of batholith and related stocks

The axis of the Ackley City batholith strikes N. 45° E. and the exposure, ampped to date, lies in a 25 mile east-west belt with extension northeastward from 20 miles on the west to 5 miles on the east. The mapped area of this batholith is 225 square miles. There are related stocks lying off to the southwest, namely: the Basse-Terre stock on the southwest tip of Hermitage Peninsula, 15 square miles and 40 miles from the batholith; the Taylor Brook stock lying between Harbour Breton and Old Bay, 25 square miles and 20 miles away; and the Old Womans stock between Old Bay and the Rachetty Hills, 20 square miles and 15 miles to the southwest.

Characteristics

The Ackley City batholith intrudes,over a distance of 50 miles, the BelleBay volcanics and very locally it intrudes also the Anderson Cove slates and the Doten Cove formation. The batholith is characterized by very low relief and a complete lack of vegetation on decomposed granite redges. There is some factor present that is detrimental to plant growth so that vegetation ceases abruptly at the contact line, except for areas of marshes and ponds. The elevations are considerably higher and the relief considerably greater in the bordering volcanics.

The batholith is composed mainly of white granite and red alaskite with granite more abundant over all and alaskite dominant in the southern part of the intrusive body. According to White, who has mapped the greatest part of the batholith, "Basic and intermediate rocks are completely absent, although early phases of the differentiation series may be represented by the Bay du Nord batholith." Chilled contacts with the volcanics and slates are rare, but may be observed locally.

At the Rencontre East molybdenite deposite, aplite is present in irregular zones adjacent to the southern contact, especially in the batholithic embayments into the volcanics and White has shown it to be a true late-stage differentiate of the alaskite. The mineralizing solution containing molybdenum as the important constituent, has found the aplite to be an excellent host rock.

The attitude of the granite contact with the country rock is rarely visible; the strike of the volcanics is parallel to the contact giving rise to the idea of a permissive intrusion.

Granite

The most abundant phase of the Ackley City batholith is a coarse-grained granite with pink orthoclase, white albite-oligoclase, abundant quartz and less than 10% mafics. Orthoclase is generally perthitic and in many cases has grown around a plagioclase core. There is evidence, according to White, of varying degrees of albitization of potash feldspar, in some cases replacement was extensive.

Coarse Grained granite - 3 miles North of
Ackley City. R. B. Ellestad, analyst

Norm		Mode	
Quartz	28.74	Quartz	27%
Orthoclase	27.80	Perthite	40%
Albite	34.06	Albite	25%
Carbon	.51	Mafica	7%
Enstatite	2.38	Misc.	1%
Magnetite	.93		
Fluorite	.12		
Apatite	.17		

(White, 1939, p. 76)

The granite grades into alaskite, as pointed out by White, by a decrease in femic constituents, accompanied by an increase in intensity of the coloration of the red feldspar. The phases are generally gradational, but White has seen the alaskite cutting across the granite.

Alaskite

The alaskite has a medium-grained granitoid texture and consists of quartz, albite, and potash feldspar, with very minor accessory biotite, chlorite, muscovite, magnetite, allanite, sphene, apatite and zircon not exceeding a total of 2%. The potash feldspar is generally perthitic orthoclase. Perthitic texture is common in alaskite but rare in aplite.

Belle Bay Alaskite porphyry

White notes a small intrusive mass of alaskite porphyry that occurs on the east side of Belle Island, which he describes as consisting of small quartz and feldspar phenocrysts in a holocrystalline ground mass of quartz and feldspar with negligible femic constituents. The alaskite nature and the occurrence of quartz-chalcopyrite-molybdenite-fluorite-carbonate veinlets suggest a genetic relationship to the molybdenite-bearing Ackley City batholith.

Widmer considers that a chocolate coloured porphyry of Salmonier Cove, Great Bay de l'Eau, may be related to the Ordovician volcanics.

Aplite

The aplite is believed by White to be a slightly later phase which has crystallized after the alaskite. Miarolitic cavities are very common in the aplite phase; they average about 1/4 inch in diameter and have crystals of quartz, feldspar, chlorite lining the walls. The texture is hypidiomorphic, with both feldspars commonly euhedral or subhedral. Quartz is contemporaneous with the feldspar or later. Granophyric intergrowths of quartz and orthoclase or quartz and albite are common in aplite but rare in alaskite. This aplite phase will be discussed further under the section on economic geology. It bears a marginal relationship to the alaskite and the batholith.

Pegmatite

White found several small rounded pegmatitic areas, nowhere over several feet in diameter, and the writer found only one. These pegmatites either were in the aplite zone or they were surrounded by an aplite shell; they have quartz centers and a narrow border zone of feldspar and quartz. Euhedral quartz is rarely present near the most pronounced mineralization of the molybdenite deposits.

Dike rocks

The dikes consist of four main groups: basalt and diabase, andesite and dacite, quartz-trachyte, and rhyolite. The dikes are the youngest rocks in the area, and are later than the major folding and faulting.

The significant features of the various dike rocks are: amygdular basalt and olivine basalt; diabase with 40% plagioclase, 45% augite, 10% biotite and 5% orthoclase; fine-grained, greenish grey amygdular dacite-andesite composite dikes with a red porphyritic rhyolite later phase; and quartz trachyte, brown with small phenocrysts of salmon-colored feldspar in a darker ground. Red porphyritic rhyolite dikes are common and widespread, exhibiting chilled border facies; they have a hackly-platy jointing adjacent and parallel to the contact, and widths varying from 10 to 100 feet. The phenocrysts of the rhyolite are about one-half quartz, and one-half orthoclase and albite in about equal proportions in a fine-grained ground mass of quartz and feldspar. Phenocrysts show rounded resorption; miarolitic cavities contain quartz crystals, iron oxide, and green epidote and chlorite.

Grole and Hermitage migmatites

Widmer further describes the Connaigre Bay phase of the Long Harbour volcanics by including two migmatite zones therein that have resulted from the intrusion of the Ackley City granite. They are best located by considering their relationships to the Basteur Stock which makes up the tip of the Hermitage

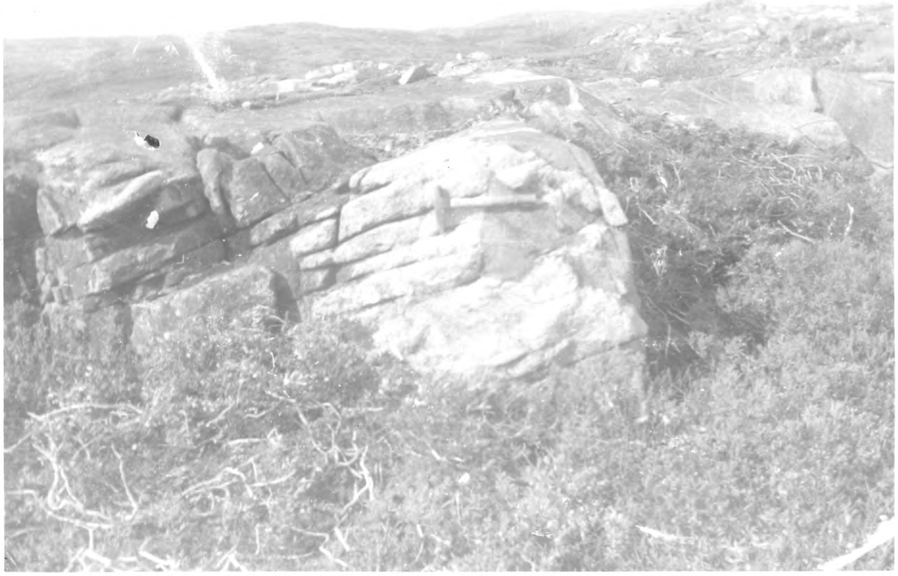


FIGURE 11. STOPING OF DIORITE (BAY DU NORD) BY THE LIGHTER COLORED ACKLEY CITY GRANITE. ONE MILE NORTH OF GRAND LE PIERRE.

FIGURE 12. GISBURN LAKE ON THE ACKLEY CITY BATHOLITH. NOTE LACK OF VEGETATION.

peninsula. The Grole migmatite lies along the northern boundary of the stock and, according to Widmer, it is a diorite-granite sequence with scattered undigested areas of basic flows. Bordering this is the Hermitage migmatite predominantly dioritic with minor amounts of granite and major amounts of undigested basic flows. Thus, included fragments range from those which have developed dioritic texture through the intermediate types to those fragments which have been absorbed and converted into the granite. The entire peninsula overlies the roof of the granite. Intrusion and digestion is seen in the field to have given rise to such structures as rapakivi and igneous breccia, in which angular fragments of lava have been insulated with rings of quartz. Local dioritic areas occur north of the Bottom of Hermitage Bay indicating a close approach of the batholith to the present surface.

Composite Batholith Hypothesis

The differences between the batholiths are not inconsistent with the hypothesis that they belong to the same general magmatic periods of intrusion. The Bay du Nord batholith is believed to be somewhat earlier because of (1) cross cutting relationships by the Ackley City granite, (2) greater abundance of granodiorite and more basic phases, (3) more strongly altered equivalent rock types, (4) abaence of miarolitic texture, and (5) absence of pegmatites peculiar to the Ackley City batholith.

North of the Racketty Hills, in White's area, locally at least, the Bay du Nord batholith grades into the Ackley City batholith. North of Grand le Pierre, in the Terrenceville area, there is a shatter zone of xenoliths of basic phases of the Bay du Nord intrusive which are exposed just inside and bordering the contacts of the Ackley City batholith. These field evidences indicate the close genetic relationships of these two batholiths.

Devonian Intrusions of the Northern Appalachians

Widespread granitic intrusion took place in the last stages of the Acadian disturbance. Until recently, most of the mid-Paleozoic intrusive bodies of Newfoundland had been dated simply on direct analogy with more accurately defined Devonian batholiths in the Northern Appalachians. J. R. Cooper (1943, p. 264) found a granite intruding Lower Devonian metamorphosed, plant-bearing slates, which did not intrude the unconformably (and unmetamorphosed) overlying Carboniferous beds. Thus, later workers have been provided with factual evidence of a Devonian magmatic period. It is conceivable, from the analysis of the stratigraphical data in the Fortune Bay area, that there may be Carboniferous beds exposed and yet unidentified as such.

The evidence for building up a case in behalf of genetically related Devonian batholiths extending the length of the Northern Appalachians is rapidly accumulating. Marked similarities are here noted between batholiths in the Fortune Bay area. White puts forth the idea that the more basic Bay du Nord intrusive is an early differentiate of the Ackley City granite in the same magmatic period; Van Alstyne (Widmer, 1947, personal communication), in the St. Lawrence area, found the Lawn (?) metagabbro succeeded by the St. Lawrence granite; and Rose (1947, p. 5) maps the Powder Horn diorite as intruded by the Northern Bight granite. All three of these composite batholiths intrude Ordovician volcanics.

Belleorum batholith

Location

The Belleorum batholith was named by Widmer for a single intrusive body centering around the Belleorum area. The actual extent of this body will be difficult to determine because its center lies under the bay. Besides one stock, there are almost a dozen small related intrusive bodies within a 10 mile radius scattered over the northern shore of the bay. The southern boundary is exposed directly south 30 miles on the shore of the Burin peninsula near Grand Beach. Fifty square miles of land exposure have been mapped to date.

Characteristics

The Belleorum granite has been dated relative to both intrusive and sedimentary rocks, for it intrudes the Devonian Ackley City granite in the Old Womans stock, and it intrudes the fossiliferous Devonian Great Bay de l'Eau conglomerate at Great Bay de l'Eau. The intrusive plug at Farmers Cove, Chapel Island may be related to this granite.

Granite

According to Widmer, the Belleorum granite is a fine-grained light-yellow, typically containing black and grey nodular, partially digested inclusions of the intruded rocks.

Related dikes

Basic dikes and sills of a porphyritic to non-porphyritic texture cut the Baie de l'Eau conglomerate and at some localities form compound dikes with a younger red porphyry. Orange and red rhyolite porphyrys are found in plugs and dikes from Harbour Breton eastward to English Harbour West. These dikes, sills, and plugs are the youngest intrusive rocks in the area as determined by Widmer.

PLATE V

HISTORICAL GEOLOGY OF NEWFOUNDLAND. MODIFIED FROM C. SCHUCHERT AND C.O. DUNBAR "STRATIGRAPHY OF WESTERN NEWFOUNDLAND. G.S.A. MEMOIR NO. 1 1934 PP 16

TIME UNIT			LOGAN'S DIVISIONS	WESTERN	NORTHEASTERN (NOTRE DAME BAY)	INTERIOR	SOUTHEASTERN	SOUTHWESTERN FORTUNE BAY AREA.
PLEISTOCENE				GLACIATION AND CRUSTAL OSCILLATION. GLACIO-FLUVIO TERRACES				25' 65' 85' TERRACES
PLIOCENE TO EOCENE				NO SEDIMENTARY RECORD. PENEPLANE OF SUMMIT OF LONG RANGE UPLIFTED AND PARTIALLY DESTROYED BY LONG EROSION; GULF OF ST. LAWRENCE REDUCED TO LOWLAND, SUBMERGED BY CRUSTAL WARPING.				EROSION. FORMATION AND DISSECTION OF THREE SURFACES. HIGH VALLEY AND LAWRENCE PPS REPRESENTED
CRETACEOUS TO TRIASSIC				NO SEDIMENTARY RECORD KNOWN. NEWFOUNDLAND PROBABLY SUBJECTED TO CONTINUED EROSION.				
PERMIAN				FOLDING AND FAULTING DURING APPALACHIAN REVOLUTION. FOLLOWED BY LONG EROSION INTERVAL.				APPALACHIAN REVOLUTION
PENNSYLVANIAN				LAND INTERVAL ?LOWER COAL MEASURES, ALL CONTINENTAL 3000' LAND INTERVAL	?	?	EROSION INTERVAL	EROSIONAL INTERVAL
MISSISSIPPIAN				WINDSOR SERIES'	NO RECORD KNOWN	WINDSOR SERIES OF HUMBER RIVER, DEER AND GRAND LAKES, AND RED INDIAN LAKE.	? WINDSOR DISTURBANCE EROSION INTERVAL	BELLEORUM BATHOLITH NO KNOWN RECORD OF SEDIMENTARY ROCKS.
DEVONIAN	UP.			LAND INTERVAL ACADIAN DISTURBANCE AND BASIC INTRUSIONS.	ACADIAN DISTURBANCE AND BASIC INTRUSIONS.	ACADIAN DISTURBANCE AND BASIC INTRUSIONS	ACADIAN DISTURBANCE	ACADIAN DISTURBANCE COMPOSITE BATHOLITHS.
	LOW.			CLAM BANK SERIES 1700'	NO RECORD KNOWN	NO RECORD KNOWN	EROSION INTERVAL	GREAT BAY DE L'EAU CONGLOMERATE 3000' UNCONFORMITY
SILURIAN				NO RECORD KNOWN	2800+ IN WHITE BAY 2000+ IN NOTRE DAME BAY	NO RECORD KNOWN	PROBABLY DEPOSITED, NOW ERODED AWAY	RENCONTRE FORMATION 3500'
ORDOVICIAN			LOGAN'S DIVISIONS	TACONIAN DISTURBANCE	TACONIAN DISTURBANCE	TACONIAN DISTURBANCE	TACONIAN DISTURBANCE	TACONIAN DISTURBANCE
	MOHAWKIAN AND AFTER	?	Q MUCH EXTENDED	HUMBER ARM SERIES AT LEAST 5000' HIGHLANDS RISING TO THE EAST.	PRESENT IN PISTOLET BAY IN FAR N. ALSO IN NOTRE DAME BAY WITH RED CLIFF VOLCANICS.	? VOLCANICS SHALES WITH GRAPTOLITES.	ALL YOUNGER FORMATIONS ERODED AWAY.	LONG HARBOUR VOLCANICS: MOORING COVE VOLCANICS 1500'; ANDERSON COVE SLATES 1500'
	MOHAWKIAN AND AFTER	?	P	COW HEAD THRUST BRECCIA. FAULTING AND ELEVATION	GOSS POND VOLCANICS	NO RECORD KNOWN		LONG HARBOUR VOLCANICS: BELLE BAY VOLCANICS 13,000'
	MOHAWKIAN AND AFTER	BLACK RIVER	O MUCH EXTENDED	LONG POINT SERIES 1530'		? VOLCANICS PROBABLY REPRESENTED.		
	CHAZYAN	CHAZY	N TO K	TABLE HEAD SERIES 1380'	SNOOKS ARM VOLCANICS TABLE HEAD PRESENT AS SHALES.	TABLE HEAD PRESENT AS SHALES WITH GRAPTOLITES VOLCANICS		
	CANADIAN		I TO D	ST. GEORGE SERIES 1570'-2080' +	LATER ST. GEORGE PRESENT AS SLATES WITH VOLCANICS.	LATE ST. GEORGE PRESENT WITH GRAPTOLITES. VOLCANICS.	WABANA 3000' BELL ISLE 6000' CLARENVILLE	POOLS COVE CONGLOMERATE 5000'
	CANADIAN		Q IN PART	GREEN POINT SERIES 1700' +	PROBABLY REPRESENTED.	NO RECORD KNOWN	POSSIBLY REPRESENTED	BAY D'EST GROUP 2000'
CAMBRIAN	UP.			MARCH POINT SERIES 1180+	?	?	JOHANNIAN 400'-500'	UNCONFORMITY
	MID.			LAND INTERVAL			MANUELS 300'	YOUNG'S COVE GROUP 2000'
	LOW.		C TO A	LABRADOR SERIES 2600'	?	?	HANFORDIAN ETCHEMINIAN 200'.	DOTEN COVE SANDSTONE 2000'
PROTEROZOIC				GREAT UNCONFORMITY RECORD UNKNOWN	GREAT UNCONFORMITY RECORD UNKNOWN	RECORD UNKNOWN	AVALON SERIES 15,000'	GREAT UNCONFORMITY GNEISSIC GRANITE
ARCHEOZOIC				? LAURENTIAN GRANTE		LAURENTIAN GRANITE	LAURENTIAN GRANITE	BAIE D'ESPOIR SERIES 10,000'

STRUCTURAL GEOLOGY

General Statement

The writer offers the idea that the Burin Peninsula and the Baie d'Espoir area are two resistant pre-Cambrian basement fault blocks which have acted as buttresses transmitting the regional compression to less resistant down-faulted Paleozoic rocks. D. W. Johnson (1925, p. 5) considers such an arrangement to be fundamental in the New England-Acadian region. The older rocks have been subjected to a greater and longer continued pressure, heat, and other metamorphic processes, and include a greater proportion of igneous intrusions. As a rule the pre-Cambrian rocks are more crystalline and more resistant to erosion. They are more likely to transmit stresses than to yield to them and thus the major forces must be absorbed by the more incompetent Paleozoic rocks.

Folds

Baie d'Espoir syncline

In the Baie d'Espoir area there is a large syncline trending north 70° east of Baie d'Espoir sediments in fault and locally intrusive contact on both flanks with the Garrison Hills Granite. It is believed that the position of the Baie d'Espoir block of sediments between resistant granite masses tended to localize later movements in the sedimentary rocks which were incompetant and unable to support large structural folds. Thus large simple folds were not formed; much of the stress was relieved by faulting and the remainder of the compression went to form this synclinorium with local varied response to regional forces. The folding according to this author probably was late pre-Cambrian. Beds are locally closely folded, to the north the folds are isoclinal, but virtually everywhere the beds are very steeply inclined. Small folds of regional strike show asymetrical anticlines or synclines with axial planes dipping southeast. Slaty cleavage and schistosity are commonly parallel to the bedding.

Connaigre Bay anticline

Widmer believes that his Connaigre Bay phase of the Long Harbour volcanics is one of the limbs of a geanticline folded in Late Ordovician time; the axis extends from Great Bay de L'Eau northeast to Bay du Nord. The outcrop pattern of the considerably faulted anticlinal core, the trace of which strikes northeast, gives the impression that the anticline plunges to the southwest. Consecutively older formations are exposed along this axis; Cambrian Youngs Cove, Ordovician Bay d'Est (redefined by Widmer) and Devonian Great Bay de L'Eau. However, these three formations are elsewhere separated by unconformities and it seems unlikely that this anticline exists.

Racketty Hills syncline

White maps a syncline on the southeast flank of Widmer's hypothetical geanticline for which there is sound structural evidence in the fold pattern. The Cambrian Doten Cove formation and the overlying Youngs Cove formation are probably involved throughout the length of the axis. The axis of this syncline strikes under the unconformably overlying Belle Bay volcanics formation and the Great Bay de L'Eau conglomerate, to the northeast and the southwest respectively. Thus the age of the folding is Late Cambrian or Early Ordovician.

Long Harbour Syncline

This is the major fold of the Rencontre East area. The folding was Late Ordovician or Early Silurian involving only the Long Harbour series which strikes northeast and are truncated by the cross cutting Ackley batholith at the head of Long Harbour. The plunge is to the southwest under the bay; the fold is asymmetrical with a steep northwest limb. Successively younger beds in the Long Harbour series are exposed southwest: Belle Bay volcanics, Anderson Cove slates, and the Mooring Cove volcanics.

Rencontre Synclines

There are four minor synclines in the Rencontre formation: at Cove, Pinkeys Cove, Spar Cove, and at Belle Harbour. These synclines are symmetrical and all plunge southwest with nearly perfect topographic expression. They have a counterpart in four small northeast plunging synclines east of Corbin on the other side of the bay also of the Rencontre formation. The areal representation of this formation rimming Belle Bay denotes that the present day Belle Bay possibly had its beginning in mid-Paleozoic time as a basin of deposition which has persisted as a zone of structural weakness. The only formation involved in this fold is the Silurian Rencontre and, because the Devonian Great Bay de L'Eau conglomerate is relatively flat-lying, it is believed that the folding took place at the end of the Silurian period.

Femme syncline

This syncline trends northeast at the head of Femme Harbour; although a minor fold, it has perfect physiographic expression, and may represent an outlier of Devonian Great Bay de L'Eau conglomerate on the volcanics. Widmer, as White's assistant in 1938, mapped it as local interstratified sediments within the Long Harbour series but at present (1948, personal communication) he favors the possibility that it may be of Devonian age.

Fortune Bay syncline

The trend of the Fortune Bay syncline is northeast; it has a length of 70 miles and a width of 10 to 20 miles. The topographic expression of the syncline is the present Fortune Bay. The northwest limb of the syncline has been cut out by the northeasterly trending Fortune Bay fault. The fault has surface expression on Brunnet Island to the southwest and for ten miles along the north shore of the Bottom of Fortune Bay. The head of the syncline is structurally outlined for 15 miles in Bay L'Argent and the southern flank parallels the northwest shore of Burin Peninsula.

Burin anticline

The northeasterly trending Burin anticline forms the southeastern limb of the Fortune Bay syncline and the northwestern limb of the St. Lawrence syncline as shown on the geologic map. (Plate VII) This anticline is a major structural feature of the region and is believed to have stood as a resistant fault block since pre-Cambrian time transmitting stresses rather than yielding to them. This structural pre-Cambrian block may be a part of the pre-Cambrian platform that makes up the Avalon peninsula.

St. Lawrence syncline

This syncline structurally is similar to the Racketty Hills syncline, both having a northeasterly strike, both composed of faulted Early Paleozoic rocks; the difference being that the St. Lawrence syncline is not as badly broken by faulting and exhibits clear cut age relations by the map pattern.

Faults

General statement

The largest faults of the area belong to a northeast system characterized by movement in which the southeast blocks moved southwest and down relative to the northwest blocks. The faulting in most cases is post-Ackley City batholith or post Devonian. The two critical fault zones of the area are the Connaigre Bay fault which separates Paleozoic rocks from pre-Cambrian rocks to the north and the South Fortune Bay fault which separates the Paleozoic rocks from the pre-Cambrian rocks to the south. The central block of Paleozoic rocks was less resistant to deformational forces and as a result it has been highly folded and faulted. The pre-Cambrian blocks are probably a part of the pre-Cambrian platform that makes up a great part of the island of Newfoundland. Besides being composed partly of igneous rocks, and due to repeated subjection to long periods of heat, pressure, and other metamorphic processes, the rocks are crystalline and more competent to withstand regional forces yielding only by large simple folds or by faults.

Baie d'Espoir fault system

The faults in Jewell's area (1939, p. 14) may be roughly grouped in two sets, one represented by strike faults of directions between N. 60° E. to N. 70° E., and the other set has a predominant northwest strike. The strike faults are either reverse or normal faults and the set at right angles are normal faults or tear-faults. The greatest movement was along the northeast strike faults. Both sets are mineralized by pyritiferous quartz and chalcedony which occurs cementing fault breccias. In the faulted and folded sedimentary and meta-sedimentary rocks the slaty cleavage and schistosity are parallel with the bedding.

Hermitage Bay fault

This fault is the longest fault present in the Fortune Bay area. It has been mapped by Widmer on the west and White on the east for 60 miles along a strike of N. 50° E. This fault separates the pre-Cambrian sequence from the Paleozoic system and has controled the long narrow Hermitage Bay fiord.

East Bay-Cinq Isles Bay fault system

This system of five faults has a fan shaped pattern with four of the faults (extended) theoretically apexing under East Bay. The faults are all approximately 25 miles in length and are turned

10° from one another, through the apex, ranging in strike from S. 60° W. to S. 30° W. These faults are dated as post-Ackley City or post-Devonian.

Long Harbour fault

This fault strikes N. 40° E. and although it actually displaces the Long Harbour series, it has little structural significance other than lying close to the axis of the Long Harbour syncline. White has mapped the fault as continuing northeastward to Gisburn Lake where it may be possible to show that its presence, as a zone of weakness, has been fundamental in the establishment of drainage. This fault has been mapped for six miles in the Ackley City batholith, so that it too is post-Devonian.

Fortune Bay fault

One of the major structural features of the Terrenceville area is a N. 60° E. graben fault structure which has formed the Bottom of Fortune Bay. The fault has been demonstrated in the field for a distance of 15 miles along the north side of the bay both in White's area and in the author's. Drag folds on the footwall show the movement of the southern hanging wall block to have been to the east. The underside of the downthrown block shows brecciation, slickensides, drag folds, silicification, and a shearing at the contact. The downthrown block in the area mapped is of limited exposure as the Bottom of the bay occupies the eroded graben.

The graben block lies mainly under the bay but there is a thin sedimentary sequence believed to represent the northwest limb of

FIGURE 13. FORTUNE BAY FAULT ON EAST SIDE OF ENGLISH HARBOUR EAST.

FIGURE 14. FORTUNE BAY FAULT ON THE WEST SIDE OF ENGLISH HARBOUR EAST.

a Rencontre syncline. Flow cleavage indicates a syncline striking northeast and plunging southwest.

The fault along the south side of the bay is based upon the following observations: the southern coast line is a natural straight line parallel to the northern Fortune Bay fault, folding on the south side of the bay is more complex; and the metamorphic rocks are dissimilar to the volcanic rocks of the northern shore.

Dike and vein patterns

Graphs have been drawn to demonstrate the structural relationships of the dikes and veins to the Ackley City batholith. The axis of the batholith strikes N. 60° E. In the Rencontre East area, all of the dikes strike within 15° of being at 90° to this axis. In the Terrenceville area the dikes show greatest distribution 60° from the batholith axis. These dikes may be referred to regional tension joints that resulted from the emplacement of the batholith.

The veins have a very pronounced localization within 10° of the batholith axis indicating that they also had structural control, in this case by compressional joints.

TABLE I

GRAPH SHOWING DISTRIBUTION OF THE STRIKES OF 36 DYKES IN THE TERRENCEVILLE AREA.

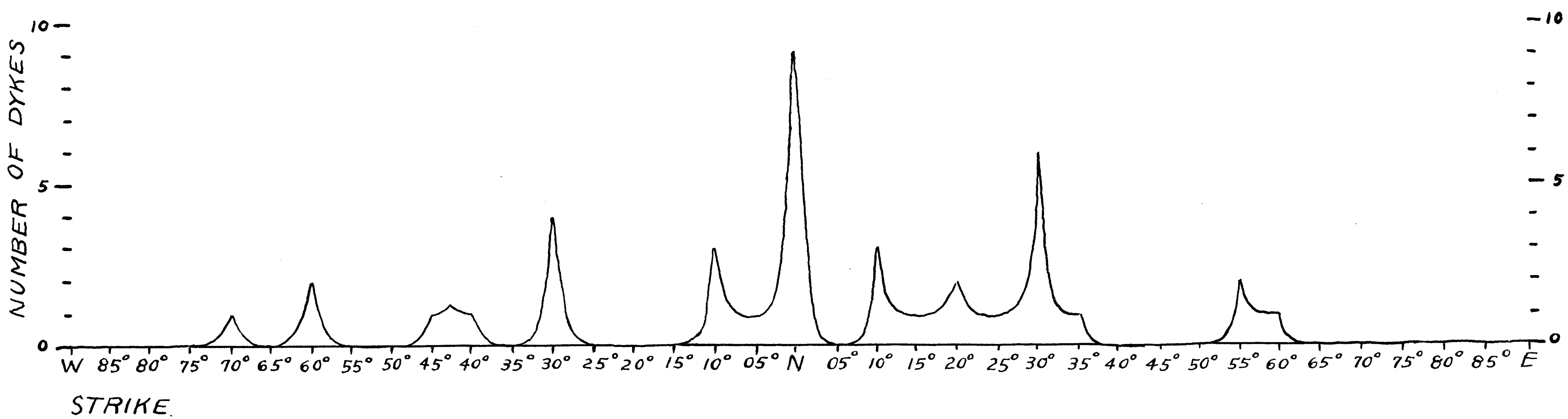
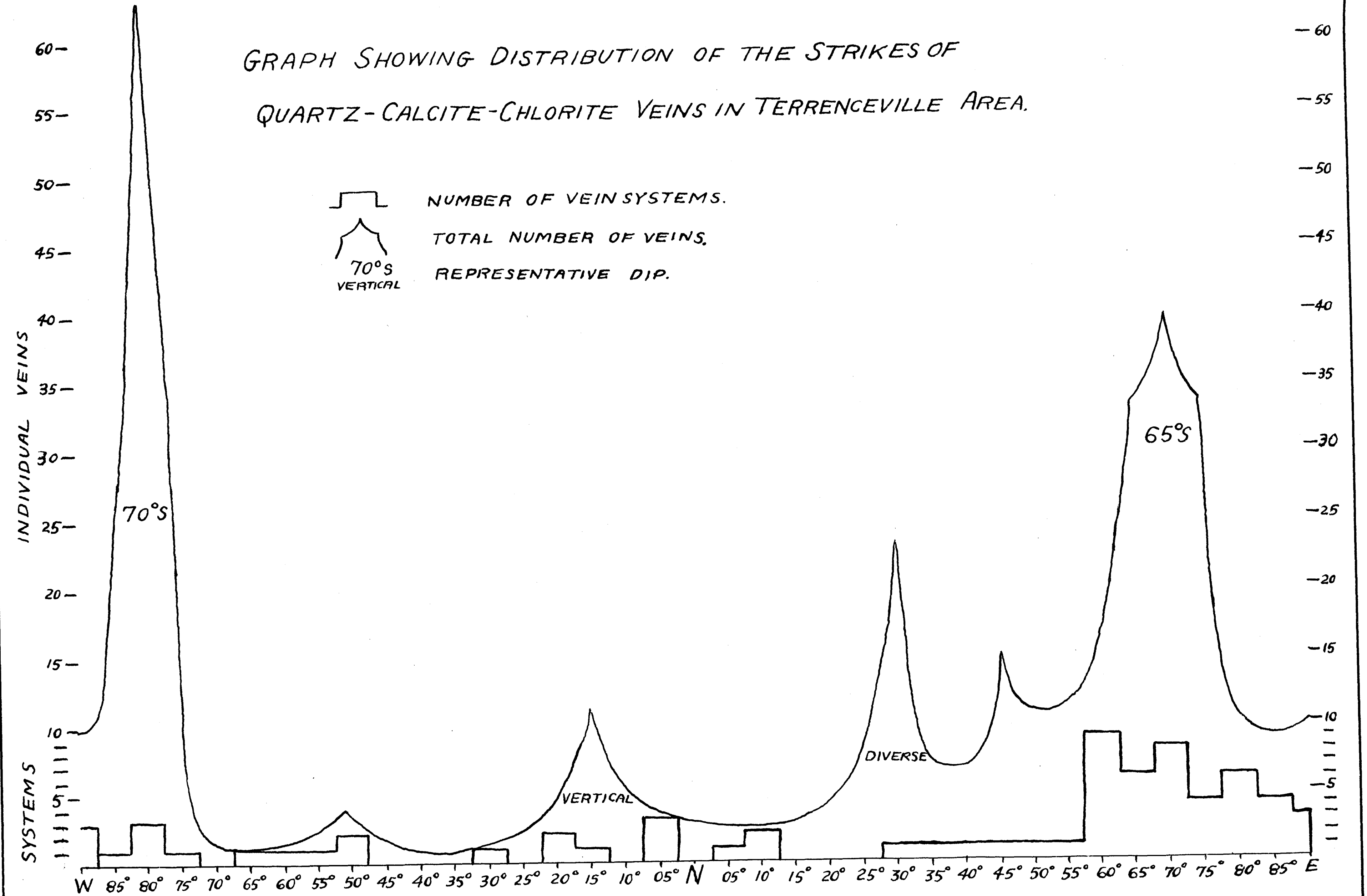


TABLE II.

GRAPH SHOWING DISTRIBUTION OF THE STRIKES OF QUARTZ-CALCITE-CHLORITE VEINS IN TERRENCEVILLE AREA.



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Science
MT
Bradley

PLATE VII

GEOLOGIC MAP OF THE FORTUNE BAY AREA,
NEWFOUNDLAND.

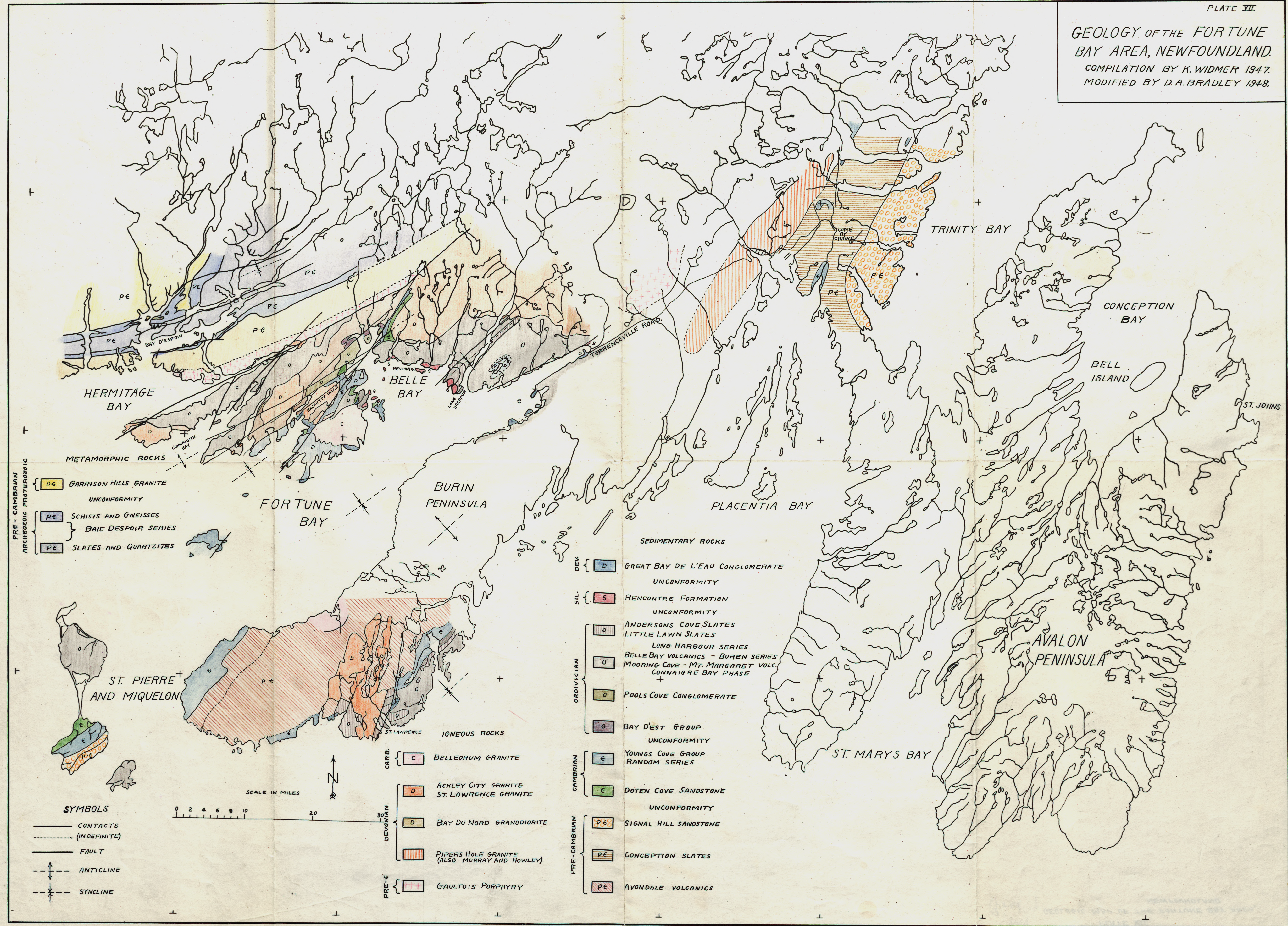


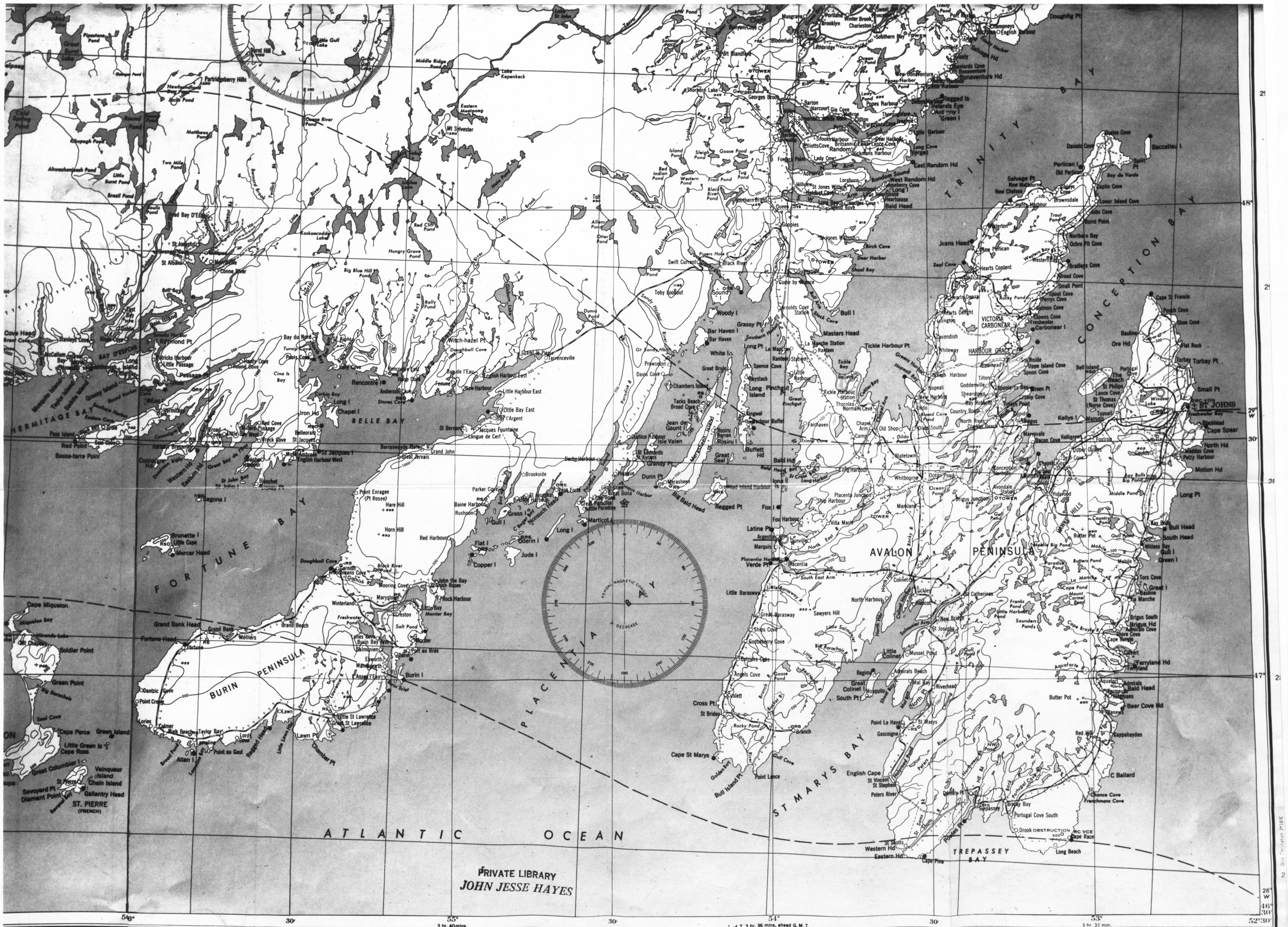
PLATE VII
GEOLOGY OF THE FORTUNE BAY AREA, NEWFOUNDLAND.
COMPILATION BY K. WIDMER 1947.
MODIFIED BY D.A. BRADLEY 1948.
TRINITY BAY
CONCEPTION BAY
BELL ISLAND
ST. JOHNS
AVALON PENINSULA
ST. MARYS BAY
PLACENTIA BAY
BURIN PENINSULA
FORTUNE BAY
BELLE BAY
HERMITAGE BAY
BAY D'ESPOIR
CONNAIGRE BAY
TERRENCEVILLE ROAD
COME BY CHANCE
RENCONTRE
LONG HARBOUR
ST. LAWRENCE
ST. PIERRE AND MIQUELON
METAMORPHIC ROCKS
PRE-CAMBRIAN ARCHEOZOIC PROTEROZOIC
GARRISON HILLS GRANITE
UNCONFORMITY
SCHISTS AND GNEISSES
BAIE DESPOIR SERIES
SLATES AND QUARTZITES
SEDIMENTARY ROCKS
DEV. GREAT BAY DE L'EAU CONGLOMERATE
UNCONFORMITY
SIL. RENCONTRE FORMATION
UNCONFORMITY
ORDIVICIAN
ANDERSONS COVE SLATES
LITTLE LAWN SLATES
LONG HARBOUR SERIES
BELLE BAY VOLCANICS - BUREN SERIES
MOORING COVE - MT. MARGARET VOLC.
CONNAIGRE BAY PHASE
POOLS COVE CONGLOMERATE
BAY D'EST GROUP
UNCONFORMITY
CAMBRIAN
YOUNGS COVE GROUP
RANDOM SERIES
DOTEN COVE SANDSTONE
UNCONFORMITY
PRE-CAMBRIAN
SIGNAL HILL SANDSTONE
CONCEPTION SLATES
AVONDALE VOLCANICS
IGNEOUS ROCKS
CARB. BELLEORUM GRANITE
DEVONIAN
ACKLEY CITY GRANITE
ST. LAWRENCE GRANITE
BAY DU NORD GRANODIORITE
PIPERS HOLE GRANITE (ALSO MURRAY AND HOWLEY)
PRE-€ GAULTOIS PORPHYRY
SCALE IN MILES
0 2 4 6 8 10 20 30
N
SYMBOLS
CONTACTS
(INDEFINITE)
FAULT
ANTICLINE
SYNCLINE

Science
MJ
Bradley

PLATE VI
INDEX MAP OF THE FORTUNE BAY, AREA.
NEWFOUNDLAND.

PURPOSE
SIGNED DATA SHEET
INTERPRETATION

Turbid.



ARMY MAP SERVICE, U. S. ARMY, WASHINGTON, D. C. 100307 3-43

A.M.S. A401 1943
First Edition 1943

LEGEND

Population over 5,000 .... REDON
Population 3,000 to 5,000 .... REDONHIN
Population less than 3,000 .... Redondinha

Light House
Lighting Facilities at Field .... LF

SHEET INDEX

Scale 1:500,000

10 8 6 4 2 0 10 20 30 Miles

10 8 6 4 2 0 10 20 30 40 50 Kilometers

HEIGHTS IN FEET

CONVERSION TABLE
Meters Feet

ARMY MAP SERVICE, U. S. ARMY, WASHINGTON, D. C. 100308 3-43