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THE PHYSICAL GEOGRAPHY OF THE AVALON PENINSULA OF NEWFOUNDLAND

A THESIS

Presented to

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In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

William Francis Summers

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CHAPTER I

INTRODUCTION

I. PURPOSE OF THE STUDY

There is no known account of the Physical Geography of the Avalon Peninsula of Newfoundland, compiled in the style of modern geographic works. Some pertinent information is contained in various publications both old and new, but most commonly as incidental impressions of investigators in other fields of research, such as geology, botany or history. No attempt has been made to collect this material into one work. Furthermore, any material written concerning the Geography of the Avalon Peninsula has been for the greater part descriptive rather than analytical or interpretative. It consequently lacked the qualifications which are the essential basis for a modern geographical report.

The purpose of this report is, therefore, to analyse the various elements of the Physical Geography of the Avalon Peninsula, showing the relationship between each and the combined relationship with the overall economic pattern of the district.

II. IMPORTANCE OF THE PROBLEM

The majority of people are unaware of the factors which were instrumental in forming the features of their environment and they are equally unaware of how important a part these features play in their mode of life. It is believed that an improved knowledge of the physical features of environment is essential in an area such as the Avalon Peninsula, where the natural resources are sometimes unwisely and incorrectly employed. It is hoped that much of the material in this work can be utilized in fostering a more intelligent use of the natural resources.

III. ORGANIZATION OF THE WORK

The body of this work is divided into six parts, each of which is considered to constitute an element of the physical geography of the area under consideration, and between which a relationship is capable of being established, showing the degree of influence of each upon the other. The final chapter is dedicated to summarizing these relationships.

The first part deals primarily with the surface features of the Peninsula; a geological sketch shows the age relationship of the rock structures and discusses major tectonic forms. The topographical features due to the course of normal fluvial erosion and subsequent alteration by glacial scouring and deposition are treated under pertinent headings. The Peninsula is also divided into five Physiographic Divisions, which are discussed in their various aspects.

A brief review of the soil types found on the Peninsula and their regional distribution is presented in the next section. The formation and structure of these soils are discussed briefly, and there follows a section on soil use.

The natural vegetation of the Peninsula is treated under three main groups, the most important of which is considered to be the forest, which is therefore given fuller treatment. The others are bog and barren which are of great areal extent, but little economic importance. There is an Appendix giving popular and botanical names of plants used in identification of site-types.

A chapter on glaciation gives a brief history of the various theories concerning the events of Pleistocene time, as they affected the Avalon Peninsula, and discloses new evidence in favour of one of these theories. This section also deals with the effects of glaciation on the Peninsula.

A general picture of the climate in and about Newfoundland is presented next. The climate of the Avalon Peninsula is compared and contrasted with that of the rest of Newfoundland and the results are shown on a series of maps and charts. An Appendix contains statistical data of various meteorological observations.

The last section of the body of the work attempts to show the relationship of all the foregoing elements to the economic life of the Peninsula.

The work concludes with a summary, the main purpose of which is to stress the importance of the striking interrelationship between the topics discussed.

Maps and figures are distributed throughout the report, in places considered advantageous for reference. A set of photographs taken during field reconnaissance on the work is placed together after the Summary.

IV. REVIEW OF PREVIOUS RELATED STUDIES

Literature written prior to 1800 pertaining to the physical geography of the Avalon Peninsula is very scarce. Some of the early visitors to Newfoundland from Europe wrote sketchy reports of conditions in the Island, but since most of the country up to that time was unexplored the information was limited and of little value. One scientific work of interest , written by Sir Joseph Banks (96)[1] in 1766, gave a short account of the natural history of parts of the country, as well as a long list of plants which were collected by the author. The original manuscript in Latin is kept in the Redpath Library of McGill University in Montreal.

In 1822 W. E. Cormack (4) set out on a journey across Newfoundland and having successfully completed the trip, returned to St. John's by boat, visiting places on the

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[1] Bibliographical numeration at end of work.

South Coast and the Avalon Peninsula. The personal account of his travels contains much information of interest. Cormack was a keen observer, and this work contains much geological, geographical and botanical data, the bulk of which, however, pertains to other places in Newfoundland than the Avalon Peninsula.

The first Government Geologist in Newfoundland was J. B. Jukes (13) (55). The observations of geographical phenomena in and about the Avalon Peninsula which are contained in his reports are still of great value. His reports fill two volumes which also contain a great deal of useful information on the physiography and natural history of the Peninsula, although the greater portion of the work concerns the other sections of Newfoundland that he visited.

In the latter half of the nineteenth century, the position of Government Geologist was filled by Alexander Murray, assisted by J. P. Howley, who later succeeded him in this position (60) (62) (63). The official reports presented by these men contain the only available geological information referring to certain sections of the Peninsula. Murray wrote several articles on the Physical Geography of the whole Island (61), which were published around that time. These contain one of the first lengthy accounts of glaciation in Newfoundland. Prior to this, in 1876 and 1877 J. Milne (57) (58) contributed several articles on glaciation, geology and the physical features of the Island. A very general account of the physical geography of Newfoundland by J. Moncton (59) was published in 1864. In 1870 a description of ice marks in Newfoundland was written by J. H. Kerr (89), most of which were observed on the Avalon Peninsula. Towards the close of the nineteenth century, in 1894, Wright (95) and Chamberlin (76) (77) published notes on the glaciation of Newfoundland. In 1896, Robinson and Von Schrenk (106) published information on the flora of Newfoundland, and in the following year Dr. R. Bell (97) included some information on the trees of Newfoundland in a work concerning the distribution of forests in Canada. During this decade Waghorne (107) also presented a wealth of material on the flora of Newfoundland. There were two important historical works published in this period, one by Pedley (21) and another by Prowse (24). Each of these volumes contained a little general geographic information. In the early years of 1900 the publication of literature related to the Physical Geography of Newfoundland was more plentiful. Many scientists and observers visited Newfoundland to study interesting problems concerning geology and botany. In 1909 Eames (99) contributed further to the knowledge of Newfoundland's flora and two years later Fernald (101) produced the first of his many accounts on the same topic.

Twenhofel (67) (68), who later contributed generously to the literature on the physiography, geology and glaciology of Newfoundland, published his first article on these topics in 1912. In 1910 an excellent historical geography of Newfoundland was published by Rogers (25) followed in 1913 by a general geography of the Island by R. Perret (22).

The period from 1914 to the present day produced a considerable amount of pertinent literature in a variety of forms. Reports of geologists employed on the Avalon Peninsula are particularly interesting. The most important of these include contributions by A. O. Hayes (51) (52), Buddington (41) (42) (43) and Vhay (69) in Conception Bay, as well as various works by Snelgrove (65) who was Government Geologist for part of this period. Twenhofel carried on his reaearch on the physiography and glaciation of Newfoundland and was later assisted by MacClintock. Fernald (84) published data on the problems of vegetation and glaciation. Glacial research was also carried out by Coleman (80) and Flint(86), the results of which are of great interest. Many articles of general geographic interest appeared in periodicals during this period, and one very important volume on economic, diplomatic and strategic studies of Newfoundland was published by R. A. McKay (16).

The bulk of available literature is therefore seen to be comprised mostly of geological, physiographical, glaciological and botanical material as well as a great deal of general geographic knowledge. In most cases, however, this information is general and usually pertains to all of Newfoundland. A recent Government publication from the Geographical Bureau at Ottawa by B. V. Gutsell (8) is perhaps the best modern geographical treatise on Newfoundland. The interior of Avalon and much of its coastline is still little better known than it was in the days of the early explorers.

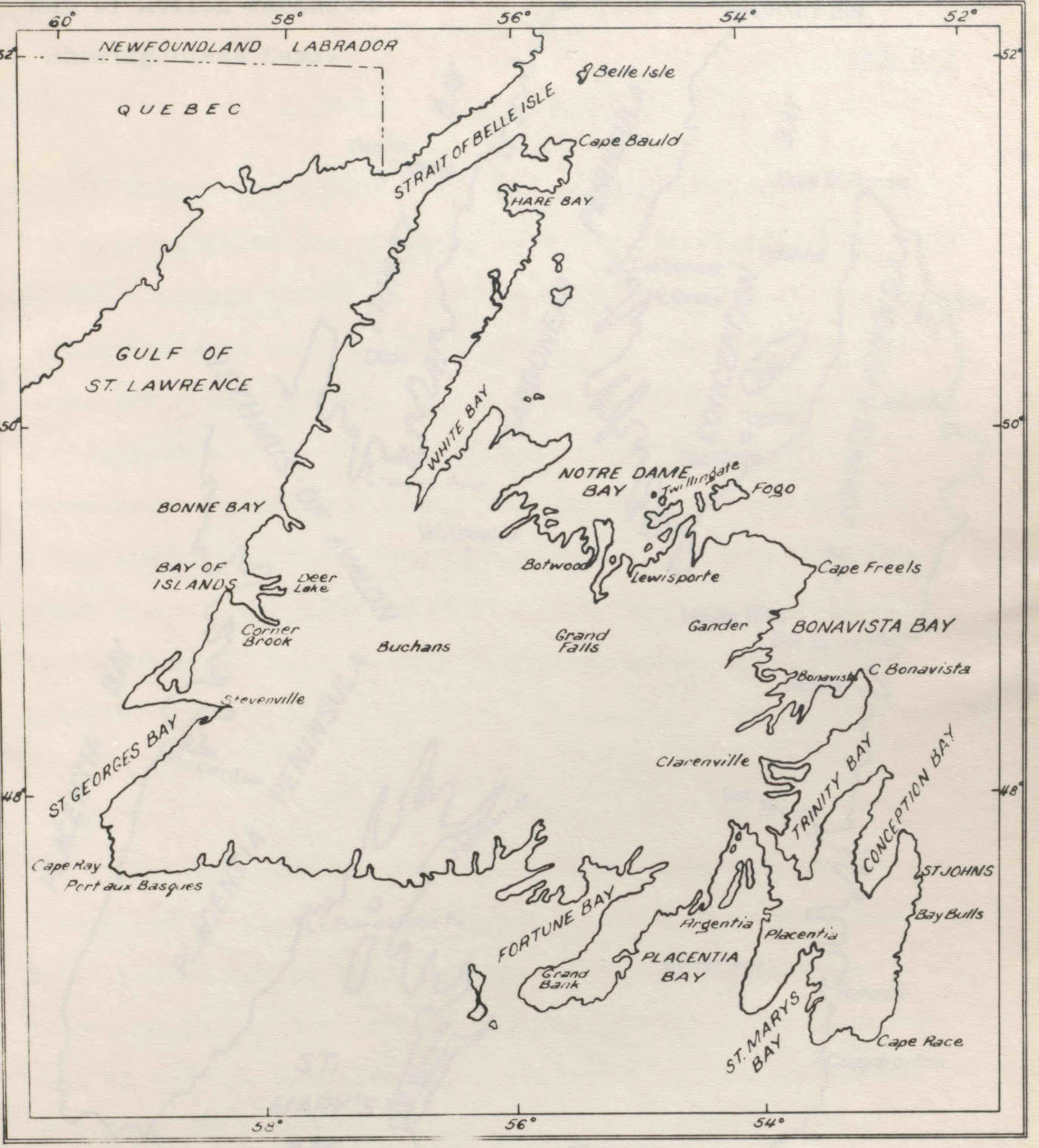
Climatological data concerning Newfoundland is not plentiful. Middleton (12) published a work on the climate of the Gulf of St. Lawrence and Newfoundland regions. Koeppe (111) included the Island in his volume on the Canadian climate. The various text books on climatology usually contain a small section on Newfoundland.

Any work written and concerned with the Physical Geography of Newfoundland is either very general and incomplete or treats the subject in a superficial manner.

In this report on the Avalon Peninsula data is presented which is only partly derived from the aforementioned sources. Most of the observations are those of the author, obtained during research in the field, and from a lifetime knowledge of the area. Where the theories or observations of others are cited reference is made to the source.

Geological data in the section on Physiography is taken from the combined reports mentioned above, as is also the material used to compile the geological sketch map. The bulk of the climatological data has been derived from the records and maps of the Meteorological Department at Torbay Airport. Information on the ice limits in Newfoundland coastal waters was obtained from the American Ice Atlas, and the average surface temperatures in coastal waters were obtained from Newfoundland Fishery Board reports. Base maps, showing drainage, physiography, etc., were taken from the 10 mile map of the Province of Newfoundland issued by the Surveys and Mapping Bureau of the Department of Mines and Resources at Ottawa. Maps R-1 and R-2, showing regional location of places mentioned throughout the text were taken from maps of the Surveys Division of the Department of Natural Resources, in Newfoundland. Submarine topography in this section of the North Atlantic was compiled from a map by Spencer (94) made in 1903.

Map R-1

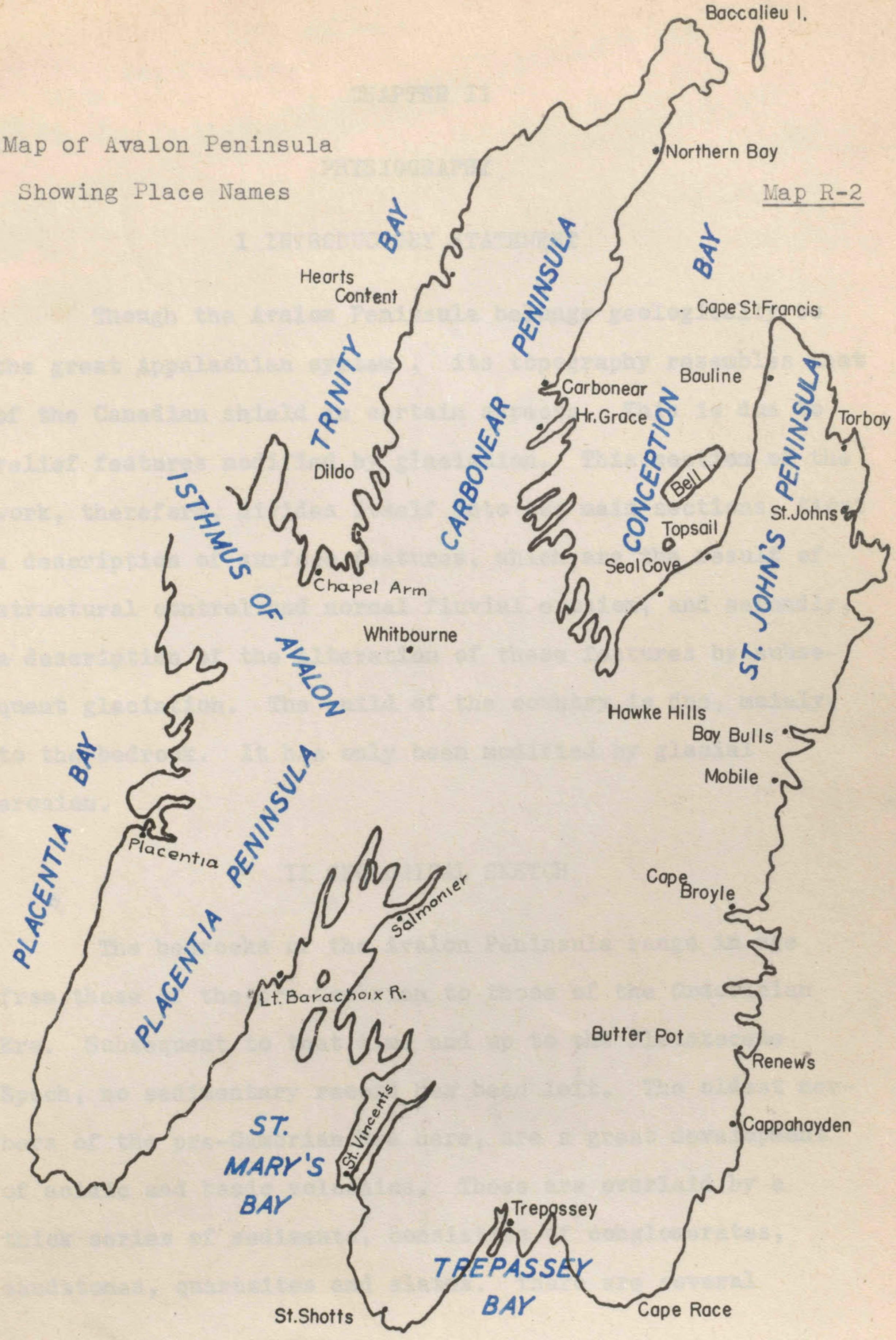


MAP OF NEWFOUNDLAND SHOWING PLACE NAMES

Map of Avalon Peninsula

Showing Place Names

Map R-2



CHAPTER II

PHYSIOGRAPHY

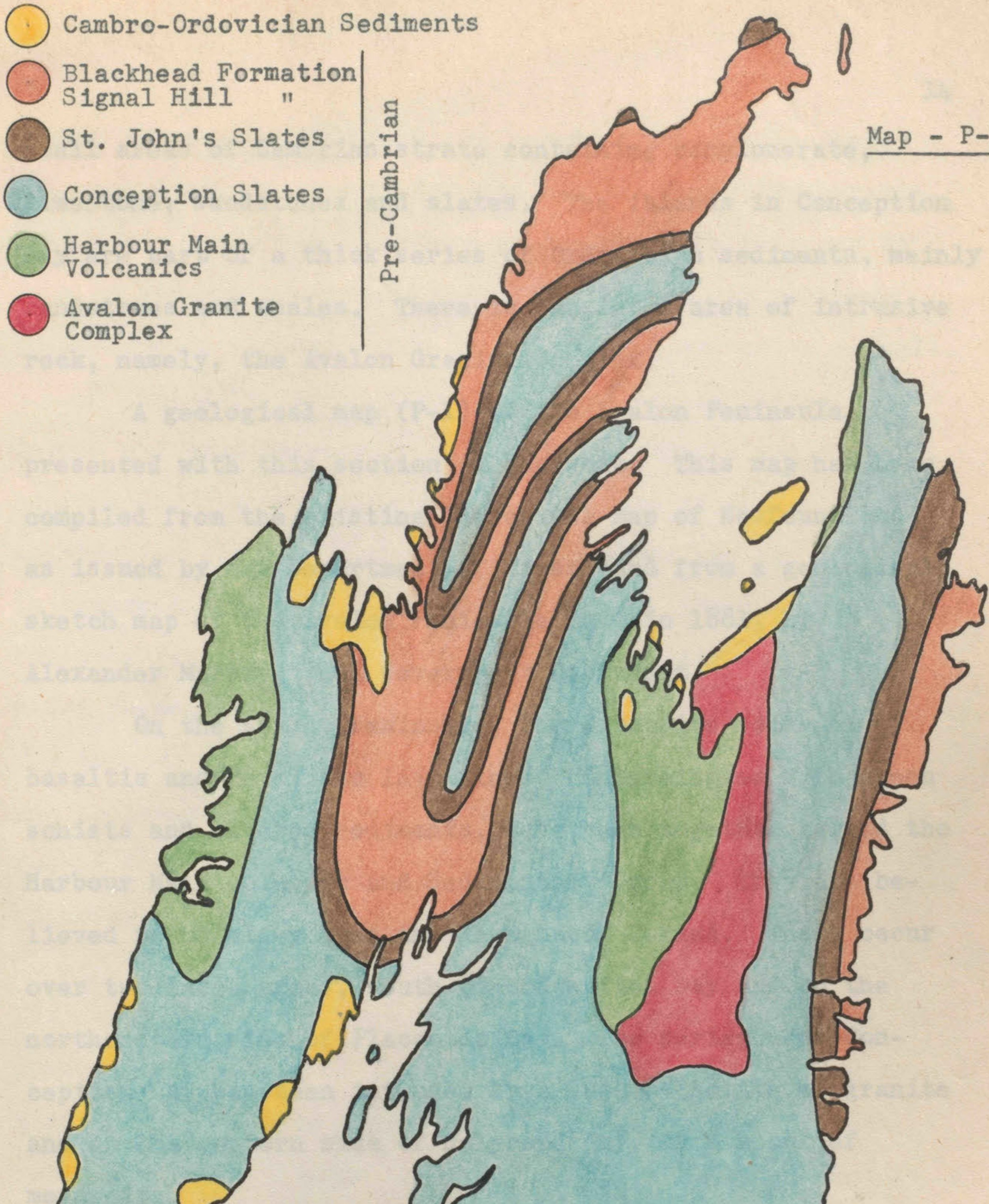
I INTRODUCTORY STATEMENT

Though the Avalon Peninsula belongs geologically to the great Appalachian system , its topography resembles that of the Canadian shield in certain aspects. This is due to relief features modified by glaciation. This section of the work, therefore, divides itself into two main sections, first a description of surface features, which are the result of structural control and normal fluvial erosion, and secondly, a description of the alteration of these features by subsequent glaciation. The build of the country is due, mainly, to the bedrock. It has only been modified by glacial erosion.

II GEOLOGICAL SKETCH

The bedrocks of the Avalon Peninsula range in age from those of the pre-Cambrian to those of the Ordovician Era. Subsequent to that time and up to the Pleistocene Epoch, no sedimentary record has been left. The oldest members of the pre-Cambrian Era here, are a great development of acidic and basic volcanics. These are overlaid by a thick series of sediments, consisting of conglomerates, sandstones, quartzites and slates. There are several

Map - P-1



GENERALIZED GEOLOGICAL MAP

small areas of Cambrian strata containing conglomerate, limestone, sandstones and slates. The islands in Conception Bay are part of a thick series of Ordovician sediments, mainly sandstones and shales. There is one large area of intrusive rock, namely, the Avalon Granite Complex.

A geological map (P-1) of the Avalon Peninsula is presented with this section of the work. This map has been compiled from the existing Geological Map of Newfoundland as issued by the Department of Mines, and from a geological sketch map of the Avalon Peninsula made in 1881, by Alexander Murray, then Government Geologist.

On the Avalon Peninsula, the extrusive rocks of basaltic and rhyolitic lava flows, intermingled with green schists and altered sediments, have been together termed the Harbour Main Volcanic and Sedimentary Group. They are believed to be older than the Keweenawan Period. These occur over two large areas, south of Conception Bay and on the northeastern side of Placentia Bay. The series near Conception Bay has been intruded by a huge batholith of granite and on the western side of Holyrood Bay, by a stock of monzonite.

A series of sedimentary rocks, some 26,000 feet thick were laid down on this older volcanic group. The whole area, at the end of the pre-Cambrian Era, was folded and faulted, and after uplift, subjected to a long period of erosion. In early Paleozoic time, the landscape was once again covered by the sea and the Cambro-Ordovician Series was deposited. Members of the Cambrian beds can be seen in several scattered localities. These are believed to be erosion remnants of a once much more extensive deposit.

During Paleozoic time, the rocks of the Avalon Peninsula suffered repeatedly from earth movements and were compressed into mountains that formed part of the great Appalachian system. They were again folded and faulted in Mesozoic time and eventually levelled. There then followed several consecutive periods of uplift and erosion, which formed the flat topped uplands of the present topography. The intense folding, to which the pre-Cambrian volcanic and sedimentary formations were subjected has had the result of producing major synclinal and anticlinal structures.

The youngest members of the pre-Cambrian sediments are the Signal Hill Group. This Group may be seen on the most eastern shores of the Avalon Peninsula, where they form a northwest pitching syncline, the western limit of which holds the coast through its length (Photo 12). The eastern limb outcrops only at Cape Spear. Underlying the Signal Hill Group is the Conception Slate Group. In a series of anticlines and synclines, with northeast-southwest axes, the members of these groups outcrop throughout the whole of the Avalon

Peninsula. The younger group appears again several times on the Peninsula between Trinity and Conception Bays and possibly comprises a considerable amount of the bedrock in the central portion of Avalon, north and northwest of St. Mary's Bay. The older Conception Slate Group has its greatest extension from the St. John's Peninsula to St. Mary's Bay, and is also extensive south of the volcanics in Placentia Bay. There are smaller occurences in the folds of truncated anticlines and synclines in the Carbonear Peninsula.

Most faulting on the Avalon Peninsula has occurred as thrusts. Fault planes generally run northeast and southwest, in agreement with the structural trend of the whole area. There are many minor faults throughout the whole territory, but the known major ones are given here. A fault at least thirty miles long forms the eastern side of Conception Bay from Cape St. Francis to Topsail. It then runs southward along the contact zone of the granite batholith and the Conception Slates. Another major fault starting at the head of Conception Bay is believed to continue on underneath the water in the centre of the bay, to cut off the Cambro-Ordovician sediments from those of the pre-Cambrian sediments. There is a likelihood of other large faults along the shores of St. Mary's Bay and on the east coasts of Placentia and Trinity Bays.

Most strata on the Avalon Peninsula is steeply tilted, due to the intense folding. An exception to this is found in the Cambro-Ordovician formations of Conception Bay. Here the beds have a northwest dip of about 20 degrees, which is observed in all the localities where these rocks outcrop.

III. GENERAL STRUCTURAL FEATURES

The section on geology has pointed out the striking feature of the parallel lineaments of the structure of the Avalon Peninsula. The axes of most folds, the major faults and contact zones, and the sides of the larger bays, all trend in a northeast-southwest direction.

It has been suggested that these larger bays are fiords. Amongst the evidence cited is the steep nature of their sides, the belief that glaciers flowed into all the bays and the presence of underwater sills across the mouths of two of them. Though it can hardly be doubted that each of these bays was the recipient of a considerable quantity of glacial ice, it does not seem correct to call them fiords. They are all very wide and some of them contain large islands. The glaciers which flowed into them were probably only agents of slight alteration rather than of formation. It seems much more likely that these bays were pre-glacial, if not as bays, at least as extensive lowlands in the existing higher terrain. In support of this theory are the submerged river channels on the ocean bed of the continental shelf. The submarine topography on map P-2 shows channels leading out from Placentia and Trinity Bays, as well as parallel channels off the east coast of the Peninsula. The northern channels extend to the edge of the continental shelf and the southern ones join the Laurentian Channel south of the Banks of Newfoundland. Indications of old fault zones throughout the length of those bays suggest that they were zones of weakness. It is also probable that before peneplaination they were the basins of Cambro-Ordovician rock. Remnants of the strata of these series are found skirting all the major bays, usually on lowlands. Even some of the smaller bays, such as those on the south-west side of Conception Bay, and on the northeast side of St. Mary's Bay would suggest a "ria" coastline rather than glacial fiords, although undoubtedly they were deepened and altered by glaciation. The east-west aligned bays of the east coast and some in St. Mary's Bay are more probably fiords, for they are narrow and deep, and run across the major structure.

It is suggested then that all the major features of the Avalon Peninsula, that is, the four sub-peninsulas and the four large bays, are all a result of the pre-dominant northeast-southwest trend of the structural features of the bedrock.

IV. PENEPLAINS

The development of peneplained surfaces on the Avalon Peninsula is apparent in certain areas. Twenhofel and MacClintock[2] have suggested that there are three erosion surfaces present, the upper two of which correspond with the Lawrence Peneplain and the High Valley Peneplain which they have defined in the western and central sections of Newfoundland. They suggest that the third is represented by a considerable portion of gently rolling land at an elevation of 200-300 feet. The following table[3] shows the suggested relationship:

PENEPLAIN	WESTERN MOUNTAINS	AVALON PENINSULA
Long Range	Around 2000 feet	Over 1000 feet and destroyed
High Valley	1300 - 1700 feet	700 - 800 feet
Lawrence	500 - 1000 feet	350 - 400 feet

The third erosion level of the Avalon Peninsula is not included here.

Unfortunately, only a fraction of the Avalon Peninsula has been mapped topographically. There are only two contour maps available, the St. John's sheet and the Bay

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[2] Twenhofel, W. H. and MacClintock, P., "The Surface of Newfoundland." Bull.Geol. Soc.Am., 51(11):p.1718,1940.

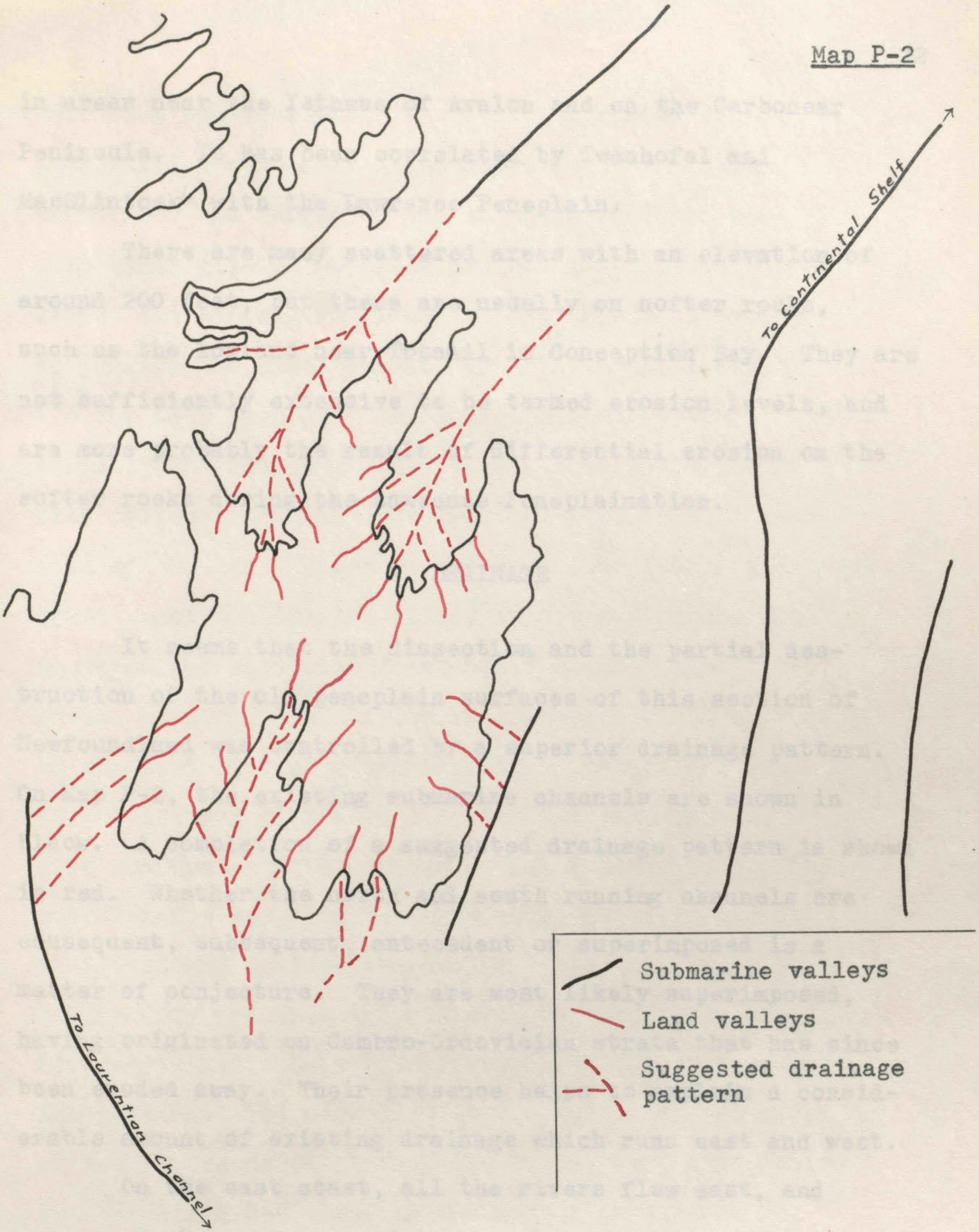
[3] Ibid., p.1721.

Bulls sheet, and the latter is not even completely marked with contour lines. It is impossible, therefore, to correlate with any degree of accuracy the different erosion levels on the Peninsula. However, certain spot heights are available, and surface observation shows a definite development of plateaus or erosion levels at different elevations.

There is a range of hills stretching from Holyrood in Conception Bay to Renews on the east coast, which is known as the Hawke Hills. These hills are carved mainly from the extensive granite batholith which lies in the same area. The average elevation of this range is between 700 and 800 feet, but there are a few peaks that rise above 1000 feet. It is suggested that these are monadnocks and that the average elevation is the surface of the High Valley Peneplain. Many points on the upland near Placentia and on the St. John's and Carbonear Peninsulas are also found to have an elevation of this order. The horizontal aspect from the top of one of these hills strongly suggests an erosion level at this height.

By far the greater portion of the Avalon Peninsula has an elevation between 300 and 500 feet. This level is widely represented by gently rolling topography along the east and south coasts and in the central morainal country, but by more scraggy and scarplike topography

Map P-2



SUGGESTED DRAINAGE BEFORE SUBMERGENCE

Submerged valleys after Spencer (Bibliog. 94) in areas near the Isthmus of Avalon and on the Carbonear Peninsula. It has been correlated by Twenhofel and MacClintock[4] with the Lawrence Peneplain.

There are many scattered areas with an elevation of around 200 feet, but these are usually on softer rocks, such as the lowland near Topsail in Conception Bay. They are not sufficiently extensive to be termed erosion levels, and are more probably the result of differential erosion on the softer rocks during the Lawrence Peneplaination.

V. DRAINAGE

It seems that the dissection and the partial destruction of the old peneplain surfaces of this section of Newfoundland was controlled by a superior drainage pattern. On Map P-2, the existing submarine channels are shown in black. A completion of a suggested drainage pattern is shown in red. Whether the north and south running channels are consequent, subsequent, antecedent or superimposed is a matter of conjecture. They are most likely superimposed, having originated on Cambro-Ordovician strata that has since been eroded away. Their presence helps to explain a considerable amount of existing drainage which runs east and west.

On the east coast, all the rivers flow east, and

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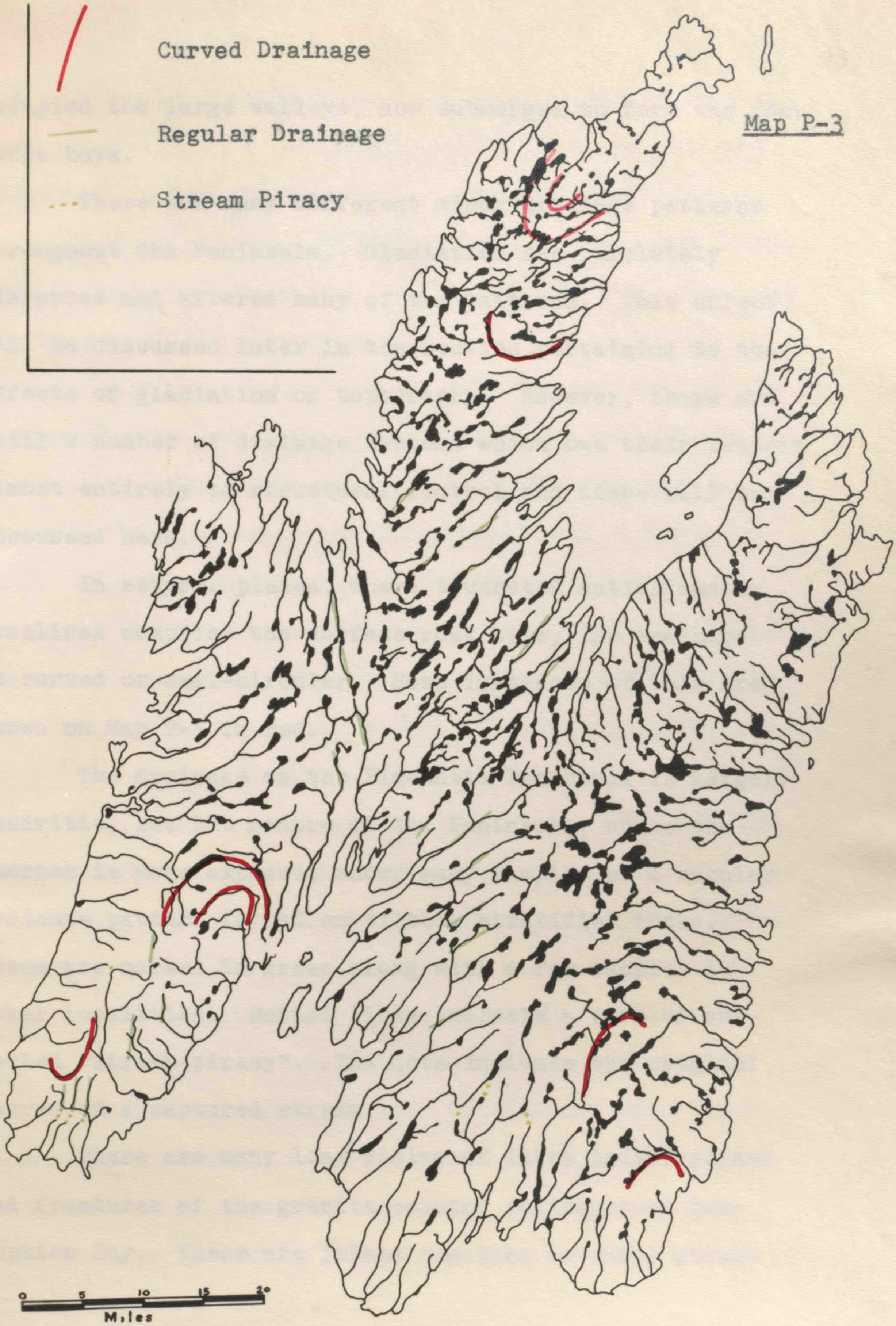
[4] Twenhofel, W. H., and MacClintock, P., loc.sit.p.1721

they have cut deep valleys across the strike of the pre-Cambrian sediments which dip towards the east throughout the length of the coastline. There was also later glacial movement towards the east on this coast, but the mature river valleys (Photo 1) seem to predate the glacial activity. The major rivers flowing into Trepassey Bay follow the structural lines of the bedrock. In St. Mary's Bay, the rivers flow obliquely to the southwest and southeast on each side of the bay. Those on the east side follow the fault zones and bedding planes of the sediments, but those on the west side flow mostly against the "grain" of the country. The latter is also true of the rivers on the east side of Placentia Bay. The northern side of the Isthmus of Avalon has north flowing rivers, here conforming with structure, but the rivers flowing into Trinity Bay from the Carbonear Peninsula are all east-west and against the strike of the strata. Conception Bay presents the converse of conditions in St. Mary's Bay. Here the rivers flow obliquely to the northeast and northwest on the west and east sides of the bay respectively. Those on the west side follow the structure but those on the east flow against it. It is thus suggested that all the major rivers of the Avalon Peninsula were tributaries to major arteries that

Map P-3



DRAINAGE MAP

occupied the large valleys, now submerged to form the four large bays.

There are many different minor drainage patterns throughout the Peninsula. Glaciation has completely disrupted and altered many of the patterns. This effect will be discussed later in the section pertaining to the effects of glaciation on topography. However, there are still a number of drainage systems which owe their pattern almost entirely to structural control and these will be discussed here.

In several places, where truncated anticlines or synclines comprise the surface rock type, the drainage is curved or semi-circular. Some instances of this are shown on Map P-3 in red.

The drainage on the Placentia Peninsula is largely dendritic, but the centre of the Peninsula, where the bedrock is more exposed, shows many samples of a regular drainage pattern formed on tilted, stratified rocks. These are marked in green along with a few samples in other localities. Dotted lines indicate a case of suspected "stream piracy". The dots indicate the original course of a captured stream.

There are many long chains of lakes in the joints and fractures of the granite country southwest of Conception Bay. These are joined together by short rivers and are mostly blocked by glacial debris, though some of them are rock-rimmed and represent scouring by the rock "load" of an ice sheet. Those lakes and rivers have a vague sort of pattern, following the fractures and joints. This is not evident on the small scale map but stands out on the aerial photographs.

There is a difference in drainage patterns on the different types of rocks, even within the sedimentary formations. The drainage on the granite batholith is greatly disorganized, with the exception of a few areas with the joint pattern just described. This area, because of its resistant nature, has formed an upland and it was consequently subjected to severe glacial scouring. The drainage on the areas of the extrusive or volcanic rock is also very erratic. Here differential erosion of bedrock with different degrees of hardness has left high massive hills as part of a very rough and irregular topography. The regions of sedimentary rock show differences between "shale" country and areas of resistant sandstone or conglomerate. Though mature profiles in any of the rivers are few, due to the periodic uplift of the region, those which have sections of their lower courses eroded nearly to base level are generally found on a soft shale or a much fractured and faulted slate. Examples are in some of the rivers flowing into the Atlantic on the east coast (Photo 1), the large rivers at the head of St. Mary's Bay and a few of the streams which enter Conception Bay from the Carbonear Peninsula. The more resistant sedimentary rocks present more formidable obstacles to the rivers in carving out their valleys. Such streams will be found to contain numerous waterfalls and rapids throughout their length.

VI COASTAL FEATURES

The seacoast around the Avalon Peninsula is almost everywhere precipitous. Exceptions are the lowlands in Conception and Trinity Bays and the heads of some of the smaller bays, which are the continuation of large river valleys. The coastline is one of submergence as evidenced by the drowned river valleys, and coastal stacks or chimneys, caves and natural arches, and the isolated islands around the coast (Photo 2). Precipitous sea cliffs are, generally speaking, structural features. The tilted strata along the east coast of the Peninsula presents a dip-slope towards the sea. The continual pounding of waves against these upturned sedimentary beds, combined with the coastal mass-wasting, has formed the high cliffs that are almost continuous along this coast. In some places there is a sheer drop of as much as 500 feet to the sea. In most other places, it is less severe, averaging perhaps only 100 feet, and at Renews, there is even the suggestion of a coastal plain carved out of the soft slates of the underlying sedimentary series.

In Conception Bay, the northeast shore is a fault scarp. Here in places, the coastal cliffs rise almost straight out of the water to elevations of 700 and 800 feet. Along the southwestern shore of this bay, the soft shales, limestones and sandstones of the Cambrian rocks have been eroded down to meet the sea at a gentle slope all along this coast. The few cliffs that do exist on this shore are composed of glacial debris and are being rapidly eroded back by the sea.

Bell Island, which is roughly rectangular in shape, is formed of Ordovician sediments, which dip gently to the northwest. It has precipitous sides all around, averaging 150 feet in height. These are probably on fault lines, and the southeastern side appears to be a fault scarp.

The southern and southwestern coasts of Conception Bay appear to constitute a "ria" coastline. Here, there are numerous long arms projecting out into the bay, parallel with the strike of the rocks and with the fault lines in this locality.

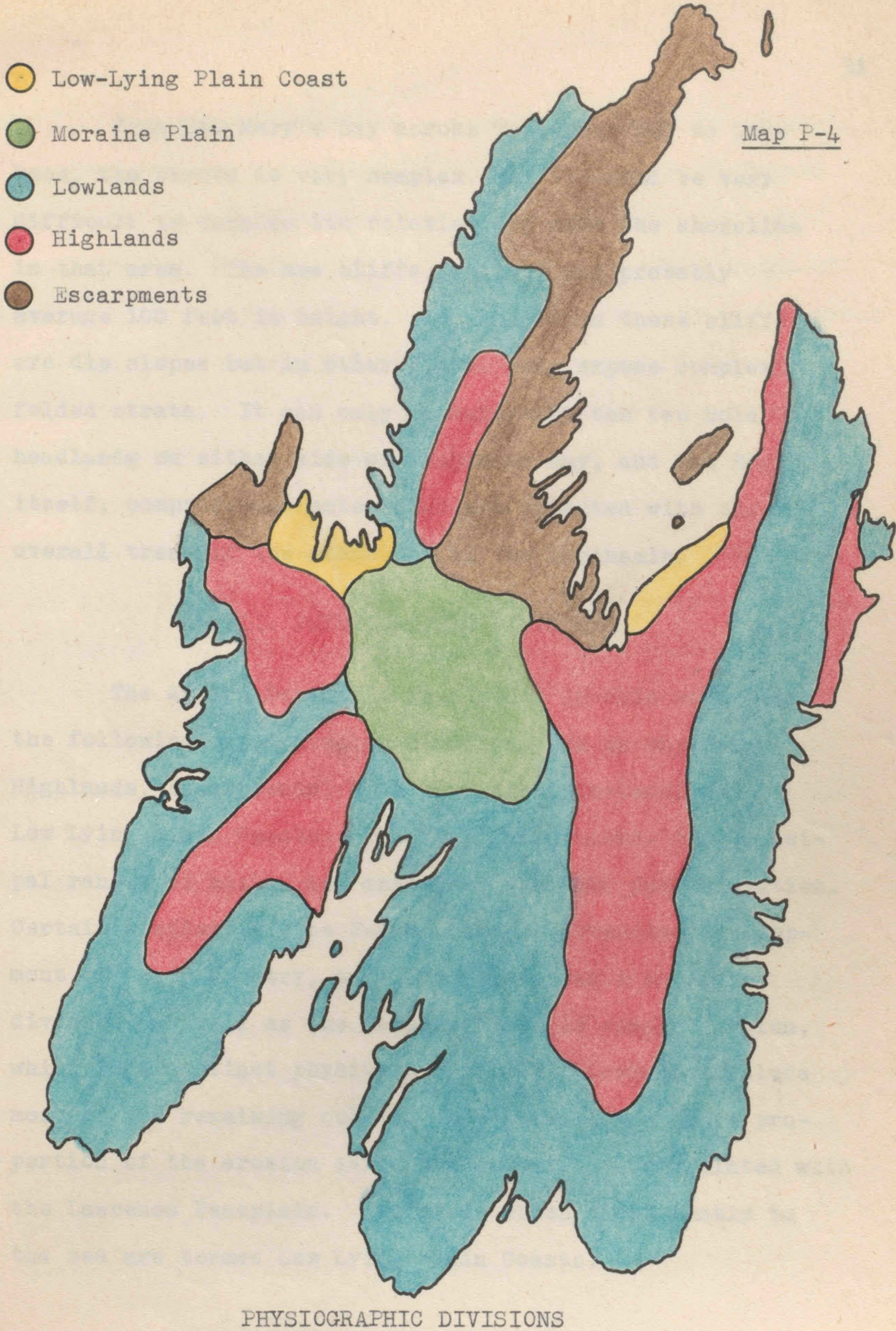
The entire coastline of the Carbonear Peninsula, from Northern Bay on its eastern side around to Heart's

Content on the western side presents a bold, upright face to the sea. There does not seem to be any continuous relation between the form of this coastline and the strike or dip of the rocks which compose it. These sheer cliffs which are the main feature of this coast and Baccalieu Island probably lie along major fault zones.

The entire eastern and southern sides of Trinity Bay are probably shaped by faults, but the area from Heart's Content south to Dildo and then northwest to Chapel Arm is one mainly of soft sedimentary rocks upon which erosion has been very efficient. There are few steep cliffs here and the coastal and inland topography becomes increasingly gentle as we move south. Around Dildo, low-lying land stretches inland from the sea.

The east and west coasts of the Placentia Peninsula are very similar. There are pockets of Cambrian rock all along these coasts and again in these places, there are relatively flat areas adjacent to the sea. Otherwise, the coast is precipitous and seems to be a combination of fault lines and dip slopes.

The north and east sides of St. Mary's Bay contain another "ria" coastline. Most of the area is of soft rocks and there are few high sea cliffs. The area is very similar to the southwest shores of Conception Bay.



PHYSIOGRAPHIC DIVISIONS

From St. Mary's Bay across Trepassey Bay to Cape Race, the strata is very complex, and it would be very difficult to surmise its relationship with the shoreline in that area. The sea cliffs are bold and probably average 100 feet in height. In some cases these cliffs are dip slopes but in other places they expose complexly folded strata. It can only be said that the two hold headlands on either side of Trepassey Bay, and the Bay itself, comprise elements which are oriented with the overall trend of the structure of the Peninsula.

VII. PHYSIOGRAPHIC DIVISIONS

The Avalon Peninsula is divided in this work into the following physiographic divisions (as on Map P-4), Highlands, Escarpments, Moraine Plains, Lowlands and Low Lying Plain Coasts. The Highlands include the principal ranges of hills, and most land over 700 feet elevation. Certain sections of the Peninsula show extensive development of scarp country, and these are given a separate division, as well as the Moraine Plain in central Avalon, which is a distinct physiographic unit. Lowlands include most of the remaining country, or in reality a great proportion of the erosion surface that has been correlated with the Lawrence Peneplain. The areas which slope gently to the sea are termed Low Lying Plain Coasts.

The largest Highland area runs from Cape St. Francis on the northern tip of the St. John's Peninsula southward to beyond the southernmost end of the granite batholith that lies south and east of Conception Bay. This range of hills lies in three types of rock, the Harbour Main Volcanics and Sediments which flank the eastern shores of Conception Bay, the Avalon Granite Complex, and resistant members of the Conception Slate Group west of Renews. The greatest elevation of a little over 1000 feet is attained in the granite country. The topography is rugged, the faces of the hills being precipitous, and almost the entire Division is barren. An exception is in the northern section where the hill slopes are well wooded.

The large Highland on the west of the Peninsula and the small area to the northeast of it are developed mostly on the more resistant rocks of the Signal Hill Group of sediments. Some of the high peaks of the range north of Placentia are on Harbour Main Volcanics. These ranges of hills are less rugged than those in the granite area, and form a more or less level and continuous ridge throughout their length. A small upland of similar origin occurs near St. John's. It runs along the coast for some twenty miles as a series of ridges with elevations over 700 feet in many places. These ridges are composed of sandstone and conglomerate of the Signal Hill Group of sediments.

There is a large development of scarp country along the western shores of Conception Bay, and a similar area on the Isthmus of Avalon. The average strike of the beds in the Conception area is northeast-southwest, and most of these scarps, formed as a consequence of differential erosion around resistant beds, or by fault lines, are aligned in that direction. This Division probably contains many elevations over 700 feet, but because of the distinctive topographic features, it was thought better to group it separately under the heading of Escarpments. These scarps are certainly a striking feature of this section of the Avalon Peninsula. On the Isthmus of Avalon, the scarps are developed on anticlinal and synclinal folds. The interscarp valleys carved out of softer strata are usually at the head of the many long narrow bays. In such localities, there is usually extensive agricultural development.

There is a large area of land in the centre of the Avalon Peninsula which is classified as Moraine Plain. It is a gently rolling terrain with typical morainal features. Here there are literally thousands of small ponds with a northeast-southwest alignment. These are formed along the margin of morainal ridges and in the depressions of this type of glacial topography. Photo 3 is a view of the landscape near Whitbourne where the land has been cultivated on this Moraine Plain. Further east there is an extensive stretch of mature virgin forest intermingled with many marshes and bogs. Further discussion of this Division will follow in the section on Glacial Topography.

The lower sections of Trinity and Conception Bays show small areas, coloured yellow on the map, which have been termed Low Lying Plain Coasts. These are both formed in soft sandstones, shales and limestones of the Cambrian age. The development of this type of topography is more extensive in Conception Bay (Photo 4). Here a narrow plain stretches from Topsail Head, where the Cambrian rocks are in faulted contact with the Harbour Main Volcanics, southwest to Holyrood in a narrow coastal strip varying in width from one to four miles. The coastline consists of a "cobblestone" beach throughout its length. This beach contains well rounded stones averaging two or three inches in diameter, which are mostly made from the harder rock material of the glacial till. They may be seen in the background of Photo 4. There are many small inlets at the mouths of the rivers which have been bridged by this material. One such bar-like beach cuts across the mouth of Manuels River to form a "barachois", or lagoon, about a mile long. Near Seal Cove the rocks of the granite complex nearly reach the coast and in this section the topography is a little more rugged, but the overall aspect of a plain is not lost.

The Low Lying Plain Coast on the south shore of

Trinity Bay is much narrower on its coastal fringe, though it extends a little farther inland than the Conception Bay Plain. The topography of these two areas is very similar, but the "ria" coastline of the Trinity Bay Plain is strikingly different from the shoreline of the Plain in Conception Bay. Reference to the map of natural vegetation (NV-1) will show that both of these Plains are under extensive cultivation. The rest of the surface of the Avalon Peninsula, or that part which has been termed Lowland, is coloured blue on the Map P-4. This includes many varieties of topography, in places resembling that of an adjacent division, but in other places possessing district features of its own. The long narrow strip of Lowland from Torbay South to Cappahayden is formed on members of the Conception Slate Group of sediments in the north, and on members of the Signal Hill Group in the south. It is a hilly area throughout, but the topography is mostly gentle, the hills being well rounded and the valleys wide and mature. The average elevation is between 300 and 400 feet, though in a few areas, hills may rise to 1000 feet and valleys may be below 100 feet, the controlling element seeming to be the resistive quality of the underlying bedrock.

The Lowlands on the western shores of the Carbonear Peninsula, on the west side of the Placentia Peninsula, and on the east side of St. Mary's Bay are all practically identical with the eastern one just described. The Lowland in the St. Mary's area is perhaps a little more rugged and hilly.

There are two areas of Lowland yet unmentioned, one in the central and eastern portion of the Placentia Peninsula and the other covering a large area north of Trepassey Bay, from St. Mary's Bay to the Atlantic Ocean. These two regions, which are similar topographically, differ widely from the other Lowland areas on the Avalon Peninsula, in that they each contain vast stretches of very gently rolling topography. There are very few scarps, peaks, or jagged features of any description, and the general aspect to an observer situated in the centre of either of these areas is that of an extensive plain or plateau spreading out in all directions to the horizon. These regions are either barren lands or bog lands, and their natural vegetation is discussed in the section under that heading. It is doubtful if much of the land of these areas is over 300 feet high and they are probably the third erosion level referred to by Twenhofel and MacClintock[5] However, it seems more likely that they could be classified as part of the Lawrence Peneplain, and their slightly lower average elevation attributed to their position on softer sedimentary rocks.

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[5]Twenhofel, W.H. and MacClintock, P., loc.sit.p.1718

In studying Map P-4, it must be remembered that this division of the Avalon Peninsula into physiographic provinces is broad. Each division may contain in places topography similar to that of another division, but by ignoring such minor exceptions, it became possible to work out this classification, which generally speaking, is true.

VIII. GLACIAL TOPOGRAPHY

The effect of glaciation on the terrain of the Avalon Peninsula is more pronounced in the presence of forms which are the result of deposition than it is in the alteration of existing features by sculpturing or deepening. The effects of glacial scouring and carving are great enough in a few localities to efface completely the pre-glacial forms of topography, but these have been mostly preserved. The highest hills, most especially in the areas of intrusive and extrusive rocks, are generally rounded, and still contain the smooth and striated surfaces of glacial erosion. Hills of softer rocks are often of the "lee and stoss" shape, that is, with one long and gently sloping smooth side facing the direction from which the ice sheet or glacier came, and with an opposite, short, steep and jagged side, the result of "plucking", as the mass of ice moved on. Many of the deeper valley sides are furrowed and grooved as are a great number of the smaller bays, especially those on the Atlantic coast.

The contents of the glacial drift in all areas shows that the shales and slates were the rocks most severely affected by the passage of the ice sheet (or sheets).[6]

Glacial "till" or ground moraine (laid down by moving ice, and consisting of two layers of subglacial and superglacial origin, but unstratified) is common and extensive in the Avalon Peninsula. In many places, it possesses considerable thickness and in such instances is an important element of the local topography. Stratified drift in the form of kames and eskers is rare, but these features are found in a few localities.

In general, the low lying country, valleys and coastal regions are covered with the thickest glacial till. The softer sediments of the different rock formations have supplied abundant material for the making of till. In places the till is over a hundred feet thick, but on the average, it probably only reaches a depth of ten or twenty feet. Kame gravels and sands were seen at Flat Rock, near Torbay, and near Whitbourne, but were not observed elsewhere on the Lowlands. Eskers are plentiful in some of the wide valleys of the bays on the Atlantic coast, and there are single occurrences near Holyrood in Conception Bay,

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[6] The problem concerning the number of ice sheets which invaded the Avalon Peninsula in Pleistocene time is discussed fully in the section on Glaciation.

inland northeast of St. Vincent's in St. Mary's Bay, on the Placentia Peninsula, and in one district on the east coast of Trinity Bay. These are nowhere very high or very long; they average 40 or 50 feet in height and the longest was traced in a broken line for about fifteen miles. Some are only a mile or even less in extent.

Most of the Lowland regions are covered with ground moraine. Many small isolated hills and ridges consist of this material and sometimes perhaps of kame gravel. Most valley sides and hillsides are covered with drift of one sort or another. In general, the drift is thicker in the coastal regions. Many headlands show a thick covering and some of the cliffs are made almost entirely of glacial material (Photo 5).

Most sections of the Highlands have a thin covering of till, thickening in hollows and minor valleys and often overlaid by thick deposits of peat, but here glacial deposits are not an outstanding feature of the general topography.

The Moraine Plain in the centre of the Avalon Peninsula is a unit in which the topography is almost entirely the result of glacial deposition. This is a region of thousands of lakes and ponds, lying between morainal ridges and in the depressions of "kame and kettle" terrain. The aerial photographs of this region show ridge after ridge of terminal or lateral moraine. The underlying bedrock is generally soft and outcrops in very few localities, thus there are seldom any rugged features, and the overall aspect is one of an extensive forest covered plain modified by thousands of low and gently rolling hills.

The disruption and general disorganization of regular drainage patterns as a result of glacial deposition is widespread through the Avalon Peninsula. A large scale map of almost any section will show thousands of tiny ponds and marshes and some districts with large, though generally shallow, lakes. The normal drainage, which followed the rock structure, the weak zones of faulting and of contact, and the inter-valley lowlands of the scarp country, was dammed and diverted by millions of tons of glacial drift during the advancement and recession of the last ice sheet. The consequent development of ponds was widespread, and new rivers and streams wandered aimlessly over the glacial drift in search of channels towards the major river valleys, which were probably not completely filled with debris. The greatest development of lakes is on the plateau-like tops of the Highlands. Here many of the lakes are in rock-rimmed depressions scoured out by the glacial action. Drainage is poor on these level areas and streams between ponds and marshes are short and sluggish. They are thus unable to make much headway in cutting down valleys low enough to drain the ponds.

Lakes and ponds are generally numerous around the foothills of the Highlands where there are often thick deposits of drift, but they are least numerous on the Lowlands where the faster flowing rivers have cut deep into the drift, often through pre-glacial valleys, and drained away much of the trapped water.

A comparison of the map showing drainage (P-3) with the map showing Physiographic Divisions (P-4) will reveal that the Highland areas are the areas on which the large lakes are generally found.

IX. SUMMARY

Geological events of the past are believed to be the dominant factor in producing the present topographical features of the Avalon Peninsula. The structural trend of this region is northeast-southwest. The major drainage arteries (now submerged), the bays, and the sub-peninsulas conform with this alignment.

Glaciation has been effective but has not altered profoundly existing topography by its sculpturing action. The most marked superficial features due to glaciation are depositional forms, and greatly disrupted and disorganized drainage.

CHAPTER III

SOILS

I. GENERAL DESCRIPTION

Newfoundland lies in the great northern belt of podzol soils. Podzolization, which is the enrichment of sub-soil horizons by leaching of minerals from the top soil, occurs in localities where precipitation is greater than evaporation, and where organic acids are percolating through the soil.

The typical soil profile consists of an A^o layer of forest litter and leaf mould, followed by the A^2 or leached horizon. Next is the B layer of brown colouration, containing the mineral accumulation that has been carried down from above, and lastly, the C horizon which is parent material of glacial drift from which the higher layers have been formed.

Coniferous forests return organic matter to the soil slowly, because of the brittle and narrow nature of the needles which do not readily decompose, and furthermore, they produce extreme acidity. There is an absence of ground worms in an acid soil of this nature and the organic horizon is not mixed with the lower horizons as in other areas where the ground worms are active. Podzols require free vertical drainage for their development. They are the dominant soil throughout the Avalon Peninsula, although the stage of development varies greatly in different localities.

The surface cover of the Avalon Peninsula is frozen to a depth of a foot or more for about one quarter of the year, and freezing temperatures are frequent during at least five months. This has two major effects on soil profile. It limits the free vertical drainage for a considerable portion of the year and it causes the cessation of bacterial activity. The former restricts leaching of the A^2 horizon, and the latter limits the decomposition of organic matter and the fixation of nitrogen from the air.

Where drainage is not free, the cool climate, the abundance of moisture, and the consequent limited bacterial activity produce a purely organic soil. In such areas the undecomposed organic matter builds up to form thick and extensive layers of peat. These are numerous on the Avalon Peninsula in all stages of development.

In rare instances there occurs the formation of alder muck soils. These are derived from the weathering of organic deposits composed of grasses, sedges and woody plants but there are no areas in which they are at all extensive. On river flats and near some boggy areas which support a bushy vegetation of hardwoods, mainly alder, this black fertile soil is found. It contains a fair percentage of essential plant nutrients, and is generally underlain by shaly till.

Different soils have been formed from the same parent material, depending on drainage conditions which vary from the driest uplands to saturated conditions in boggy lowlands.

II. MINERAL SOILS

The extensively distributed glacial till is the parent material upon which are built the podzol soils of the Avalon Peninsula. The organic or A^{0} layer is everywhere very thin, varying from three or four inches in some places, to an almost imperceptible layer in others. The degree of perfection in the vertical drainage determines the thickness of the leached or A^{2} horizon. This is always present in thicknesses of as little as a quarter of an inch in some localities, but averaging three to four inches in most places. Its ashen grey colour often forms a distinctive line beneath the dark surface layer in exposed profiles. The brown layer, or B horizon is generally thick and may measure anywhere from twelve to twenty-five inches.

The rock content of the parent material is an important factor in producing the structural features of the over-lying soil. Most soils on the Peninsula are closely related to the underlying bedrock, for in no instance has the glacial till been transplanted far from its source. Thus the situation of a region in relation to one type of bedrock or another is an excellent indication of its soil structure. The height of a particular section of the terrain will be an indication of the thickness of the soil that it supports. During the last glaciation the highlands have been largely swept clean of all loose material that may have accumulated on them, either of residual origin or from former glacial deposition. This mass of debris has been transported and dumped on the nearby lowlands.

Sometimes the soils are extremely rocky (Photo 16), yet amazingly enough seem to possess sufficient finely disintegrated material to be capable of supporting a fair forest growth. The boulders in these soils are part of the original super-glacial till and usually have been transported but a short distance from the parent bedrock. The amount of boulders in the soil varies from the extreme case demonstrated to a boulder free soil in the moraine deposits of the centre of the Peninsula. However, most agriculture is carried out on the coastal regions, and in these localities rock removal presents a problem to the farmer (Photo 19).

Some areas on the Avalon Peninsula possess alluvial soils on the flats of the lower courses of the larger rivers. The accumulated mineral content makes these soils slightly superior to the podzols of other localities.

III. ORGANIC SOILS

The numerous depressions, hollows, and kettles in the glacial drift of the Avalon Peninsula favour the formation of peat bogs. There is no soil profile development in peat although it often contains a certain amount of silt and clay. The water table which is at or near the surface prevents oxidation, leaching, and other soil-forming processes. These peat bogs are widespread throughout the area in different stages of formation. When a considerable accumulation of peat has been formed the area concerned is often built up sufficiently to be drained by natural causes. The mass of partially decomposed plant remains, begins to support a more advanced type of vegetation, and may then be classified as a soil (Photo 6). These soils are, however, particularly deficient in mineral content and will not support a large forest cover. In most districts they are three or four feet thick, but thicknesses of over twenty feet can be attained.

IV. REGIONAL DISTRIBUTION OF SOILS

Soils are generally thin and sterile in places of high elevation. The topmost peaks in the highland regions are smooth and rounded and contain no soils at all. However, since most of the highlands have plateau-like surfaces, they have been able to retain some of the glacial drift which was deposited on them. This thin covering of drift is usually extremely rocky, and in many cases provides insufficient finely divided material to constitute a soil.

The highland formed on the Avalon Granite Complex contains very thin and poor soils. These are mostly of very rocky and sandy loam overlaid by a thick leached layer, and a very thin coating of humus. They are very acid and of little or no economic importance.

In the other highland regions of the Avalon Peninsula the soils are a little thicker and are slightly improved in structure. These highlands are on sedimentary rock, often sandstone quartzite or conglomerates, but there is always shale in the till and thus the parent material is more thoroughly broken down than in the granite country. Boulders, nevertheless, are plentiful, and there is no question of employing these soils for agriculture. Some of them support forests, usually on the better drained upper valley slopes, and are thus of some economic importance.

All the highland areas contain peat bogs. These are formed in the hollows carved out of the rock by glaciation, or in depressions of the glacial till (Photo 17). They are nowhere very thick but sometimes they become well drained and support a grassy and sedgy vegetation in which sheep and goats forage in summertime.

Soils in the lowland areas have different characteristics, depending on their position in relation to the direction of movement of the last ice sheet. Ice moved outwards from the centre of the Avalon Peninsula and deposited till and stratified drift with a rock content, which was transported but a short distance from its source.

Thus, the lowland areas which extend over a bedrock of shale, may have a shaly soil, but if they are adjacent to the central upland of granite the lithological content may be considerably altered.

On the lowlands of the St. John's Peninsula the glacial till is thick in most localities, and in the eastern section is generally composed of soft shales, slates and sandstones (Photo 20), but the western and southwestern sections have a greater percentage of volcanic and granitic material and are consequently much more rocky. There are at least two areas in this district which have a covering of stratified drift. Kame gravels occur at Flatrock, near Torbay on the northeast coast, and the shoreline near Topsail contains deposits of glacial outwash material. Such areas have a deep free drainage, and support a relatively good soil. The Topsail area is particularly favoured in those sections of it which lie on limestone beds of the Cambrian strata;

The whole narrow strip of lowland that stretches aouth from St. John's to Trepassey Bay is covered with glacial drift in varying amounts, usually thickest near the coast, (Photos 21 and 5), and in the valleys, but thinning towards the highlands of the west. When rock fragments in till are composed predominantly of slate the soil is usually deep and good. Nearer the inland hills there is an increased number of granite boulders and generally poor soils. West of

Cape Broyle there are some very large level areas of peat bogs. These have been drained in places and utilized for composting and fuel.

All of the lowland areas north of Trepassey and on the Placentia Peninsula contain both mineral and organic soils with similar characteristics to those just described, and varying in structure and extent as controlled by topography and drainage. North of Trepassey, drainage is better than on the Placentia Peninsula and consequently there are more stretches of peat bog in the latter. Some slightly better soils are found in the pockets of soft Cambrian rocks that occur along these coasts. Some of the podzol profiles in the drift on the barren country north of Trepassey show the soil to be identical with other podzols in some forested areas. Why this soil is unproductive is unknown, but the question is discussed in the section on natural vegetation.

The lowlands around the head of St. Mary's Bay as well as those near Placentia, are covered with very thick drift and in the St. Mary's area boulders are not plentiful. The mineral soils are generally well drained and support good forests. In these areas both the organic layer and the mineral layer are thicker than usual. The soils seem more mature, this probably being the result of better drainage, a slightly warmer climate and an increased return of organic matter to the soil due to the presence of birch in the forest.

The lowlands on the west side of the Carbonear Peninsula have soils of two main types. Some are built on slate, shales and sandstones, and are identical with those in the St. John's area, but as in other regions mentioned a better soil is found on the numerous outcrops of Cambrian strata that are found along this coast.

The scarp country on the west side of Conception Bay is not covered with thick drift. However, the soils which have developed on the scarp slopes and in the valleys are well drained and there is considerable agricultural development. This is mainly incidental, the primary occupation being the fishery.

Some of the river flats in this area contain alluvial soils, and some coastal regions are known to support outwash and kame gravels. These latter sections have the best agricultural land.

The best virgin soils on the Avalon Peninsula are in the Moraine Plain north of St. Mary's Bay. The kames and morainal ridges of this Plain have excellent drainage and the drift is deep and in most places boulder free. The soil on the higher ground is a silty, sandy loam, although there are many areas of peat bog in the depressions. The climate is also slightly warmer than in the coastal regions and some of the best timber in the district grows here.

Not much has been said regarding the fertility of the soils. In general the lowlands have the best soils, both from a structural and chemical point of view, for they have advanced further towards maturity than the highland soils and are thus more fertile than those in the highlands. There is, however, no great difference in fertility amongst the lowland soils themselves. In general, they have a low fertility, for a newly cleared piece of land will not support a successful crop without the addition of lime and fertilizer. The following section will discuss fertility and soil use on the Avalon Peninsula.

V. SOIL AND MAN

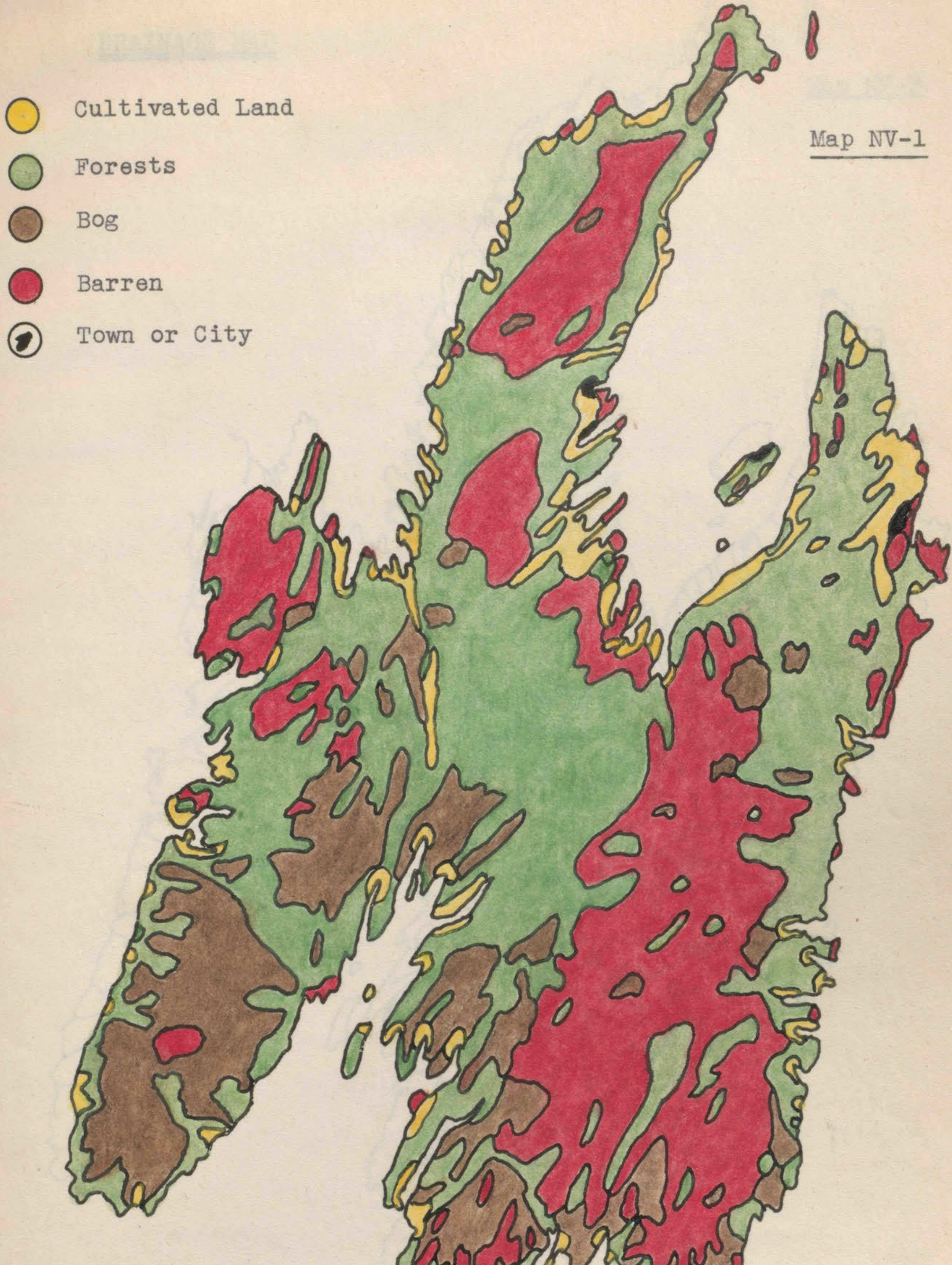
Generations of farming on the Avalon Peninsula have caused deterioration of the soils through erosion and improper land use. Lack of knowledge of correct procedure and poor management have been the cause of the destruction of some of the best stretches of soil throughout this region. The virgin soils on the Avalon Peninsula are extremely acid due to the acid organic solutions formed from the litter of coniferous forests. These solutions percolate through the upper layers and alter the phosphates to an insoluble form. Nitrogen is also deficient because of the reduced bacterial activity of the cold climate. The humus layer is thin and the leached layer often thick, although the enriched layer can attain a thickness of two feet or more.

The majority of Newfoundland small farmers are actually fishermen employed in part time farming, making their own vegetable gardens. These "farmers" try to remedy the defects of the soil with the yearly addition of fish bones and entrails and stable manure. After the soil has been planted these are deposited and left to rot. The consequent bacterial activity builds up a small amount of humus and nitrates, and certain plant nutrients are derived from the bones. However, the soils gradually deteriorate, because of the excessive demands to which they are subjected. Furthermore, trenches between plants are always made to run up and down hill, thus encouraging erosion, and there is little attempt at crop rotation to help restore nutrients to the soil.

There are few large scale farms on the Avalon Peninsula but some of the districts near the larger centres of population support fair vegetable and dairy farms. With the direction of the Department of Agriculture some of these are now introducing modern methods with an amazing increase in yield and improvement in soil conditions. Unfortunately, however, the greatest percentage of the soil under cultivation is in the hands of small owners who are not even aware of the adverse effect of the acidity of the soils to plant growth.

During the past decade the Government policy has been to aid farmers by supplying information as to correct farm procedure. Some success has been attained, but the customs and practises of centuries are not readily altered.

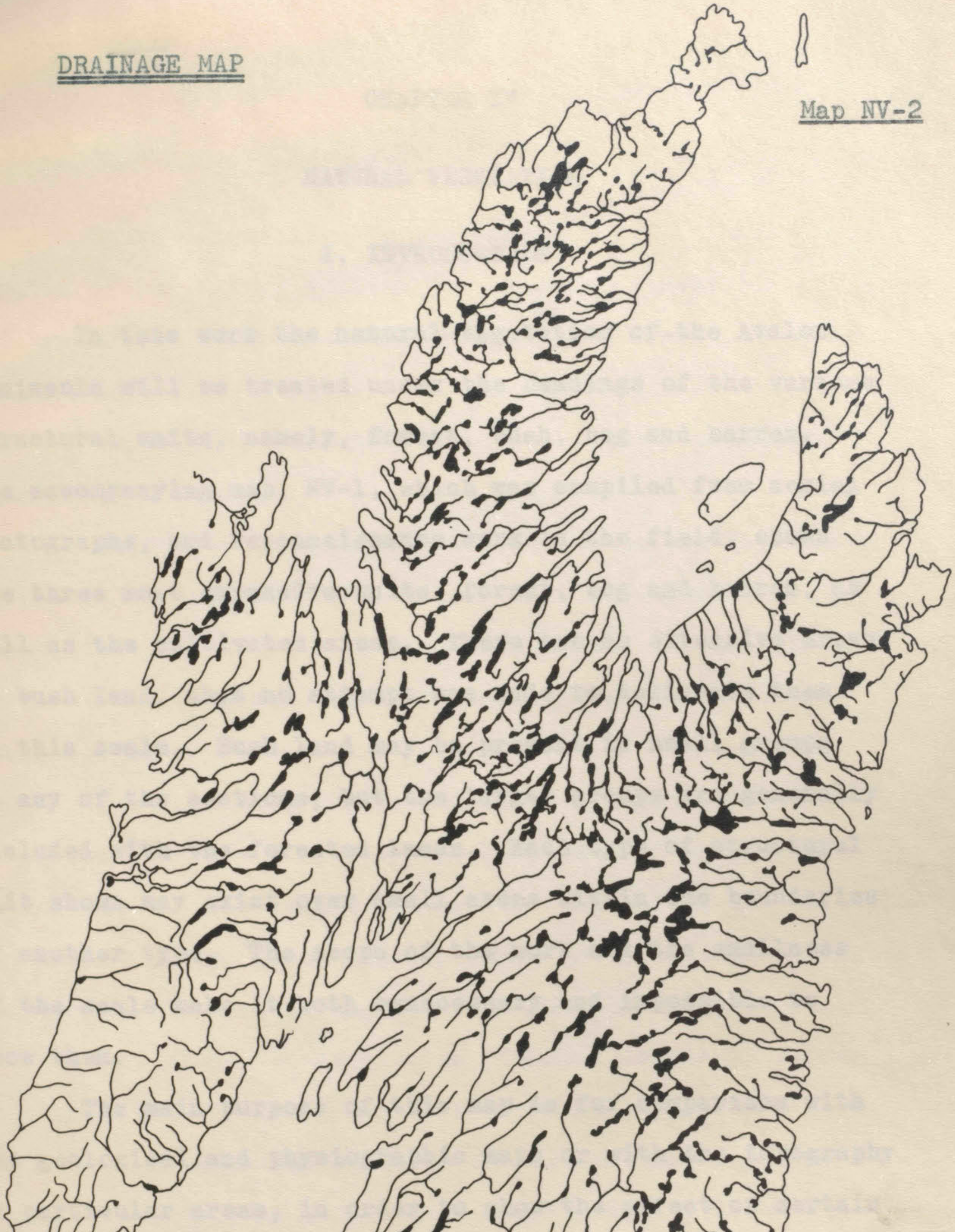
Map NV-1



NATURAL VEGETATION

DRAINAGE MAP

Map NV-2



CHAPTER IV

NATURAL VEGETATION

I. INTRODUCTION

In this work the natural vegetation of the Avalon Peninsula will be treated under the headings of the various structural units, namely, forest, bush, bog and barren. The accompanying map, NV-1, which was compiled from aerial photographs, and reconnaissance work in the field, shows the three most expansive units, forest, bog and barren, as well as the cultivated areas. There are no extensive areas of bush land, thus no attempt was made to delineate them on this scale. Bush land may be present in small groups in any of the sections, but the larger groups are generally included with the forested lands. Each type of structural unit shown may exist over small areas within the boundaries of another type. The scope of the work and the smallness of the scale make it both unnecessary and impossible to show them.

The main purpose of this map is for comparison with the geological and physiographic maps or with the topography of particular areas, in order to show the effect of certain features on the distribution of the various types of natural vegetation. The principal lakes and rivers are shown on the drainage map, NV-2, on the following page to help show the relation between drainage and vegetation.

II. FORESTS AND BUSH

Newfoundland lies in the Boreal Conifer Forest region of the North American Continent. A large portion of the island is covered with coniferous forest, but many localities, especially those of the greatest elevation, have a vegetation cover more akin to that of the tundra region.

There are only slight differences in the vegetation cover of the Avalon Peninsula and that of the rest of the Province. The lowlands of the west coast, having superior soils and a slightly warmer climate, support a more advanced type of vegetation.

The forests of Newfoundland have been divided by Robertson[1] into six site-types, only four of which were recognized on the Avalon Peninsula. These four are described in the following paragraph and names given to each type will be adopted for use throughout this section of the work.

The site-type designated "Cornus" is widely represented. This forest grows on soil which ranges from loam to sand, and which is situated on well drained flats and valley slopes. The ground level vegetation includes the cracker-berry (Cornus Canadensis), false lily of the valley (Maianthemum Canadense), the lily (Clintonia borealis)

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[1] Robertson, W. M., "Forests of Newfoundland" Forestry Chronicle, 21(1):11, 1945.

and feather mosses and ferns in profusion.[2] The principal heaths are blueberry (Vaccinium Tenellum), and sheep laurel (Kalmia augustifolia) of scattered distribution. The cover type consists of white and black spruce (Picea glauca) and (Picea mariana), balsam fir (Abies balsamea) and paper birch (Betula papyrifera). Birch appears unable to survive alone and if left standing when the forests which contain it are cleared of spruce and fir, it soon dies. Furthermore, it fails to regenerate for several decades, and this site-type may then consist of a subclimax of pure balsam or spruce or a balsam-spruce association. White Pine (Pinus strobus), which is also a dominant in the "Cornus" site-type, is not found on the Avalon Peninsula.

Wet, poorly drained flats, with acid peat loam or sand support the "Sphagnum" type of forest. The ground vegetation is represented by prolific sphagnum and associated mosses. The heath-level strata are comprised of Labrador tea (Ledum Groenlandricum), sheep laurel and blueberries. There is also a scattered distribution at ground level of sedges and gold thread (Cornus Captis). The principal tree species is black spruce, with sub-dominants of fir or larch (Larix Americana).

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[2] Botanical names are given only once in this text. Appendix B contains a complete list of the principal trees and plants of the Avalon Peninsula, with their respective botanical names.

Two site-types support the "Kalmia-Ledum" forest which grows on either a poorly drained acid peat soil bordering a bog, or on light shallow sandy soil in dry situations. Labrador tea and sheep laurel are profuse in each type, but the wetter site supports the bakeapple (Rubus chamaemorus). The trees on the wet site consist of scattered and stunted black spruce, and on the dry site, stunted balsam fir. The reproduction of this forest after cutting is slow, taking 150 years or more to reach maturity.

The last type, "Cladonia" occurs on the borders of barrens and on upper slopes and hill tops. Here the soil is dry and sandy supporting only such zerophytic plants as reindeer mosses and lichens. The forest cover is a scrubby black spruce.

The growth rate of forests in Newfoundland is equal to that of Eastern Canada, but the stature of mature trees is generally smaller. Robertson[3] compared the climate of various localities in Newfoundland with that near Ottawa and found that although the mean annual temperatures in Newfoundland were slightly lower, the more equable temperature range, the greater precipitation and the higher humidity combined to promote this comparable tree growth. He also stated that the balsam fir of Newfoundland is superior to that of eastern Canada in that it remains merchantably sound up to 100 years,

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[3] Ibid;, p.20.

whereas the mainland fir begins to deteriorate after 60 years.

The five principal tree species, namely, balsam fir, birch, larch, black spruce and white spruce will now be treated separately with emphasis on habitat, stature and associations with other vegetation.

The balsam fir is the commonest tree species on the Avalon Peninsula. We have seen that it is a dominant in the "Cornus" forest and in the drier "Kalmia-Ledum" forest, as well as being sub-dominant in the "Sphagnum" site-type. It requires a well drained acid mineral soil for maximum growth. Reproduction is prolific on a cool damp ground cover of mosses. No obstacle is presented to the growth of the seedling which sends down long roots to the mineral soil. Growth, of course, varies with site, and the largest firs are found in the most favourable environment, namely, the "Cornus" forest cover. Here they may obtain a height of 60 feet and a diameter at the base up to 18 inches, although the average on the Avalon Peninsula is perhaps only one quarter of that figure. The Avalon Peninsula has been settled for a great number of years and now holds a large proportion of the total population of Newfoundland. There are, consequently, many areas which have been cut over for firewood or lumber. Fir regenerates prolifically on cut over land but grows up thick and crowded, each seedling having equal advantages. It is this condition, combined with reduced nourishment from a partially leached soil, amongst other factors, that produces the fir trees of smaller stature in the area, compared with the better timbered areas of Newfoundland. This disturbance of nature by human interference has produced many stands of timber which are subclimaxes of the "Cornus" site-type, for they lack the correct percentage of spruce and birch to be truly climax.

In general, the balsam fir is found in the localities with good drainage and deep soils. Lower valley slopes, morainal topography, hillsides, and the coastal areas overlaid with deep glacial drift all support a forest cover that is dominantly fir.

White spruce is common only in the "Cornus" site-type where it is usually a dominant. Unlike the fir, the white spruce requires a warm mineral soil to germinate. Furthermore, it has fewer seed years than the fir and thus its reproduction is not so prolific. If areas with deep soils have the forest cover removed by fire, ideal conditions are then presented for the reproduction of white spruce, for there is no longer a thick ground cover of damp mosses and the spruce seed stored in the soil is released.

In the best stands of timber on the Avalon Peninsula the white spruce matures with a stature equivalent or a little larger than that of the fir.

Black spruce is second to the balsam fir in abundance but it is commonly smaller in size. It occurs in all the classifications cited and matures at a height of fifteen to thirty feet in the "Cornus" and "Sphagnum" type forest, but it is generally dwarfed or stunted in the "Kalmia-Ledum" and "Cladonia" groups. This tree seems to have a high tolerance to soil conditions as evidenced by its presence in a variety of localities, but it survives best and matures with the greatest stature on well drained soils. It was observed in all sections of the Peninsula, even on the moss barrens and the windswept hilltops. In such cases, however, it occurs in clumps of a scrubby nature, sometimes only a foot or two high. The ring count on one of these small trees showed it to be over fifteen years old, yet it was barely an inch in diameter and only three feet high.

The marginal areas of mature stands of timber in the "Cornus" group, if at all wet, are usually favourable to the growth of black spruce. Similarly the edges of many bogs and poorly drained flats in river valleys are often covered with a short and crowded stand of this species.

Photo 7 taken at eight hundred feet elevation, near Butter Pot, Renews, shows dwarfed black spruce growing from the rock crevices in the foreground. The forest immediately behind on the valley slope is of the "Cornus" variety, but the trees are stunted due to the high elevation and consequent exposure. A noticeable feature is the long thin strip of forest vegetation along the river valley in the background. In these mountain areas the few soils that exist are confined to the valley floors or to the base of small talus slopes. The smaller vegetation around the edges of the forests shown consists mainly of scrubby black spruce.

The larch or tamarack is as widely distributed as the black spruce, but it is not so plentiful. It is a sun-loving tree growing at well spaced intervals and is rarely seen in a pure stand. Turner[4] states that large areas of tamarack were killed by the Larch Saw-Fly some time ago, but he believes reproduction to be well established in most parts of the country. Larch seems to have an even higher tolerance than the black spruce for it is equally at home on wet or dry land and at any elevation. This tree seems to grow in greater numbers on marshy ground where it can attain a height of 20 or 30 feet. In this habitat, however, the average height would be about 12 feet. In drier places and on higher land the average is a little less than this. An exception to this can be seen near Placentia where a well drained valley slope supporting a splendid balsam-spruce forest, also contains scattered larch trees over 40 feet high. An interesting feature of the larch tree in Newfoundland is that its top

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[4] Turner, J., The Forests of Newfoundland. The Book of Newfoundland, 1:58.

always bends towards the east. This is probably caused by the prevailing winds which are northwesterly to southwesterly. Photo 8 shows scattered larch trees bordering barren lands on the high country west of Renews.

The presence of paper birch is an indication of stabilized topography. It survives to maturity in the "Cornus" site-type, where it is a dominant in the climax forest. It grows to about the same height as the spruce and fir with which it is associated, but the diameter of its trunk is generally much thicker. Its habitat is on thick loam soil that is well drained.

Photo 9 shows a mature forest of the "Cornus" site-type. The paler leaves of the birch are clearly visible where it grows amongst the conifers on the highest ground. A pure balsam-spruce association can be seen nearer the shore of the lake.

Smaller birch trees of this species are also common, along with other hardwoods on some burned over areas. After a forest fire there may be insufficient humus left to support the immediate growth of a new stand of conifers. In this case the affected area may support a growth of hardwood trees such as dogberry (Pyrus Americana), wild cherry (Prunus pennsylvanica), black birch (Betula lenta) and alder (Alnus crispa), as well as the paper birch under discussion. Those deciduous trees produce an abundance of forest litter that aids in restoring the humus to the soil. A later section will deal more fully with forest recovery after destruction by fire.

A description of the forested regions, or all those areas coloured in green on Map NV-I, will now be given in the following paragraphs. These regions will be treated section by section in a clockwise direction around the Avalon Peninsula starting at St. John's.

The area between Conception Bay and the Atlantic Ocean, termed the St. John's Peninsula is almost completely forest covered. Exceptions are a few small barren and boggy areas, and some large tracts of cultivated land. There are two short ranges of rugged hills on each side of this minor peninsula. The summits of these coastal ranges are barren and the intermediate topography, carved out of the softer shales and slates of this area, is mature and gently rolling. This section is generally well drained and covered with a thick mantle of glacial drift. It is thus suitable to the "Cornus" type of forest, which grows in most localities, but as already stated there is a shortage of birch, as most of the stands are new growth after repeated fires and centuries of exploitation by the inhabitants of this area.

An experiment in thinning out this crowded tangle of new fir growth is being conducted on the shores of

Windsor Lake by the Forestry Division of the Department of Natural Resources of the Newfoundland Government. It is too early yet to comment on the outcome of this venture, but there seems to be no reason why it should not be successful. Adjacent areas on exactly similar sites which appear to have escaped cutting for the last half century at least, are stocked with some splendid large individuals of white spruce and balsam fir.

The green coastal strip south of St. John's from Bay Bulls to Cappahayden is not as well forested as the St. John's area. The rugged topography and consequent exclusion of glacial drift on the numerous east-west highlands between the valleys is partially responsible. This area was one of the earliest to be settled, and it still possesses a large fisher-farmer population. These inhabitants have seriously depleted their limited forest resources. An example of the extent of local cutting is shown in Photo 1. The whole area shown in this photo was once as well stocked as the rectangular forest patch on the left hand side of the picture. This is a stretch of private property that has been protected by the owner. The rest of the terrain is in the birch-alder stage of recovery. Here and there a young conifer may be seen pushing through the hardwood growth, but the softwoods are cut long before they reach maturity. The only other source of wood for the people of this district is from some patchy stands of good timber in sheltered and favourable places, amongst the barren areas some ten or twenty miles inland. About half of the region should perhaps be designated as bushland, but since it is potentially good forest land, it has been included under that classification.

The country south of a line between Cappahayden and St. Vincent's in St. Mary's Bay, contains very little forest vegetation. The well drained valley slopes and some coastal strips are sparsely forested. The lower valley slopes are sometimes of the "Cornus" site-type, but the higher elevations quickly grade through a scrubby "Cladonia" forest of black spruce to the barren or boggy highlands.

The eastern and northwestern coasts of St. Mary's Bay from St. Vincent's to Salmonier and thence to Little Barachoix River, contain a series of long narrow bays into which flow some of the largest rivers of the Avalon Peninsula. The valley sides and coastal areas contain a thick glacial drift and well drained soils. There are some excellent stands of mature "Cornus" forests along the water courses and on the lake sides. The individual species grow much higher here than on the St. John's Peninsula, and the climax of birch-spruce-fir is reached on the best sites.

It must be remembered that in all these forested areas there are thousands of small, boggy regions where organic soils have filled the poorly drained hollows and depressions of the glacial topography.

The large green area in the central portion of the map is one of gently rolling topography on thick glacial moraines, and it supports the most extensive stands of mature timber on the Peninsula. The country here is dotted with thousands of lakes and ponds, many of which are linked together to make a series of long, straight chains lying in a northeast-southwest direction. Photo 9 is a view across one of these lakes, and shows the climax forest on the crest of one of the morainal ridges. Photo 24 is a closer view of this climax forest taken on a roadside where the soil is well exposed. Note the thick layer of humus on the boulder free soil. This area also contains minor stands of black spruce and balsam fir of the "Sphagnum" site-type and as elsewhere on the Peninsula there are numerous small bogs and marshes distributed throughout the area. The topography was probably once purely of the kame and kettle or morainal ridge variety, but the kettles and hollows have since been filled with thick peat bogs. The kames and ridges support the forest growth.

The peninsula which lies between St. Mary's Bay and Placentia Bay supports a forest in its coastal regions, and in the larger river valleys. Conditions here are almost exactly the same as in the area north of Trepassey, and the forest cover is nowhere of any significance. A balsam-spruce subclimax of the "Cornus" forest is attained in the lower valley slopes, and the stunted spruce of the "Cladonia" site-type makes up the rest of the wooded areas.

The forested areas east of Placentia and those on the south shore of Trinity Bay are much the same as those of the Salmonier region. The greater percentage of these areas are "Cornus" with the birch-spruce-fir climax on the better sites, and the balsam-spruce subclimax on the less well drained sites. The remainder consists of black spruce, "Sphagnum" or "Kalmia-Ledum" forests, on the borders of swampy areas, or black spruce "Cladonia" on inter-stream areas, hilltops and barrens.

The forest cover on the long peninsula between Trinity Bay and Conception Bay is mainly of two classes. The western and more sparsely inhabited side has a thick cover of fir and spruce. In a few areas the "Cornus" climax is reached, more commonly in the south, but in the north the subclimaxes are predominant. The eastern side is thickly populated and is largely given over to agricultural land. Here the forest has been repeatedly cut and burned, and many areas are really only bushland. As in other localities barren areas on the central highlands contain some stands of short black spruce, usually of the "Cladonia" site-type.

In general it will probably be found that only about ten per cent of the Avalon Peninsula contains mature forests of the "Cornus" climax. About twenty-five per cent consists of subclimax forests of the same site-type, and about ten per cent supports some variety of stunted black spruce forests or bushland.

As already stated there are no large areas of pure bush on the Avalon Peninsula. The cut-over and burned-over forest areas sometimes revert to a bushy vegetation in their recovery, but this is not a climax. Some river flats (Photo 15) and some of the marginal areas between forest and bog seem to have a permanent bushy vegetation. Here the soil is often a muck. The dominant in this cover type is probably the alder, with sub-dominants of mountain ash, wild cherry, wild pear (Amelanchier canadensis), bush honeysuckle (Lonicera coerulua), black birch and willow (Salix discolor).

The recovery of a forest after a fire depends on several factors. If the soils were originally thin and rocky and the fire intense, then the whole terrain may be reduced to a seemingly permanent rocky barren. Recovery here may take hundreds or even thousands of years. The humus is burnt and what little soil exists is thoroughly leached. Photo 16 shows the complete devastation wrought by fires in such areas. The first sign of recovery is the encroachment of a barren vegetation of such plants as blueberry, sheep laurel and some mosses. Eventually these plants supply sufficient organic matter, which decomposes to restore again to the area a fertile soil.

If the area burned is one of thicker soils with fewer boulders, recovery may be much quicker. The humus layer may not be completely destroyed and the soils may be protected from serious leaching. In this case new vegetation may begin to spring up within a few years, usually consisting of small hardwoods such as alder, cherry and black birch, with some young spruce and fir seedlings. After ten or twenty years these areas may start to produce a softwood forest again. Photo 10 shows an early stage, and Photo 11 a late stage, in recovery of this type.

Areas that support the climax "Cornus" site-type may recover very quickly after burning. Here the fire is usually more intense on the crowns. The relatively thick humus lying on the superior boulder-free soils may be only partially destroyed. Recovery often starts with a birch forest within a few years. The birch approaches maturity and improves the organic soil layer with abundant forest litter. Eventually the spruce and fir seedlings force their way up through the birch and finally crowd it out to a few separated individuals. Probably few areas on the Avalon Peninsula escaped burning at one time or another.

III. BOGS

There are several factors which combine to make favourable conditions for the formation of bogs in Newfoundland. The scouring of the rocks and deposition of glacial till during the Pleistocene has had the effect of greatly changing and disrupting the normal drainage of the countryside. Numerous shallow lakes and marshes were formed in poorly drained pockets leaving ideal conditions for the formation of bogs. Precipitation is high in Newfoundland and regularly distributed, while evaporation is low. The resulting abundance of moisture is conducive to the growth of bog-forming plants.

In the early stages of bog formation, a mat of vegetation from the sides of a shallow pond progresses inward from the periphery to bridge across the surface. This mat consists mainly of sedges and rushes, but eventually decays and builds up an organic layer that supports numerous sphagnum mosses, heaths and later trees.

All stages of peat bog formation may be seen on the Avalon Peninsula. The areal extent of bogs shown on the Map NV-1 is very general. The predominantly boggy areas are coloured brown, but here are included many small areas of barren vegetation. Similarly the barren areas shown in red contain bogs and marshes (Photo 17), but these are too small to be separately delineated.

The large areas of bog on the Placentia Peninsula and on the eastern side of St. Mary's Bay are the result of extremely poor drainage. In these regions the topography is almost level in places and is generally only gently rolling.

The dominant plants of the bog vegetation were collected and identified. There seems to be little difference in the vegetation cover no matter where the position of the bog on the Peninsula. Immediately above the peat layer there is a thick carpet of sphagnum mosses. These are often bright red in the moist new growth above the old plant. Intermingled with the mosses are the crackerberry and the bakeapple. The heaths include sweet gale (Myrica Gale), leather leaf (Chamaedaphne calyculata) and Labrador tea. The highest layer of vegetation often consists of many varieties of grasses and sedges, cotton grass (Eriophorum tenellum) usually being profuse. The pitcher plant (Sarracenia purpurea) grows in abundance, its tall red flowers often being the highest feature of the vegetation.

Exposures of sections of soil in many areas on the Peninsula show ancient peat bogs of considerable depth. Photo 5 shows one of these bogs filling a depression in glacial drift. The regions containing such peat soils are now well drained and in this case the land has been utilized for the production of hay.

IV. BARRENS

Areas completely devoid of soil or with a thin or sterile soil covering are termed barrens. These regions shown in red on Map NV-1 are generally the highlands and hilltops. Some exposed headlands (Photo 12) and coastal strips are also included in this classification.

The vegetation of the moss-barren is almost everywhere the same except on the very top of the highest hills, where it peters out almost to extinction (Photos 13 and 7). These hilltops have been exposed to heavy denudation by glacial action, and the only soils formed since are confined to the rock crevices or are amongst softer rocks that have since been broken down by frost action.

There are several large areas of barren on the Avalon Peninsula, and these are almost exclusively on areas of high elevation. The large tract of barren land southeast of Conception Bay is the most rugged and rocky, for here massive outcrops of rock are numerous, and granite boulders are plentiful. Reference to the geological Map G-1 will show a remarkable similarity in the situation of the granite batholith shown there and this barren area. This barren extends further south than the granite and the extended area is rather different in composition. Here as Photo 14 shows, the barren is continuous across miles of open and relatively level country.

There are some areas on this barren which contain deep and seemingly fertile soils. The reason for the lack of forest vegetation is unknown. It is suggested that as the area is open and exposed the "salty" air from the ocean may have an adverse effect on growth, or ancient forest fires of great intensity at ground level may have burnt out all the seeds. Neither of these explanations is entirely satisfactory, but the latter is perhaps the more tenable.

The barren areas further north on the Peninsula are slightly different from the type just described. There are more open spaces completely devoid of vegetation, yet there are occasional patches of small larch and black spruce trees (Photo 18). The northern barrens and the more southerly ones are underlaid by the sediments and volcanics of the Avalon Peninsula, and the terrain is not so rugged nor so windswept as that of the granite country.

The typical barren vegetation consists primarily of a carpet of sphagnum mosses, amongst which the crowberry (Empetrum nigrum), the partridge berry (Vaccinium Vitis-Idaea) and the cracker-berry grow in profusion. Heaths are numerous, the dominants being rhodora (Rhododendron Canadense), sheep laurel and Labrador tea. Occasionally there are some stands of gnarled and stunted black spruce and larch.

Barren areas on the Avalon Peninsula probably make up about twenty-five per cent of the landscape. The estimate for forests and bush was forty-five per cent. The remaining thirty per cent is largely bog. The brown areas on the map are certainly not as extensive as the red but allowance is made for boggy lands within the forested areas.

CHAPTER V

GLACIATION

I INTRODUCTION

The glaciation of Newfoundland during the Pleistocene Epoch has been the subject of much controversy, for it presents many interesting and baffling problems. Many observers have studied glaciation in different sections of the Island, several purely as glaciologists, but many others while engaged in activities of a geological or botanical nature. The theories presented as a result of this research are many and varied. The principal differences of opinion are concerned with the number of glaciations which occurred in Newfoundland, whether they were complete, the origin of the ice sheets, and the direction of movement of each. The degree and extent of post-glacial crustal warping is also a problem for lively discussion.

There is general agreement that Newfoundland was glaciated in Wisconsin time. One or more earlier glaciations are claimed by some[1], but others[2], though they do not deny

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[1]Anteves, E., "Maps of Pleistocene Glaciation", Bull. Geol.Soc.Am., 40:631-720 (1929)

Coleman, A.P., "The Pleistocene of Newfoundland", Jour.Geol. 34:193-223 (1926)

[2]McClintock, P., and Twenhofel, W., "Wisconsin Glaciation of Newfoundland", Bull.Soc.Am., 51:1729-1756 (1940).

earlier glaciations, are skeptical of the evidence suggesting them and believe all traces of glaciation found to be attributable to the Wisconsin Ice Sheet. There is disagreement on the question of the origin of the Wisconsin Ice Sheet which covered Newfoundland. Evidence exists which suggests that the ice sheet which was centered in Labrador, and which flowed over most of Eastern Canada and the Eastern United States, also invaded Newfoundland, but on the other hand, there are grounds for believing that Newfoundland possessed its own ice cap. Furthermore, there is abundant evidence to suggest that the Avalon Peninsula was covered with a separate ice cap.

These problems will be discussed on the following pages in as far as they concern the glaciation of the Avalon Peninsula. New evidence, derived from field work in that area will be presented in support of the theory suggesting a separate Wisconsin glaciation of the Peninsula by individual ice caps, and some new light is thrown on the post-glacial uplift of this region.

II EARLY PLEISTOCENE GLACIATION

It seems probable that most of Newfoundland was glaciated at least once before Wisconsin time. It would indeed be unusual for it to escape glaciation of some sort considering its relation to the great ice sheets that flowed much further south on the mainland during the first stages of

Pleistocene time.

Evidence in favour of earlier glaciation is strong but the nature and extent of the ice sheets which caused them are very obscure. The Grand Banks, which form a series of ridges on the Continental Shelf southeast of the Avalon Peninsula are suspected to consist of terminal moraine. Stones and pebbles taken from the ocean bottom in those areas have been found to contain striations and to resemble the typical stones of glacial drift. However, this does not furnish convincing proof that the Banks are morainal ridges, and further evidence would certainly have to be collected before the final word could be said on the theory. The northern half of Newfoundland has been uplifted, the uplift increasing towards the north. This suggests that the Island was subjected to a load of ice which originated from the mainland in Labrador and moved south over the country, the greatest mass, however, being concentrated in the north. Coleman[3] reports shell bearing gravels, near Curling on the west coast of Newfoundland to lie between two sheets of glacial till. He cites this as evidence of at least one long interglacial period. He further suggests that marine terraces may be of two ages, the highest ones being formed in a much deeper sea, which resulted

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[3] Coleman, A.P., loc. sit.

from a depression of the land by a heavier load of ice than that of Wisconsin time. Coleman also found an ancient boulder clay in some sheltered valleys, and greatly weathered erratics on the highlands of the interior. These he attributed to an earlier glaciation from Labrador, possibly Jerseyan or Illinoian.

McClintock and Twenhofel[4] who carried out extensive glaciological research in Newfoundland in 1940, found no evidence of any older glaciation than the Wisconsin. They further state that all erratics examined were remarkably fresh and none of the drift investigated showed any signs of being old or weathered.

Examination of glacial phenomena on the Avalon Peninsula during the field reconnaissance in connection with this work supports the view of the last named authors. All till seen was very fresh, and weathering of moutonnee forms was in most cases slight, except where frost action was particularly severe. Many of the granite erratics found on the uplands were well rounded, suggesting that they had been transported for a considerable distance, but this was the only fragment of evidence found to suggest that the Avalon Peninsula may have been glaciated in pre-Wisconsin time.

Considerable discussion has revolved around the

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[4]McClintock, P., and Twenhofel, W., ibid.p.1732-1750

question whether or not Newfoundland was completely glaciated in Wisconsin time. Fernald[5] found ancient plants at high elevations in the Long Range Mountains. These plants are only known to exist in other remote regions of the Northern Hemisphere, the nearest place being in Alaska. Since no satisfactory explanation can account for a post-glacial migration of these plants from such distant places, it is assumed that they survived the passage of the ice sheets on nunataks or unglaciated ridges. Further evidence in favour of unglaciated regions lies in the fact that some of the mammals of Newfoundland are endemic to that Island. These facts have been used in support of a theory suggesting a mild and local Wisconsin glaciation.

III WISCONSIN GLACIATION

Most observers now subscribe to the view that Wisconsin glaciation in Newfoundland was in the form of a separate ice cap, at least in the waning stages, as striae found throughout the country suggest a radial movement of ice out from the centre of the Island. An initial invasion of Labrador ice could be the cause of the uneven crustal warping, but the partial recession of this ice sheet could have left Newfoundland with an ice cap sufficiently large to flow

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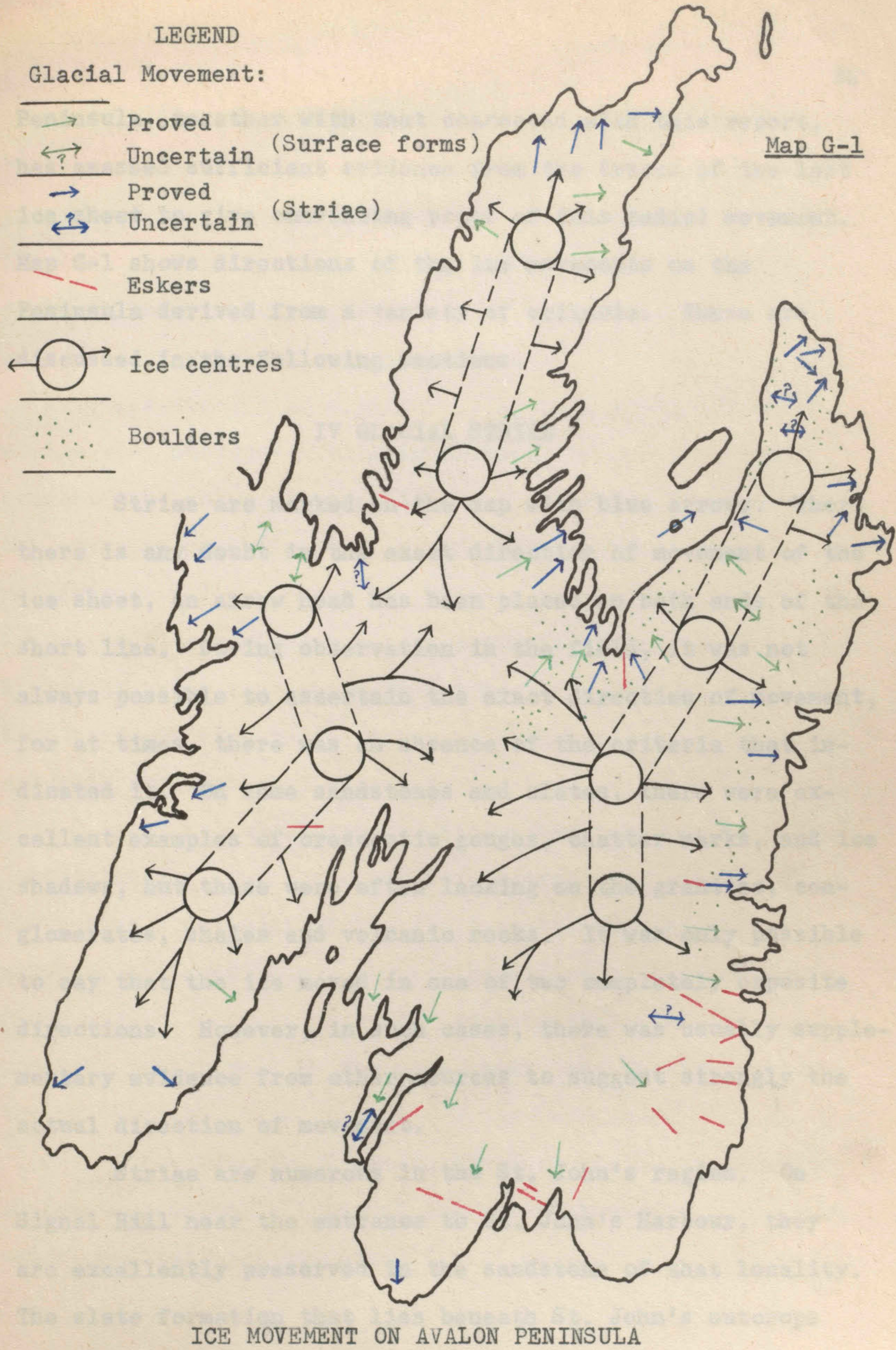
[5]Fernald, M.L., "Unglaciated Western Newfoundland", Harv.Alum.Bull. Jan.1930, also Rhodora,13:109 (1911), 28:328-336 (1926).

outward from the high central plateau. Besides the inequality in the crustal deformation, support to the theory of invasion by Labrador ice in Wisconsin time is found in two localities where there are glacial striae indicating a southward movement. These are the Newfoundland side of the Straits of Belle Isle and at Port-au-Port on the west coast of the Island.

Much the same order of events seems to have occurred on the Avalon Peninsula. There is slight evidence for an invasion of ice from the west, though it is meagre and not thoroughly convincing. Some serpentine rock was found in a glacial till near St. John's and since there is no serpentine known on the Avalon Peninsula, it is assumed to have come from deposits in central Newfoundland. Some of the glacial striae in the vicinity of the Isthmus of Avalon suggest a movement of ice from the west, but kames and moraines in the same district imply a movement from central Avalon. There are also rounded granite erratics which seem to have been transported from a distant source. It is, therefore, possible that an ice sheet flowed over the Avalon Peninsula from central Newfoundland in Wisconsin time, but if so, on recession, it left the Peninsula with its own ice cap. There is overwhelming evidence to show that the last ice movement on the Peninsula was one of radiation from a central point, or possibly points. Most previous research on the



ICE MOVEMENT ON AVALON PENINSULA

Peninsula, together with that connected with this report, has amassed sufficient evidence from the traces of the last ice sheet to give convincing proof of this radial movement. Map G-1 shows directions of the ice movements on the Peninsula derived from a variety of criteria. These are discussed in the following sections.

IV GLACIAL STRIAE

Striae are marked on the map with blue arrows. Where there is any doubt in the exact direction of movement of the ice sheet, an arrow head has been placed on both ends of the short line. During observation in the field, it was not always possible to ascertain the exact direction of movement, for at times, there was an absence of the criteria that indicated it. On some sandstones and slates, there were excellent examples of crescentic gouges, chatter-marks, and ice shadows, but these were often lacking on the granites, conglomerates, shales and volcanic rocks. It was only possible to say that the ice moved in one of two completely opposite directions. However, in such cases, there was usually supplementary evidence from other sources to suggest strongly the actual direction of movement.

Striae are numerous in the St. John's region. On Signal Hill near the entrance to St. John's Harbour, they are excellently preserved in the sandstone of that locality. The slate formation that lies beneath St. John's outcrops at the surface in many places in the city. Here also, striations, accompanied by gouges and chatter-marks, are numerous. There is every indication of a movement towards the east on Signal Hill, although further inland the ice seems to have flowed northeasterly, down the valley, on the west side of which St. John's is built.

Near Torbay, in a valley lying in a NE/SW direction, striae were observed similarly aligned, but also in this locality the southeast trending striae, indicated on the map, were in valleys lying in a SE/NW direction. Striae at Flatrock and near Cape St. Francis point directly out to sea in easterly and northeasterly directions respectively. Along the coast near Bauline in Conception Bay, no definite direction was ascertained from the striations seen in the volcanic rocks of that district.

Along the southeastern and southwestern shores of Conception Bay, there are numerous examples of striae, all indicating a movement of the ice into the Bay, on all parts of the coastline. Glacial scratches on the Carbonear Peninsula, found mostly in the northern sections, infer a movement to the east on the east coast, and to the north on the north coast.

On the Isthmus of Avalon the only striae found which indicated a definite trend of ice movement were on the south coast, and here the suggested direction was to the south.

One striated outcrop near Dildo showed north to south running striations, but the absence of gouges and other criteria made it impossible to state definitely whether the ice flowed north or south. A few hills in this locality with a lee and stoss form indicate a movement to the north, but these were not visited and they may be escarpments.

The coastline of the Placentia Peninsula shows indication of ice movement towards the sea in all localities. On the southern end of this Peninsula, the trend of the striae has a southerly direction as shown by the arrows on the map.

On the east side of St. Mary's Bay, because of the thick mantle of glacial drift in this locality, only one striated outcrop was seen. This was on the vertical sides of a fiord-like bay and the direction suggested for glacial movement was southerly, although absolute evidence was lacking. Eastward from the mouth of St. Mary's Bay, near St. Shott's, scratches show that the ice moved southward in this area.

The east coast of the Avalon Peninsula is well supplied with striated surfaces on the coastline and on the hill tops of the interior highlands. Many localities here show definite signs of ice movement towards the sea. The best preserved striations and gouges seen on the Peninsula were found at Cape Broyle in this district. Scratches and grooves are poor on the granite and conglomerate of the interior hills, but moutonnee forms were observed to run east and west (Photo 13).

V. TOPOGRAPHICAL FORMS

Green arrows on Map G-1 indicate the direction of glacial movement as inferred from such major features as lee and stoss hills, alignment of lakes and drainage and also from moutonnee rock surfaces on hilltops and valley sides.

The aerial photographs of the Avalon Peninsula, when assembled in a mosaic, show remarkably well the direction of ice movement. This is most striking on the east coast, south of St. John's, and on the southwestern and western sides of Conception Bay. In these localities, the mosaics show all major features, lakes, drainage, ranges and even strips of forest to align perfectly in the same direction. In fact, examination of individual photographs usually gives an indication of the direction of glacial ice movement for any area. Where the directions inferred on the aerial photographs are confirmed by lee and stoss hills, or other criteria, green arrows have been used to indicate them on Map G-1.

The alignment of lakes is striking in some regions. The large lakes in the granite of the highland regions, west of Renews, fail to show much suggestion of a pattern, but further south, on the same upland region, the lakes formed on the sedimentary strata are often aligned in the direction of ice movement. This is also true of the Carbonear Peninsula and of the Moraine Plain to the south.

The zonation of forests and boglands in parallel lines can often be an indication of glacial movement, the forest being on the drier, well drained ridges, and the bogs in the interspaced valleys or depressions. This zonation is faintly discernible in the background of Photo 13, which shows the lowland regions of the east coast of the Peninsula. The moutonnee forms in the foreground are running east and west.

VI. BOULDER TRAINS

Boulders which have been transported from known sources are indicated on the map by green dots. The position of these green dots is general and is only intended to convey an impression of the scattered distribution of boulders originating from the Avalon Granite Complex or the upland formed on Harbour Main Volcanics on the St. John's Peninsula. The principal localities into which these boulders have been carried are the Lowlands of the east coast, the Moraine Plain in the centre of the Peninsula and the Low-Lying Plain Coast of Conception Bay. In 1882 Murray[6] reported syenite and granite in the till near Renews as well as trap rocks near St. John's; the latter probably came from the volcanics

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[6] Murray, A., "Glaciation in Newfoundland", Proc. and Trans Roy.Soc.Can. 1:55-76(1882).

on the west of the St. John's Peninsula. Boulders of these volcanic rocks are found throughout this lowland and they are most numerous on the northeastern shores of Conception Bay. Chamberlin[7] found crystalline rocks of the granitic type as well as red sandstone removed but a short distance from their source in the vicinity of Bay Bulls. All these were found east of the parent bedrock.

VII. ESKERS AND MORAINAL RIDGES

Eskers occur in several localities on the Avalon Peninsula. They are most numerous in the southeastern sections but there are three single occurrences in other parts of the Peninsula. They are marked in red on Map G-1. The longest found was on the east coast near Renews and was traced for about fifteen miles inland (Photo 23) though it is broken in several places. Most others on the east coast are very short but they have a similar alignment parallel to striae and other criteria of the direction of glacial movement. The average height of these eskers is about 40 or 50 feet and they are usually about 100 feet wide. They have suffered greatly from erosion and in places peter out entirely.

In the country north of Trepassey, some eskers seem

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[7]Chamberlin, T.C., "Notes on the Glaciation of Newfoundland", Bull.Geol.Soc.Am. 4:464 (1895).

to follow the assumed trend of glacial movement, but the most southern ones lie across it. These were not visited but were observed on aerial photographs as long sinuous ridges. They might possibly then be mounds of terminal moraine formed during the retreat of the ice in this region as also may be the esker (?) shown on the northern part of the Placentia Peninsula.

A single esker north of Dildo, in Trinity Bay, is short but very well formed, and is a useful indication of glacial movement in this district. Similarly, the one marked near Holyrood at the head of Conception Bay, is very small, and in this case is poorly developed.

The Moraine Plain of central Avalon consists of numerous morainal ridges, many of which are aligned northeast-southwest. These probably consist of terminal and lateral moraine. Their origin is suggested in a later section.

VIII. STRUCTURAL CONTROL OF ICE MOVEMENT

The foregoing observations determining the direction of ice movement lead strongly to the conclusion that this movement was almost entirely controlled by the underlying topography, and that the last ice sheet was consequently very thin. This control by structure is so reliable that it is possible to predict the directions of the striations in most areas before actually observing them.

The ice seems to have flowed from the uplands to the lowlands down the river valleys and out into the bays. All the evidence seems to point to a local and fairly mild glaciation, and in fact it seems probable that there were several centres rather than only one ice cap. These centres or individual ice caps seem to have occupied all the upland regions, radiating ice towards the lowlands and the sea. Their position is suggested on Map G-1 by small circles combined with arrows indicating the probable movement of individual tongues. The tongues probably moved in a variety of directions from each centre on the Peninsula, intermingling with or overriding one another on the Moraine Plain, and all combining to deposit the great thickness of drift which is found in that area. On recession of the individual tongues, the morainal ridges were formed as well as the kame and kettle topography which is a present feature of the landscape.

IX. INTER-DRIFT VEGETATION

Throughout a great portion of the Moraine Plain and in the vicinity of Bauline on the St. John's Peninsula, the presence of an inter-drift layer of partially decayed plant and forest remains was noticed, usually occurring in morainal ridges or kames. The glacial deposits on either side of this layer are very similar. Each is fresh and only slightly weathered and contains almost identical rock fragments,

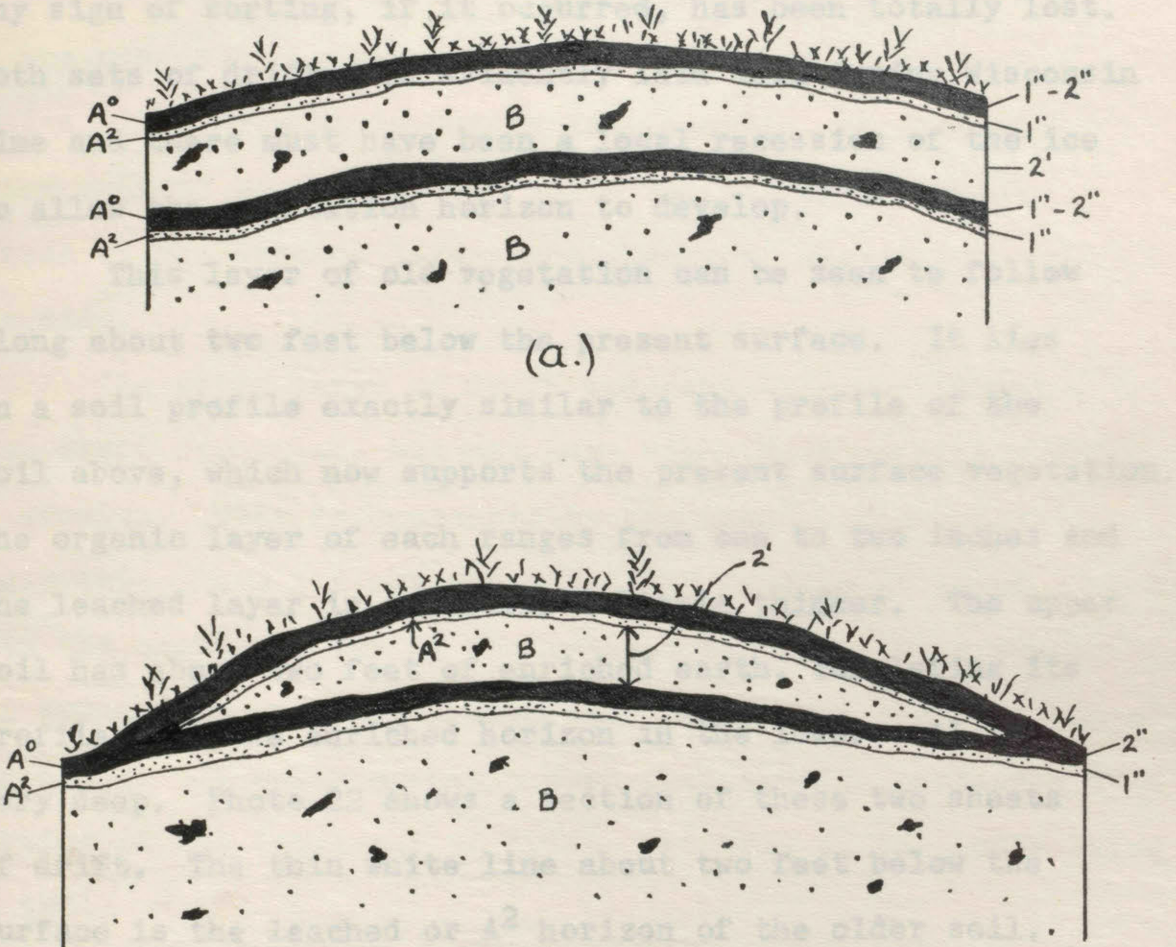

Fig. 3. INTER-DRIFT VEGETATION BED

(a) At Whitbourne

(b) Near Bauline

composed of shale, sandstones and slates, of the underlying or neighbouring bedrock. Thus, there is no suggestion of this layer being the result of a long inter-glacial period. Any sign of sorting, if it occurred, has been totally lost. Both sets of drift were evidently laid down during Wisconsin time and there must have been a local recession of the ice to allow the vegetation horizon to develop.

This layer of old vegetation can be seen to follow along about two feet below the present surface. It lies on a soil profile exactly similar to the profile of the soil above, which now supports the present surface vegetation. The organic layer of each ranges from one to two inches and the leached layer is generally a little thinner. The upper soil has about two feet of enriched earth, completing its profile, but the enriched horizon in the lower soil is very deep. Photo 22 shows a section of these two sheets of drift. The thin white line about two feet below the surface is the leached or A^2 horizon of the older soil. The organic layer above this contains many remains of woody plants and in places sections of trees with the bark still preserved.

The period between the recession and the advancement of the ice must have been several hundred years long, for it would undoubtedly take that length of time for a soil profile to be built up on the drift and become sufficiently mature to support a woody vegetation of the sort that is now partially preserved there.

Fig.3 (a) shows the position in which this layer of old vegetation is found in relation to the surface on the ridges and kames of the Moraine Plain in central Avalon. The drawing is purely diagrammatic, no attempt being made to show a correct scale relationship. Thicknesses of the various layers are, however, marked on the side.

The upper layer of drift may have been much thicker when first deposited, but may have since been greatly reduced by erosion. This is suggested by the condition shown in Fig.3 (b). Here the old organic layer is seen to blend with the organic layer of the present surface. This sketch was drawn from an example seen near Bauline on the St. John's Peninsula. It seems probable here that erosion carried away a portion of the top layer of drift, and some of the lower layer as well.

The advance and retreat of tongues of ice from the different ice cap centres during the waning period of Wisconsin time must have been responsible for depositing this higher layer of drift on existing vegetation. Possibly there are other explanations, but further research is necessary before the definite relationship between the different layers of drift is established.

X. POST-GLACIAL UPLIFT

Marine features that have emerged since the Ice Age are well developed around the coast of Newfoundland. For some time it was assumed that only the northern half of the island had risen above the present sea level. Undoubtedly, the greatest degree of emergence has occurred in the northernmost regions where marine terraces are found up to 250 feet, but recent discoveries have disclosed emerged deltas and wave-cut benches on the south coast of the island. Formerly it was assumed that there was a "hinge line" across Newfoundland from St. George's Bay to the east coast in the vicinity of Notre Dame Bay. All features of emergence showed a gradual increase in elevation northward, but evidence of uplift was not observed in the south. Recently, however, there has been need to modify this theory. Flint[8] has received reports of emerged deltas up to 50 feet in the vicinity of Fortune Bay, and also of wave-cut benches at the same elevation a little further to the west, near Connaigre Bay. Mr. Edward Rose, of the Geological Survey of Canada reports raised beaches up to 60 feet in Placentia Bay and up to 35 feet on the east

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[8] Flint, R.F., "Late Quarternary Changes of Level in Western and Southern Newfoundland", Geo.Soc.Am.Bull. 51:1773 (1940).

coast of Avalon, near Mobile. He also says that there is suggestion of a terrace at 150 feet in Logy Bay, just north of St. John's.[9]

Besides the features seen by Rose in Logy Bay and Mobile, uplift to the extent of 35 feet was observed at Cape Broyle during the field work in connection with this report. Here, a mature river valley previously eroded almost to base level is now seen to contain a sharp waterfall which is formed on a shelf near the coastline.

Before the discovery of these features of emergence on the Avalon Peninsula, it was possible to draw a continuous series of isobases across Newfoundland, increasing in value northward from the "hinge line". These isobases could also be roughly correlated with those on the mainland. The new evidence makes the picture much more complicated. It is possible that these old strand lines have been formed at different times, certain groups being related to different glacial periods. There is also a possibility that upwarping was not consistent and different sections of the island responded more completely than others when freed of the glacial load. On the other hand it may be that only certain sections of the coast were exposed to the sea for long periods, the rest being covered by tongues from the inland

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[9] Oral communication.

ice mass. Under this condition strand lines would be developed only in exposed regions.

XI. CONCLUSION

The contradictory reports and lack of conclusive evidence make it impossible to make a definite statement on early Pleistocene glaciation of the Avalon Peninsula. It is only possible to say that there is some evidence to suggest such earlier glaciation, but all definite traces seem to have been obliterated. There is, however, no doubt that this Peninsula was subjected to glaciation in Wisconsin time, most probably by a number of relatively small ice caps. The unmistakable radial movement of ice from centres in the highlands is indicated by a wealth of evidence shown in striations, moraines, eskers and the topographical forms on the present surface.

The presence of beds of ancient vegetation between two sheets of drift suggests that there was periodic advancement and recession of tongues of ice from the centres of the ice masses. The vast area of morainal deposits in the centre of the Peninsula also gives weight to this theory.

Occurrences of emerged marine features in various parts of the Avalon Peninsula indicate crustal deformation after removal of the ice. These features of emergence are not sufficiently numerous or regular to furnish information towards the compilation of isobases. It is thought probable that upwarping after the removal of the ice mass varied in degree for different localities, or that possibly the raised beaches and terraces observed were remnants of a strand line more ancient than that formed since Wisconsin time.

CHAPTER VI

CLIMATOLOGY

I. INTRODUCTION

A clearer picture of the climate of the Avalon Peninsula will be presented if consideration is given as well to the general climatic conditions of the whole Island of Newfoundland. The maps, diagrams and statistical data pertaining to this section have, therefore, been compiled from the meteorological records of many of the observation stations throughout Newfoundland. Special attention, however, is paid to the Avalon Peninsula, and the characteristics of its climate are compared and contrasted with those of the other parts of the Province.

II. THE CLIMATE IN GENERAL

The climate of Newfoundland is continental in character, though greatly modified by marine influences. Newfoundland does not possess a marine climate corresponding to the humid west coast type in the Province of British Columbia, although this might be expected from the point of view of its geographical position, that of an island jutting well out in to the Atlantic Ocean and surrounded on all sides by great expanses of water. Furthermore, although Newfoundland is three hundred and seventeen miles long and three hundred and seventeen miles wide, no section of the interior is more than seventy miles from the sea, as there are numerous long and narrow bays penetrating far inland. Despite these marine features, Newfoundland's position on the extreme east coast of a continent subjects it to an almost continual invasion of air masses from the west and northwest, and consequently to air that already has a continental history. This continental feature in the climate is more prevalent in the west and northwest portions of the island, or those regions which are nearest to the mainland, than it is in the south and southeast sections.

Newfoundland possesses two types of climate which will fit into the Koppen[1] system of classification. However, it would be very difficult, with the present sparsity of meteorological data to define the exact boundaries of these two climatic provinces. Generally speaking, the northern and mountainous sections of the country fall into Koppen's Dfc type, which is defined as a region with the mean temperature of the coldest month below 26.6 degrees[2], and that of the warmest month above 50 degrees, and is further classified as having cool short summers, and no dry season (that is, no season without a monthly rainfall of at least 1.2 inches). The western and southern section of the island would be termed Dfb type. Areas falling into the Dfb classification

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[1]Koppen, W., Grundiss der Klimakunde. Berlin, 1931.

[2]All temperatures are given in Fahrenheit.

differ from Dfc types only in that they have at least four months with mean temperatures above 50 degrees. The Dfc classification defines areas within the "taiga" province. The winter season in northern Newfoundland and in its mountainous districts is not as severe as in the interior "taiga" of Canada and Russia, but there is sufficient similarity in the natural vegetation to justify terming these regions "taiga".

The southern half or Dfb section of the island is akin to the neighbouring provinces of Nova Scotia and New Brunswick in climate, but it is difficult to find sufficient similarity to classify it with the climate of Quebec, northern Ontario, or parts of the prairie Provinces, although by using the Koppen system sections of the three last named Provinces fall within the Dfb category.

The following sections are designed to clarify and modify this general statement of climatic type as they deal in order with air masses and winds, pressure centres, storm tracks, air temperatures, precipitation, coastal fogs and the influence of ocean currents. In conclusion there is presented a section treating of the relation of climate to occupance.

III. AIR MASSES AND WINDS

Newfoundland is periodically subjected to the invasion of three types of air masses, namely, polar continental air from the west and northwest moving out from the cold interior of northern Canada and the southern Arctic region; polar maritime air from the northeast, passing down across the chilly waters of the Labrador Current, and tropical maritime air from the south and southwest, or part of that mass of air which invades the whole eastern section of the North American Continent from the Gulf of Mexico, but which swings outward again to travel northeastwards over the Maritimes.

Frontal systems, or contact zones between the warm and cold masses of air, frequently lie across or near Newfoundland, thus subjecting the whole region to numerous fluctuations of warm or cold weather. The cold, dry polar air from the continent invades the Newfoundland area at all seasons, although most commonly in wintertime. This air often arrives with undiminished velocity and is the dominant influence in creating the type of climate which the region possesses. This is most apparent in the northern and northwestern sections of the Island.

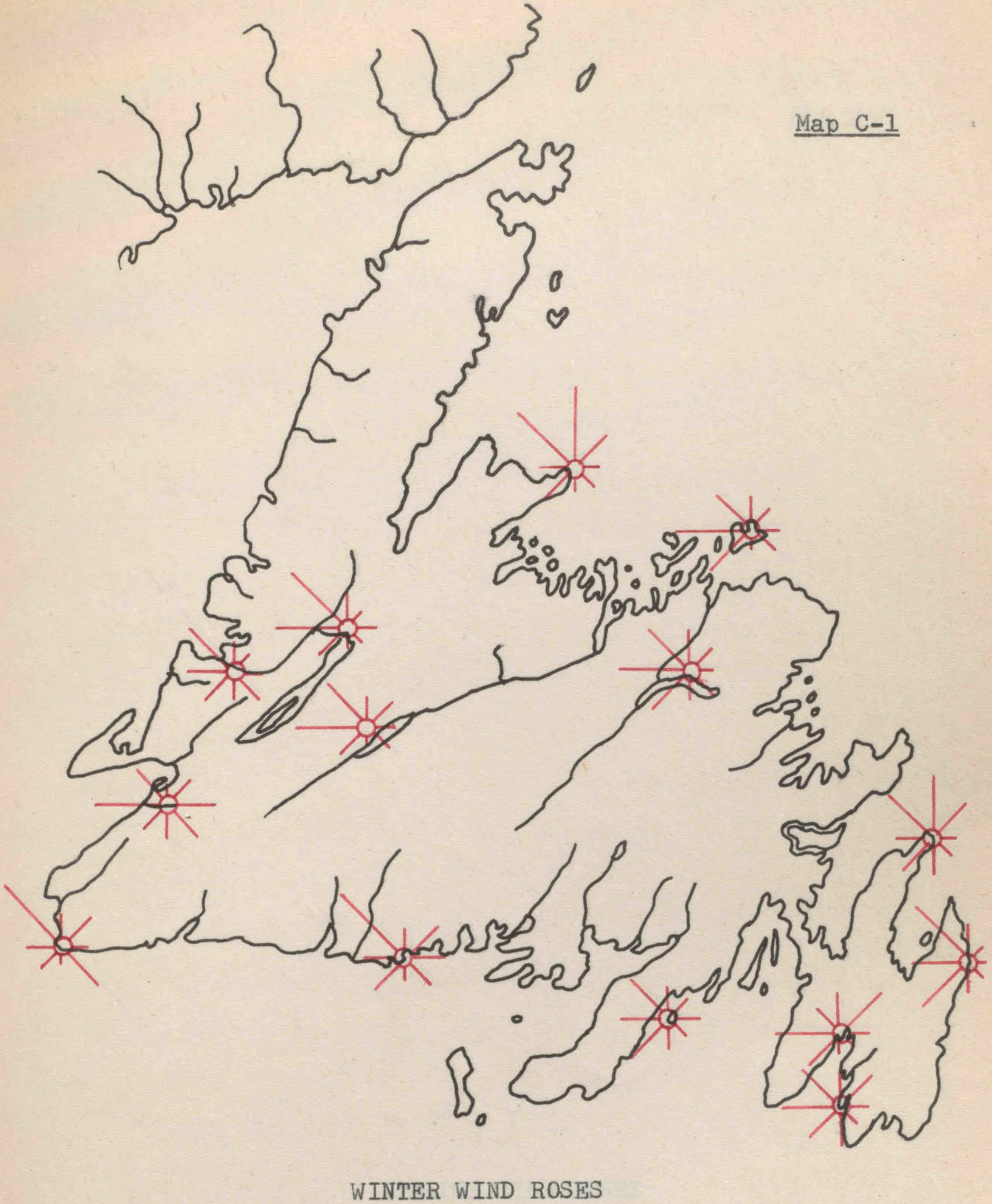
It is the polar continental air mass which produces the shorter and cooler summers, compared with the longer and more truly marine summers of similarly located areas of equal latitude, but with the same potential oceanic influence. The winters are equally more severe, as northwest winds, of this air mass, blowing across the Island in January, February and March may bring temperatures as low as

31 degrees below zero in the Belle Isle area and in the western interior, and 19 degrees below zero at St. John's on the Avalon Peninsula. However, the average yearly extreme minimum temperature for these two localities is much higher and the most extreme cases have been quoted.

Polar maritime air is common and moderate at all seasons. In winter it is cold and moist, but not nearly as severe as the polar continental air mass just described. In summer, the northeast winds from this body of air occasionally bring unseasonably cool weather to all Newfoundland, as they blow in across the Labrador Current, the waters of which remain near freezing point until late in the season. However, the occurrence of wind from this quarter is often accompanied by clear skies and bright sunshine. The resulting insolation alters considerably what would otherwise be typically autumn weather in the midst of a warm summer season.

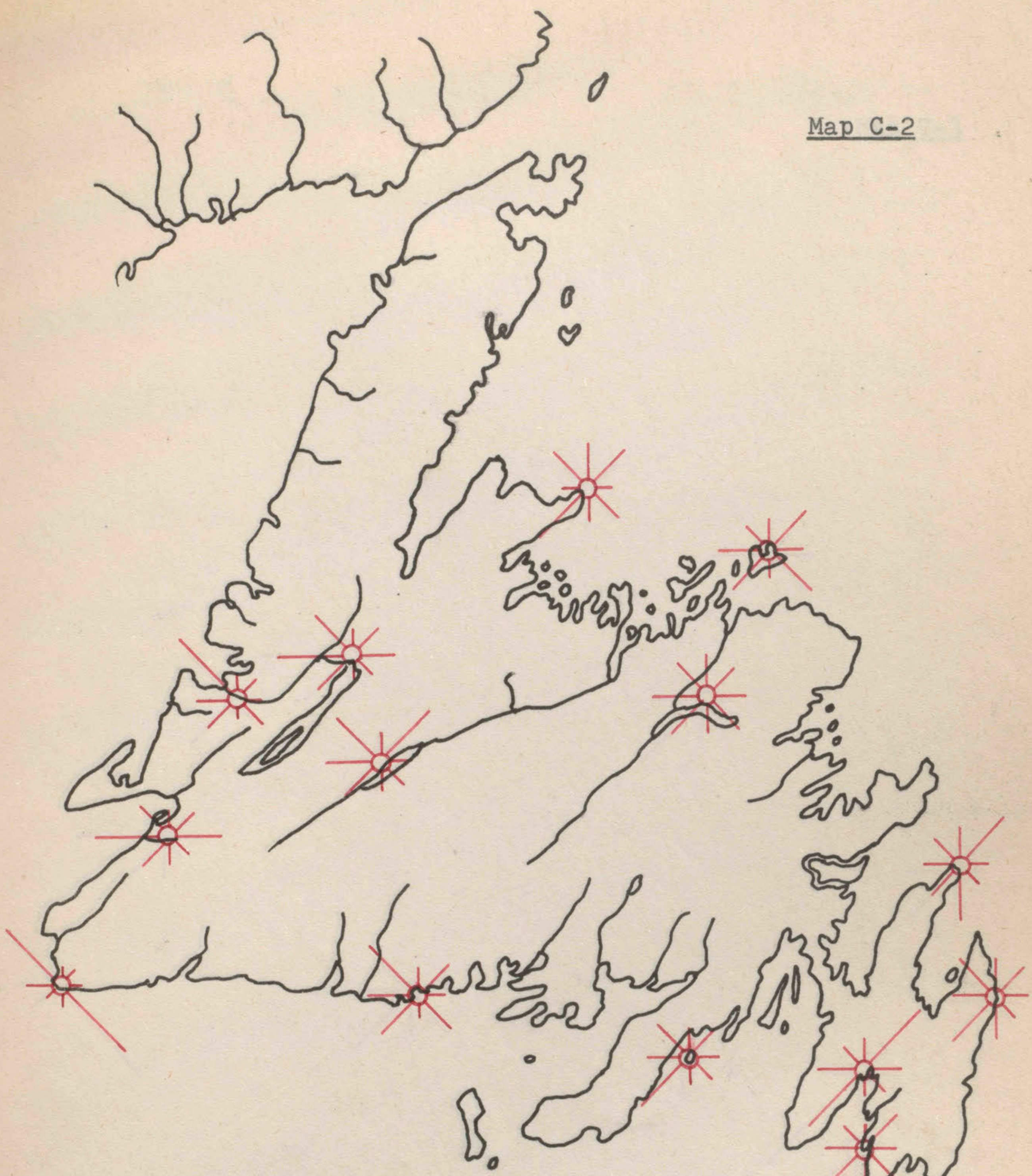
The air mass which does most to modify the continental characteristic of Newfoundland's climate is the maritime tropical type which invades the area at low levels during the summer half year, and occasionally during winter, although it usually occupies a higher position in the atmosphere at that season. The south and southwest winds of this air mass are warm and generally moist. They are the prevailing winds of summer throughout the island, with the exception of

Map C-1



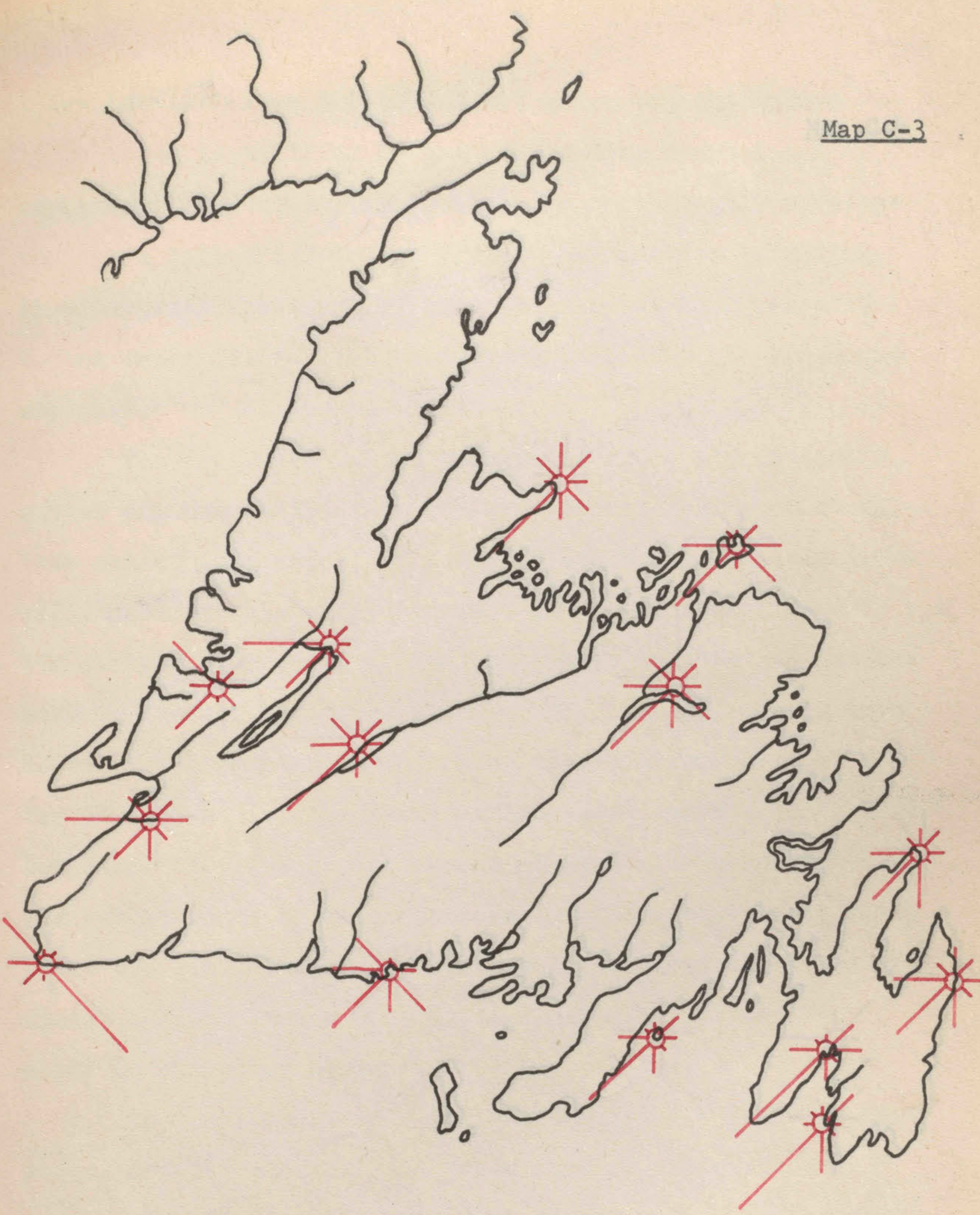
WINTER WIND ROSES
(DEC-JAN-FEB)

Map C-2



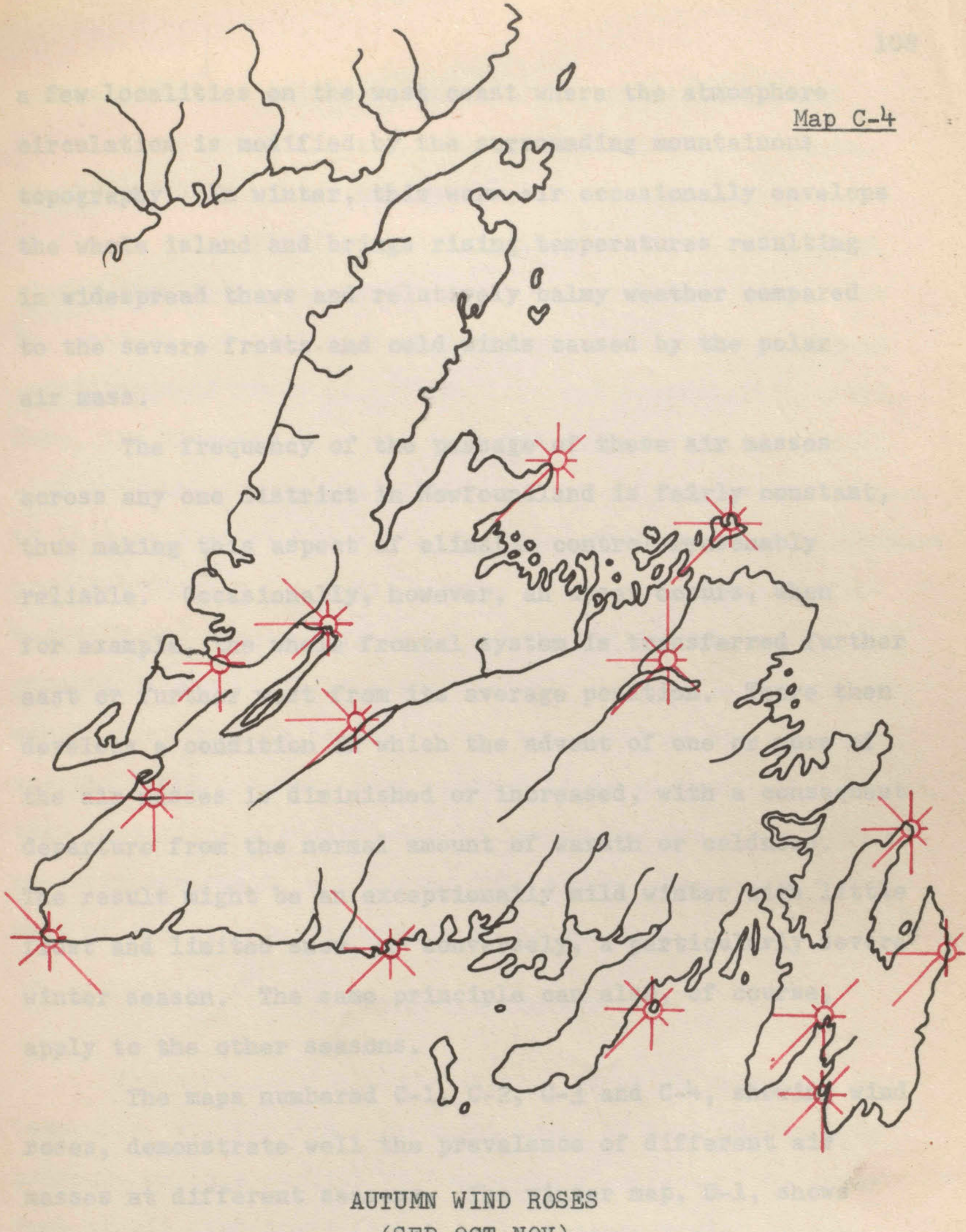
SPRING WIND ROSES
(MAR-APR-MAY)

Map C-3



SUMMER WIND ROSES
(JUN-JUL-AUG)

Map C-4



AUTUMN WIND ROSES
(SEP-OCT-NOV)

a few localities on the west coast where the atmosphere circulation is modified by the surrounding mountainous topography. In winter, this warm air occasionally envelops the whole island and brings rising temperatures resulting in widespread thaws and relatively balmy weather compared to the severe frosts and cold winds caused by the polar air mass.

The frequency of the passage of these air masses across any one district in Newfoundland is fairly constant, thus making this aspect of climatic control reasonably reliable. Occasionally, however, an upset occurs, when for example, the whole frontal system is transferred further east or further west from its average position. There then develops a condition in which the advent of one or more of the air masses is diminished or increased, with a consequent departure from the normal amount of warmth or coldness. The result might be an exceptionally mild winter with little frost and limited snow, or conversely, a particularly severe winter season. The same principle can also, of course, apply to the other seasons.

The maps numbered C-1, C-2, C-3 and C-4, showing wind roses, demonstrate well the prevalence of different air masses at different seasons. The winter map, C-1, shows that throughout the island the dominant wind direction is from the north, west, or northwest. The east and southeast coasts receive a fair percentage of northeast winds, and all stations receive a good proportion of southwest winds. In spring the northern and western stations have recorded an almost equal distribution for all directions, with some places showing an emphasis on west and southwest winds, but the eastern and southeastern districts have reported higher percentages of winds of northeastern and southwestern origin. Here, the increase in winds from the northeast is due to a high pressure area which builds up over the ice covered waters of this section of the North Atlantic, thus creating a pressure gradient towards the land. Summer winds are predominantly westerly and southwesterly throughout the island, again with exceptions due to local topographical relief. In autumn the continental high is beginning to form again on the mainland, and the coastal waters have reached their highest temperatures, thus conditions are particularly favourable for winds with a westerly component, and during this season observations from most of the stations show this to be the case.

IV. PRESSURE CENTRES

The centres of the air masses, to which reference has been made, are the semi-permanent areas of high atmospheric pressure on this section of the earth's surface. The movement of air down grade from a high pressure system to a low is modified in its direction by the rotation of the earth.

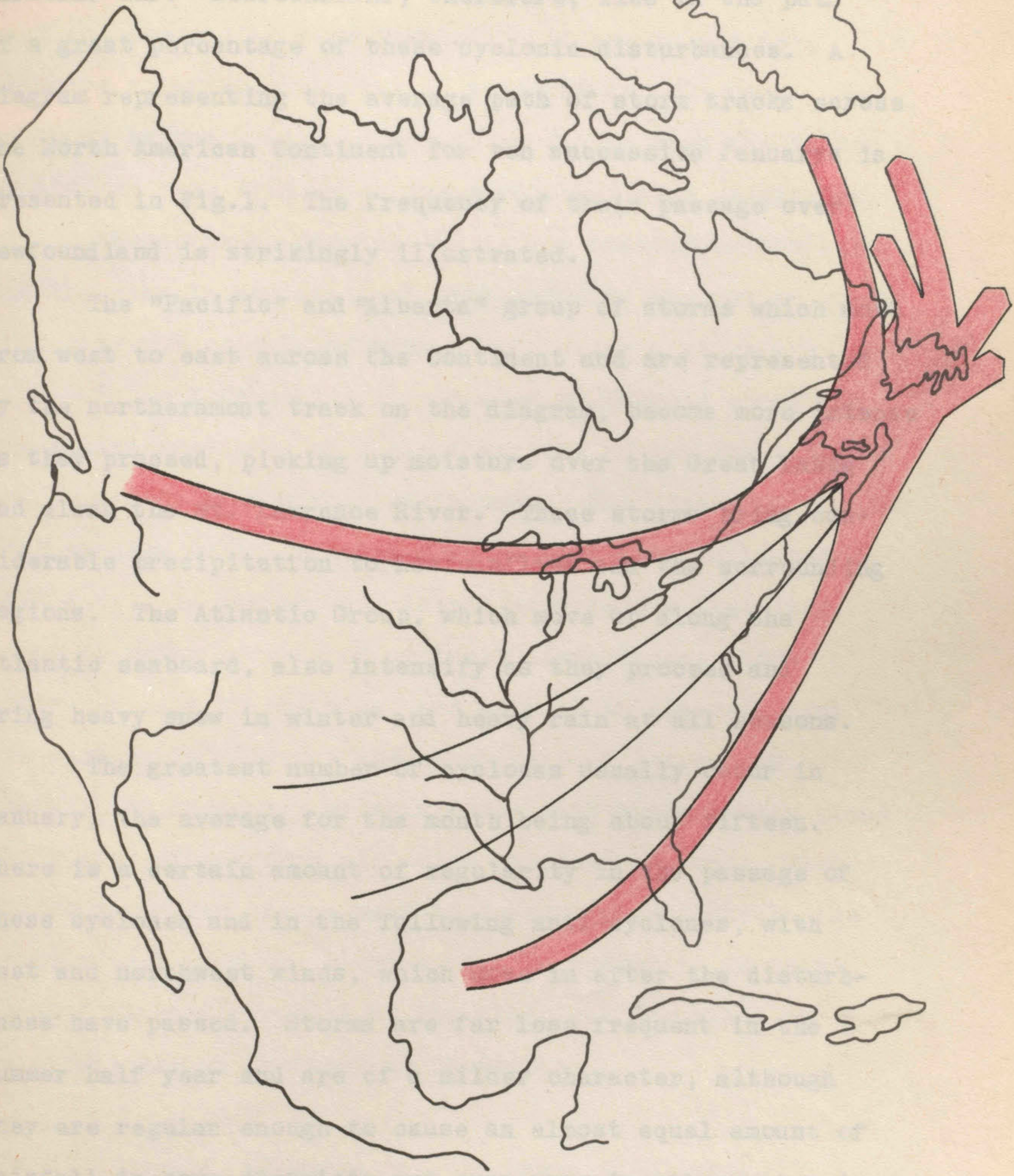
Thus, in winter the prevailing northwest winds of New-foundland are the result of air movement from the continental high of this season towards the Atlantic low. These are modified by deflection towards the right as they move first to the northeast, then to the east, and finally to the southeast. In summer the position is reversed. The low pressure area is over the relatively warm continent and the high is over the Azores. The prevailing southwest winds of summer are those which move up along the eastern section of the continent from the Azores High towards the inland low, but which are similarly deflected to the right in their course. Spring is a period of transition. Gradients are less pronounced, and more local pressure centres dominate the winds. At this time, on and off shore sea breezes are common along the east coast.

In general the first half of the year sees a pressure gradient change altering the wind direction from northwest to southwest, and the last half of the year sees the reverse.

V. CYCLONIC DISTURBANCES

Storms move eastward and northeastward along the two great frontal systems of the North American Continent. These systems are, the Atlantic Polar Front, which is the contact zone of maritime tropical air and continental polar air, and the American Arctic Front, which is

Fig. 1.



AVERAGE PATH OF STORM TRACKS

frontogenesis between polar continental air and polar maritime air. Newfoundland, therefore, lies in the path of a great percentage of these cyclonic disturbances. A diagram representing the average path of storm tracks across the North American Continent for ten successive Januarys is presented in Fig.1. The frequency of their passage over Newfoundland is strikingly illustrated.

The "Pacific" and "Alberta" group of storms which move from west to east across the Continent and are represented by the northernmost track on the diagram, become more intense as they proceed, picking up moisture over the Great Lakes and along the St. Lawrence River. These storms bring considerable precipitation to Newfoundland and the surrounding regions. The Atlantic Group, which move up along the Atlantic seaboard, also intensify as they proceed and bring heavy snow in winter and heavy rain at all seasons.

The greatest number of cyclones usually occur in January, the average for the month being about fifteen. There is a certain amount of regularity in the passage of these cyclones and in the following anti-cyclones, with west and northwest winds, which move in after the disturbances have passed. Storms are far less frequent in the summer half year and are of a milder character, although they are regular enough to cause an almost equal amount of rainfall in some districts and even more in others than in the winter half year.

Winds blow from a great variety of directions during the passage of these low pressure centres. Sometimes, the wind is observed to blow from all quarters in one day, bringing remarkable changes in temperature. It may suddenly become colder or warmer depending upon the nature of the air mass from which the particular wind originates.

Though these passing storms are continuous throughout the year in Newfoundland, the majority are not of great intensity and reports of wind damage after a storm are rare.

Table I, Appendix A, compiled by Koeppe[3] shows the percentage frequency of a great variety of weather types at St. John's in both winter and summer. The effect of cyclonic disturbances on the weather type is partially reflected in this data. In winter, St. John's experiences the windy, snowy or rainy effects of cyclonic disturbances about fifty per cent of the time, and it will be observed that the weather is fair for the other half of the season. The highest frequency of rain comes with disturbances along the border of the warm and moist tropical air mass, when the front is far enough west to leave Newfoundland in the rainy rather than the snowy area. In summer it is rainy about forty-one per cent of the time, but the winds are not as strong nor as frequent as in winter.

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[3] Koeppe, Clarence E., The Canadian Climate. (McKnight & McKnight, Bloomington, Ill., 1931).

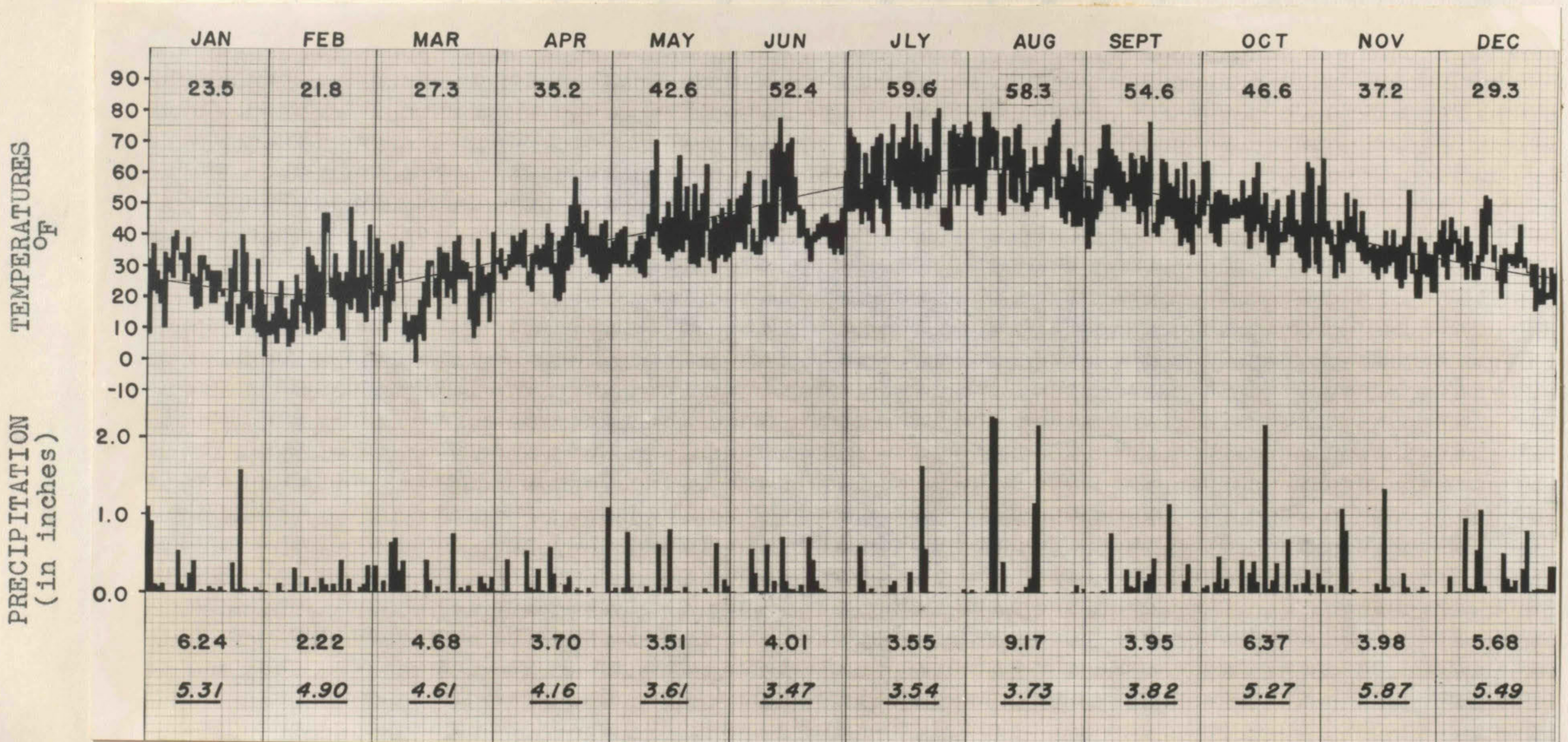


Fig. 2. CLIMATIC DATA AT ST. JOHN'S, 1939

The top row of figures shows the Mean Monthly Temperatures. The top graph shows the daily maximum and daily minimum plotted along the long term Normal Temperature Curve. The lower graph shows the daily precipitation. The monthly precipitation for 1939 is shown in upright figures. The slant figures are the Mean Monthly Precipitation.

The thunderstorms which accompany the "Alberta" group of cyclones as they pass up the St. Lawrence River valley are far less frequent in Newfoundland. In most years the average is one or two at the most. Evidently, the violent turbulence resulting from rising warm air currents is of rarer occurrence, thus limiting this climatic phenomena in the Newfoundland region. Occasionally, thunderstorms can be quite severe and can be the instrument of torrential downpours, sometimes of several inches of rain in a few hours. The chart in Fig.2 shows that most of the rainfall for the month of August in that particular year fell during three days. Part of this precipitation was accompanied by intense thunderstorms.

Another interesting phenomena which is of common occurrence in Newfoundland but which is rarer in most other localities, is freezing rain, locally known as "silver thaw". When rain comes to Newfoundland in wintertime with a mild south or southwest wind it often falls on surface features which are still below the freezing point. Consequently, houses, trees, power lines and even personal clothing become coated with a thin glittering film of ice.

VI. ATMOSPHERIC TEMPERATURE

There are three main temperature gradients in Newfoundland, one attributable to difference in latitude, one to difference in elevation, and one to distance from the ocean.

The nature of the climate of any area is largely dependent on its latitude and the consequent degree of insolation received from the sun. This latitudinal variation in Newfoundland is evident from the calculated mean temperatures of the two following meteorological stations. Belle Isle, off the extreme northern end of the island has a January mean of 10.5 degrees; St. John's, on the southeastern corner, has an average of 23.5 degrees for the same month. This represents a difference of 3.2 degrees in mean temperature for each degree of latitude, which is almost the same as the latitudinal gradient from Maine to Florida on the east coast of the United States. The July mean at St. John's is 59.6 degrees and the mean for this month at Belle Isle is only 46.9 degrees. However, the latitudinal separation of these two localities is not the sole factor determining such a great difference in the average atmospheric temperature. It has been stated in a previous section that the northern regions of Newfoundland are more frequently subjected to outbursts of polar air than are the southern sections, and in consequence there is a general lowering of mean temperatures in the affected areas. On Map C-6, the isothermal map for the month of April, the latitudinal effect on temperatures is notable. At this time of year there are no violent gradients in the main pressure system and thus fewer invasions of polar air masses. The latitudinal effect on temperature is much milder towards the south. In July the gradient between St. John's and Halifax is only 1.9 degrees per degree of latitude and in January it is zero.

Statistics showing the differences in mean atmospheric temperature due to topographical relief are not available, for there are no meteorological stations in Newfoundland in any of the areas which have an elevation above 1000 feet. However, some indications of the altitudinal effects on air temperature can be derived from such evidence as tundra-like vegetation on mountains and uplands higher than 1000 feet, or from perennial snow lying in the cirques of the Long Range Mountains. In these areas much lower mean temperatures must exist than in the forested valleys and heavily timbered lowlands. Elevation has been taken into consideration while drawing the isothermal lines for Maps C-5, C-6, C-7 and C-8. The evidence supplied by the vegetation and the perennial snow seem to make this procedure justifiable in the absence of direct meteorological observation. One meteorological station on the west coast of the Province, near Corner Brook Lake, was situated at an elevation of approximately 910 feet. It was, however, in operation for only a brief number of years and has since been abandoned. Its records are consequently sketchy and unreliable, but a rough calculation of mean temperature showed a ten degree negative difference from that of Corner Brook which lies near sea level in the same locality.

The temperatures and currents of the surrounding ocean and its nearness to all parts of the island affect to a considerable extent the air temperatures over Newfoundland. The general physiographic structure of the country, as shown in the relief maps, C-5 to C-8 draws attention to the long narrow bays and the interspaced narrow headlands as well as to the plateau-like surface of the interior which slopes eastward from the summits of the westward facing Long Range. The marine influences on the climate of Newfoundland are therefore great, and the role of the ocean as a heat regulator brings about higher mean temperatures in winter and lower ones in summer than those of the neighbouring mainland climatic provinces to the west and to the north. These are more perfectly continental in type.

A comparison of climatic data between Montreal and St. John's, two localities in approximately the same latitude, will be useful here to demonstrate the extent of this oceanic influence. Montreal has a yearly mean of 42.3 degrees, St. John's 40.9, but Montreal has three months above 60 degrees and St. John's has none. In wintertime

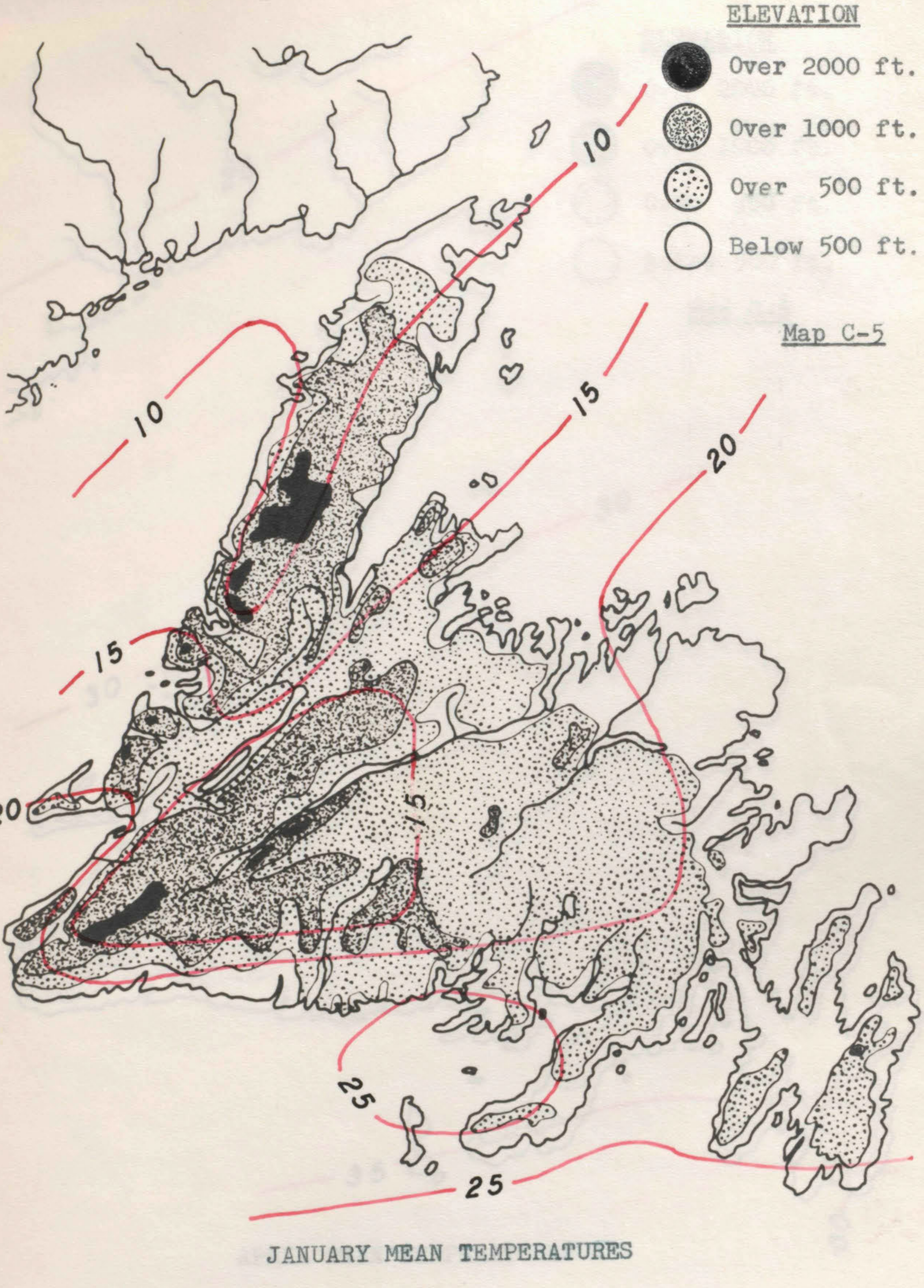
Montreal has three months with the mean temperature below 20 degrees, while St. John's has none, its lowest mean being 21.8 degrees for February. Maximum temperatures in the nineties are no rare occurrence in Montreal, but St. John's recorded a 90 degree temperature only once since the establishment of its meteorological station over fifty years ago. The yearly extreme maximum at St. John's is usually around 81 degrees. Sub-zero temperatures are common during a normal winter in Montreal but in St. John's as much as 5 degrees below zero is a rarity and zero or lower is recorded in only half the years.

The annual range of temperature in Newfoundland is short when compared with interior localities of Canada, but it is long when compared with districts in lower latitudes. The annual range of temperatures on the west coast of Canada is only half as much as it is in Newfoundland.

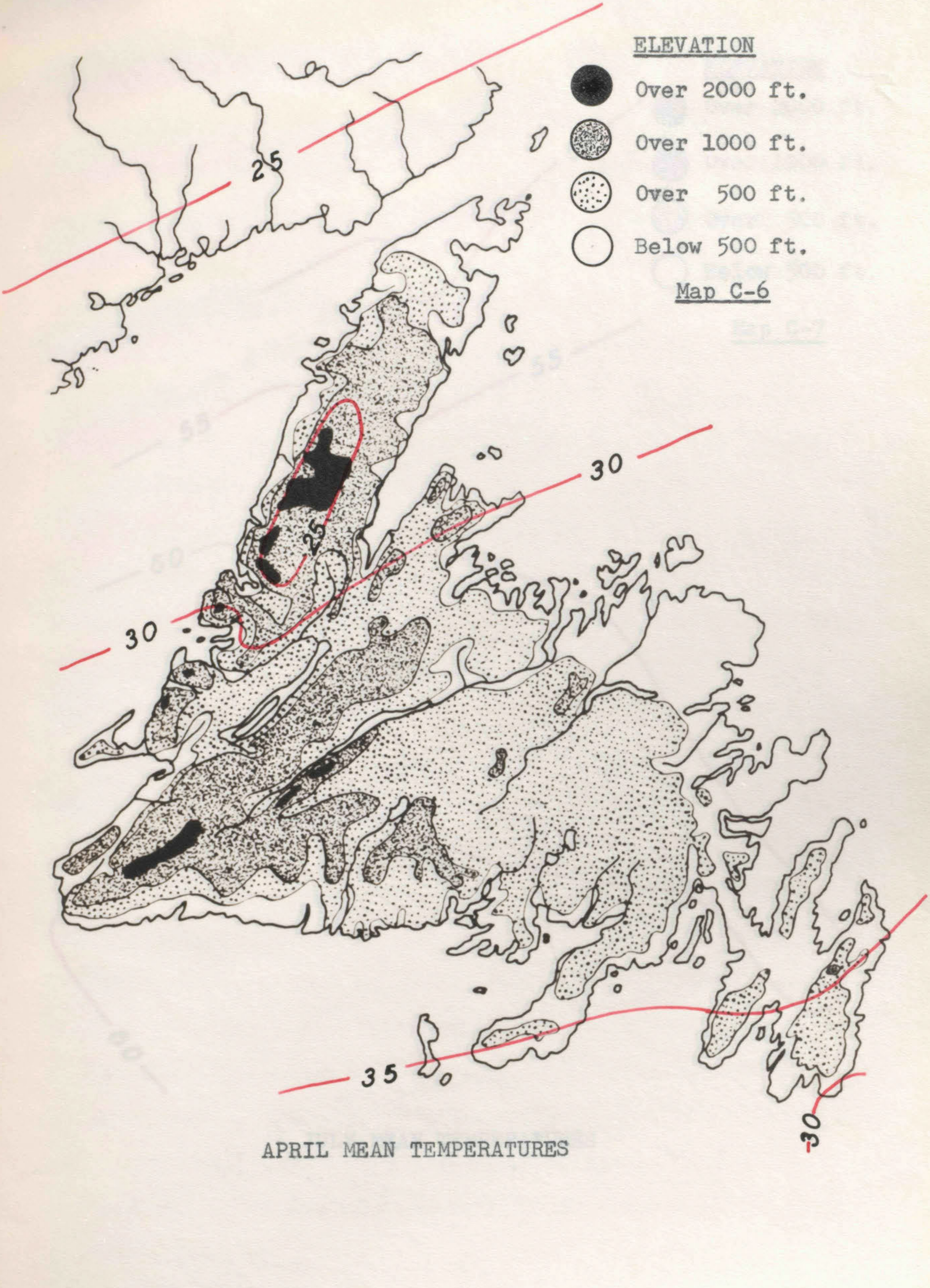
There is a slight difference noticeable in the mean temperature of inland and coastal localities within Newfoundland itself. Figures from Buchan's, Millertown and Grand Falls show the July mean to be usually one or two degrees warmer than at stations on the coast of equal latitude. The January mean is generally five or six degrees lower in the inland towns. Even Whitbourne in the centre of the Avalon Peninsula has a higher July mean and lower January mean than St. John's or Cape Race on the coast.

One of the striking effects of the ocean's role as a regulator is seen in the delayed arrival of the warmest and coldest months. In many sections of the island August is warmer than July and February colder than January. The curve of the normal temperature for the year at St. John's in Fig.2 shows the warmest period to be equally divided between the latter part of July and the first half of August. The coldest period is similarly divided between January and February.

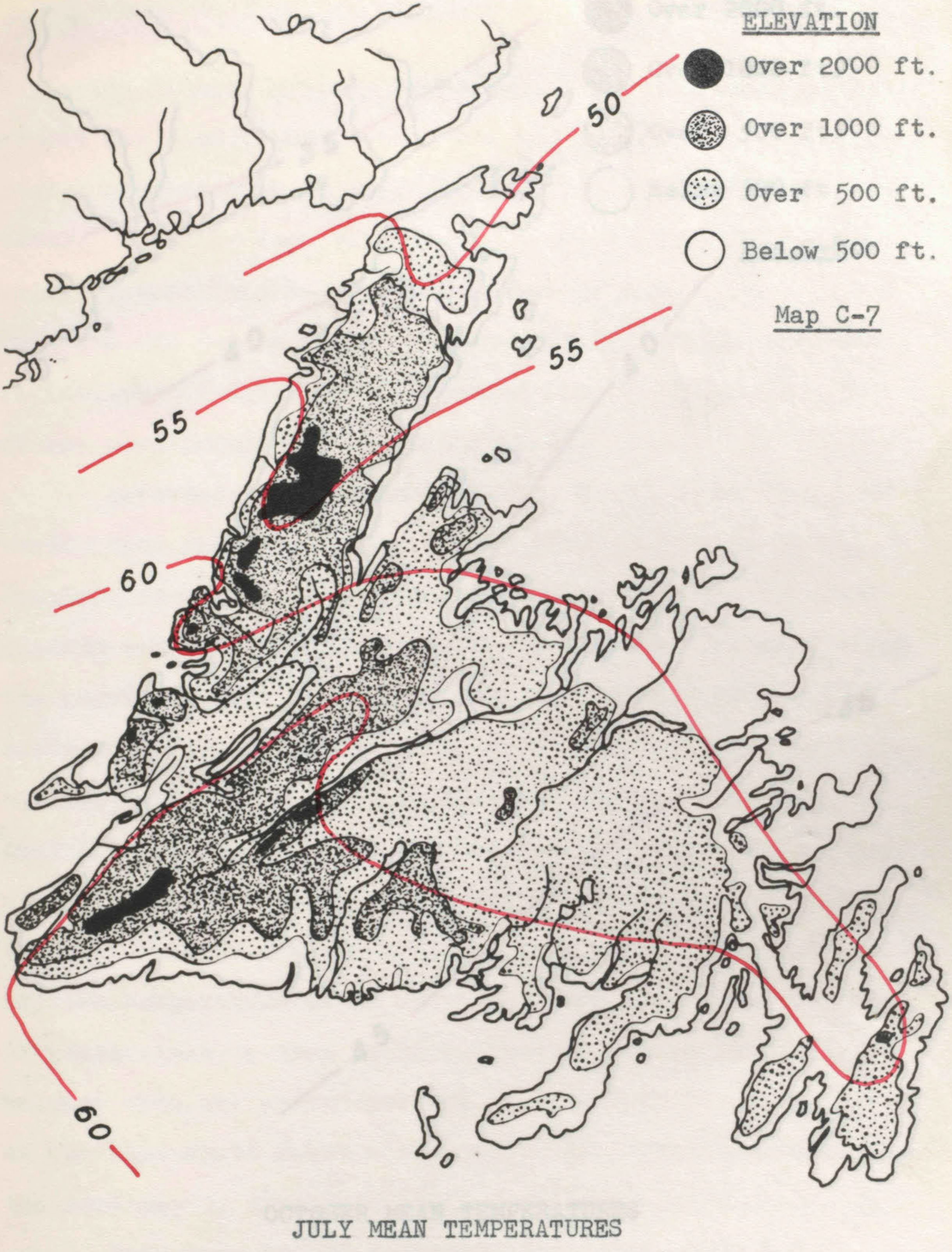
Some unusual features of atmospheric temperatures in Newfoundland are presented here to show the great variability and frequent departures from average conditions which occasionally do occur. Because of the frequent and continual changes of air mass type throughout Newfoundland, the maximum temperature for the day does not necessarily occur in the afternoon. In fact, nights are often warmer than days in wintertime when a warm air mass from the southwest chooses those hours to arrive. On such occasions the minimum for the day can occur in the morning, during bright sunshine, or the time when the cold polar air mass is present. At St. John's January and February show a maximum above 40 degrees at least once a year, such temperature usually being recorded in maritime tropical air. Tables IIa and IIb, Appendix A show the extreme maximum and minimum temperatures recorded for a representative group of localities. There is a wide



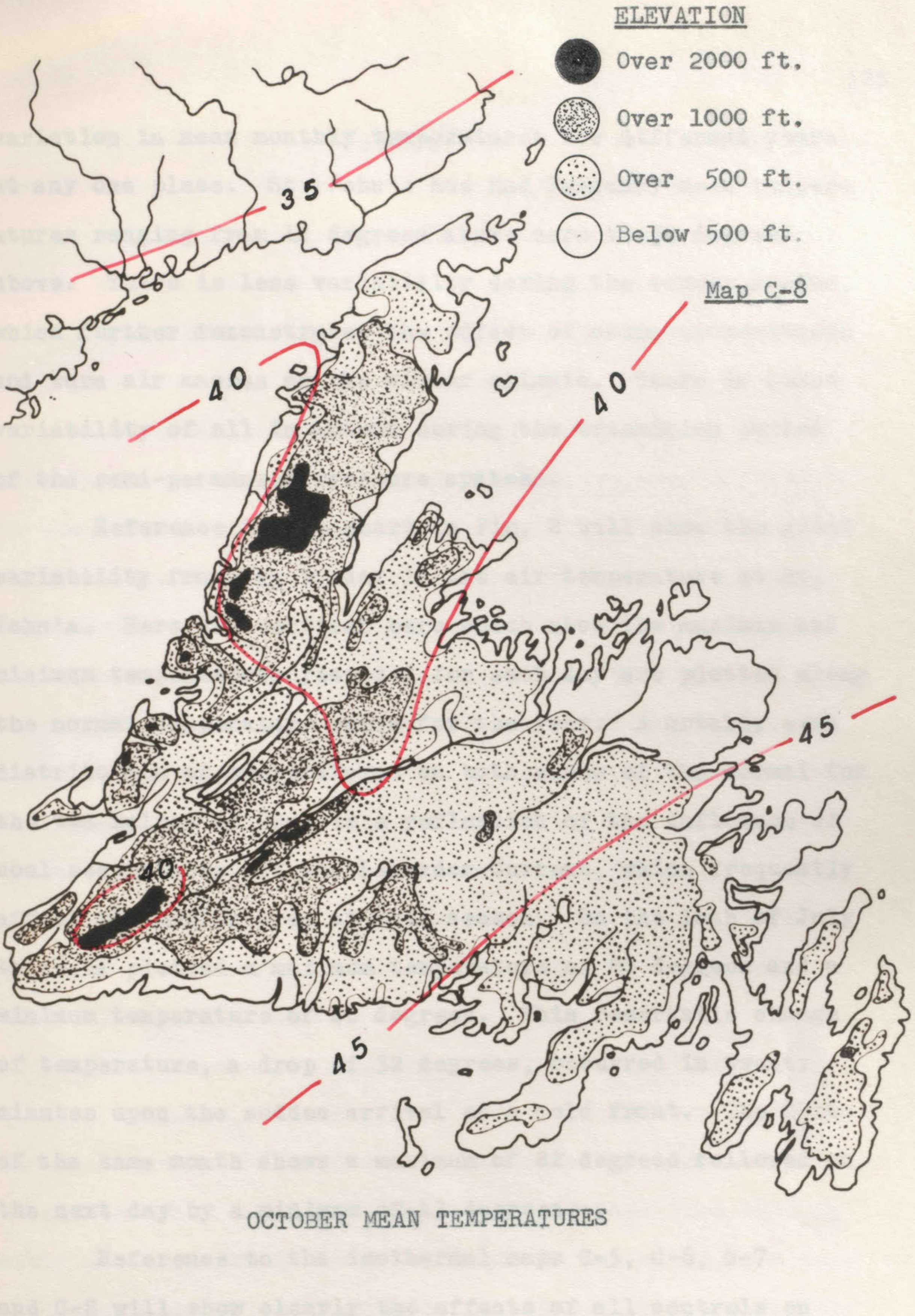
JANUARY MEAN TEMPERATURES



APRIL MEAN TEMPERATURES



JULY MEAN TEMPERATURES



OCTOBER MEAN TEMPERATURES

variation in mean monthly temperatures for different years at any one place. St. John's has had February mean temperatures ranging from 12 degrees above zero to 32 degrees above. There is less variability during the summer months, which further demonstrates the effect of ocean temperatures and warm air masses on the winter climate. There is least variability of all in autumn during the transition period of the semi-permanent pressure systems.

Reference to the chart in Fig. 2 will show the great variability from day to day in the air temperature at St. John's. Here the vertical bars which show the maximum and minimum temperatures recorded for each day are plotted along the normal temperature curve for the year. A notably even distribution of temperatures on both sides of the normal for the two halves of June is a reflection of the influence of cool sea breezes off the Labrador Current, which frequently affect the Avalon area at this season. On the 16th of July there is plotted a maximum temperature of 80 degrees and a minimum temperature of 48 degrees. This remarkable change of temperature, a drop of 32 degrees, occurred in twenty minutes upon the sudden arrival of a cold front. The 26th of the same month shows a maximum of 82 degrees followed on the next day by a minimum of 43 degrees.

Reference to the isothermal maps C-5, C-6, C-7 and C-8 will show clearly the effects of all controls on the distribution of mean atmospheric temperatures during the four seasons of the year. The January map shows the decided marine effect in the Avalon area and the colder conditions in the northern sections of the Province, as well as in the western interior highlands, indicated here by the closed 10 degree isotherm. One peculiar feature of this map is the closed 25 degree isotherm on the south coast. This area is in the shelter of the Burin Peninsula with respect to the Labrador Current, which having passed Cape Race heads westward along the south coast of the island. This area also has the longest growing season of the country as estimated from the number of days with the maximum temperature above 43 degrees. The Labrador Current is probably an important factor in bringing about the unequal distribution of temperature in adjacent localities on this coast. The temperature of all the inland towns for this month are very much of the same order, but places on the west and southwest coasts show an increase due to their marine location.

The temperature distribution in spring (Map C-6) is very simple. At this season there are but two isotherms, the 30 degree and the 35 degree, to cross the island. There exists in April a slightly lower mean at Cape Race than in other parts of the Avalon Peninsula, as indicated by a repetition of the 30 degree isothermal line. This is probably due to coastal ice in the Labrador Current causing more frequent onshore winds and consequently more abundant fog.

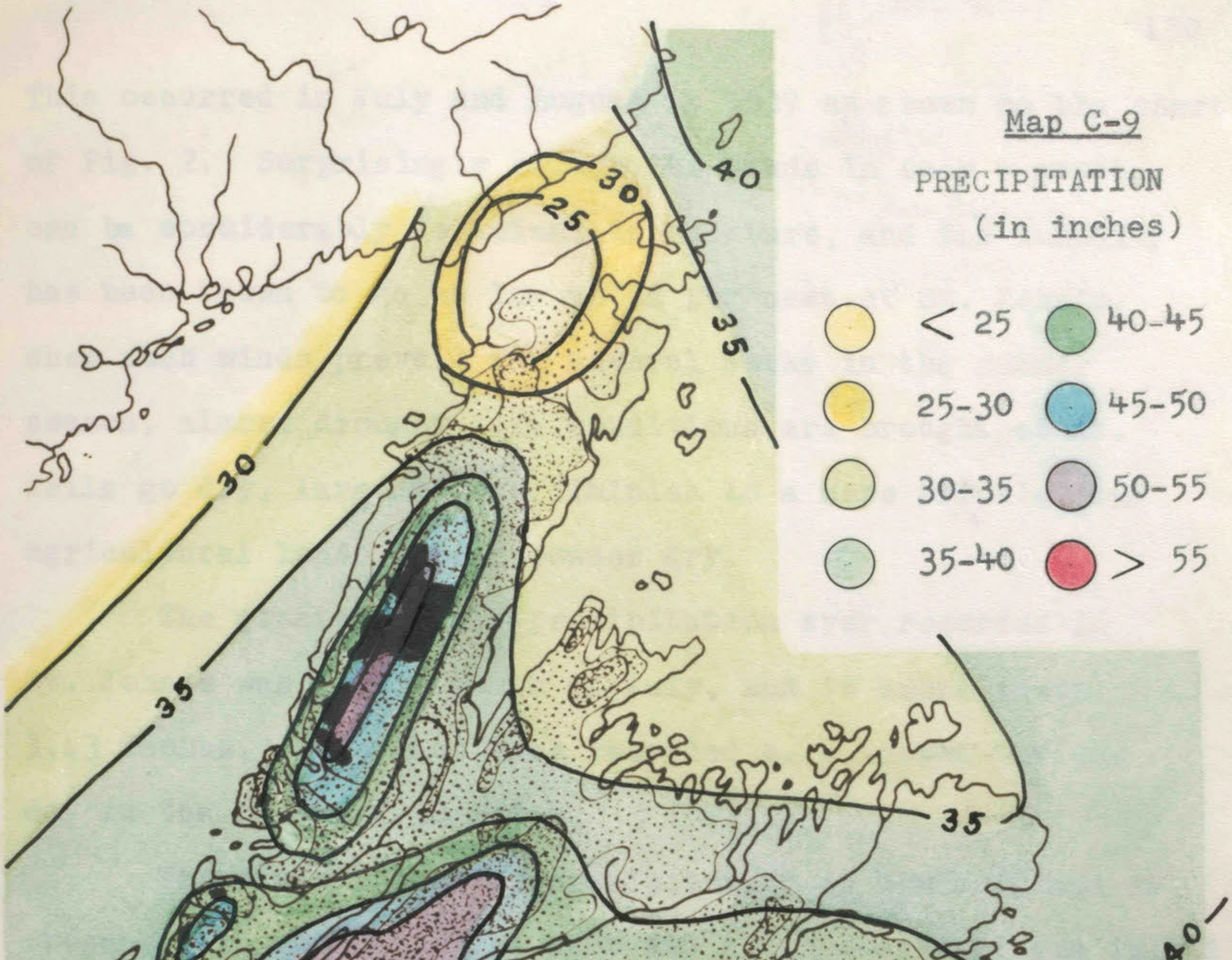
The July map (C-7), as representative of the summer season, demonstrates admirably the controls on climatic conditions. Here we have a temperature gradient from north to south due to the combined effects of air masses and latitudinal separation, yet a warmer interior shown within the 60 degree isotherm. The eastern and southern coastal regions are slightly cooler than the western shores of the island.

The October conditions shown on Map C-8, are even more simple than those of the spring, for almost all localities have a very nearly equal mean temperature. It is slightly cooler in the north and in the interior regions.

VII. PRECIPITATION

Precipitation in Newfoundland is everywhere abundant and equally divided between the seasons. It ranges from a 55 inch yearly average in the southeast to a 25 inch yearly average in the northwestern corner. Some of the mountainous areas on the west coast are also believed to receive over 55 inches of precipitation a year. As already pointed out, the two families of cyclones which cross Newfoundland are usually moisture laden and they combine to bring the province the greater percentage of its rainfall and snowfall. In the wetter southern section there is measurable precipitation on 150 to 200 days a year..

The distribution of precipitation throughout the year varies for different sections of the island. In general autumn is the wettest season in most districts, but on the Avalon Peninsula there is 12 per cent more precipitation in winter, and at Port Aux Basques both seasons have about equal distribution. Table III in Appendix A shows the seasonal distribution of precipitation for most of the meteorological stations in Newfoundland. The monthly rainfall and snowfall can also be very variable. Table IV shows the extremes between the wettest and the driest years. Here St. John's is seen to vary between 45.59 inches and 62.82 inches, showing adequate precipitation at all times. St. George's on the west coast recorded only 14.14 inches in 1918. The summer of that year was probably dangerously dry from the point of view of agriculture and water supply, for July and August have the lowest rainfall in normal times. Burin, on the south coast holds the record for the greatest precipitation ever measured in Newfoundland. In 1915 the meteorological station there recorded 81.67 inches, which is half as great again as the normal precipitation of 54.68 inches. The record in St. John's for the wettest month is an October measurement of 13.11 inches. Summer months show an average rainfall not far removed from that of other months, but occasionally July or August can be extremely dry, with nearly all the precipitation falling in one or two days.



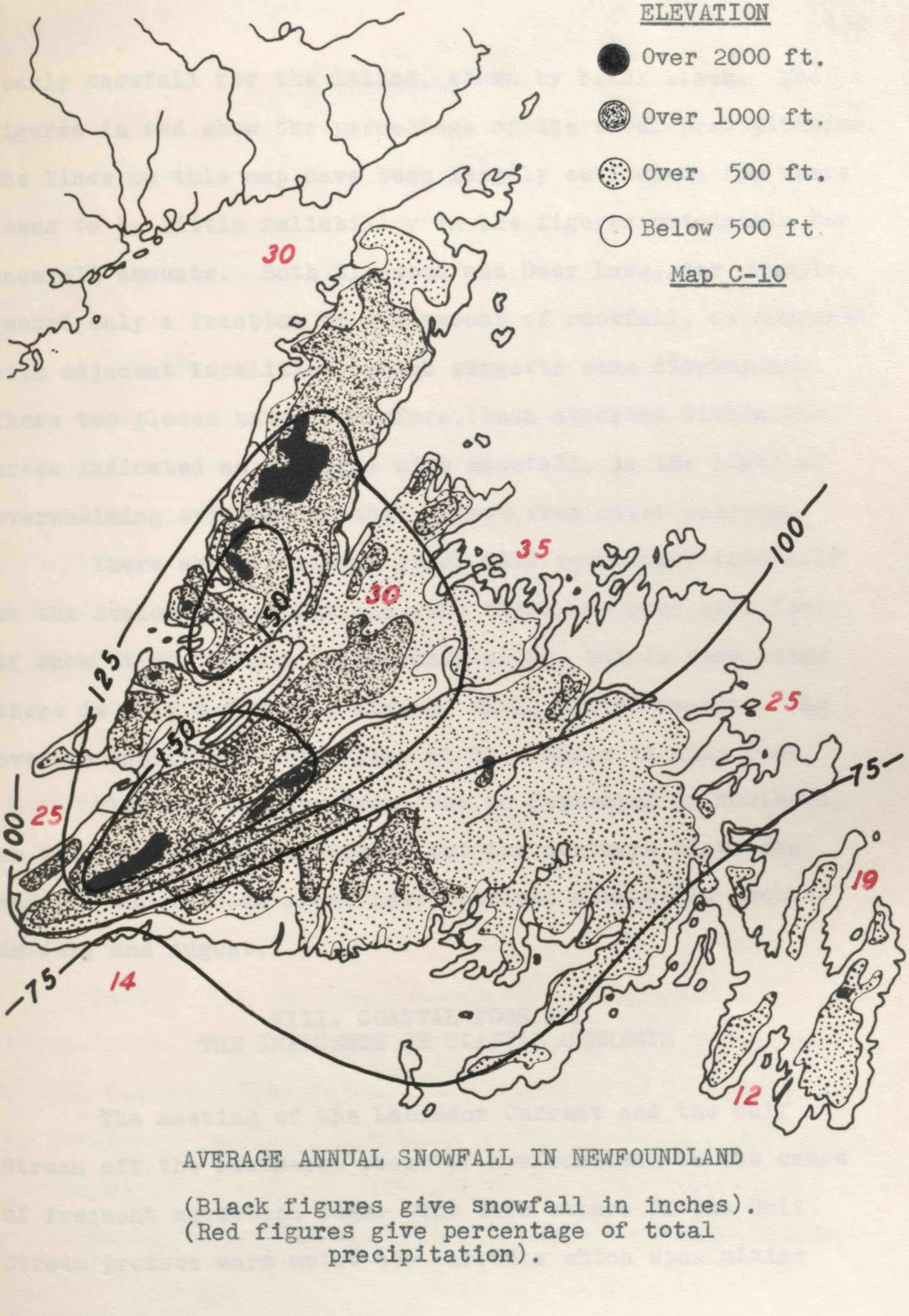
AVERAGE ANNUAL PRECIPITATION IN NEWFOUNDLAND

This occurred in July and August in 1939 as shown on the chart of Fig. 2. Surprisingly enough the winds in such a month can be considerably deficient in moisture, and the humidity has been known to go as low as 12 per cent at St. John's. When such winds prevail for several weeks in the summer season, almost drought-like conditions are brought about. Wells go dry, large rivers diminish to a mere trickle, and agricultural lands become powder dry.

The greatest daily precipitation ever recorded in St. John's was in the month of July, and it amounted to 3.43 inches. Cape Race once recorded 4.14 inches for one day in the month of August.

The distribution of precipitation in Newfoundland is presented in Map C-9. The west and south coasts of the island are the first barriers, as it were, that the approaching cyclonic storms encounter when they reach the area. It is therefore along these coasts that the heaviest precipitation is recorded. There is a gradual decrease in the yearly average towards the north, the Belle Isle area showing less than 25 inches.

Snowfall makes up about one half of the precipitation in the top of the Northern Peninsula. The ratio of snowfall to rainfall decreases from north to south and from west to east, so that in St. John's the total precipitation contains only twenty per cent snow on the average. Map C-10 gives the



AVERAGE ANNUAL SNOWFALL IN NEWFOUNDLAND

(Black figures give snowfall in inches).
(Red figures give percentage of total precipitation).

yearly snowfall for the island, shown by black lines. The figures in red show the percentage of the total precipitation. The lines on this map have been largely estimated, for there seems to be little reliability in the figures obtainable for snowfall amounts. Both Glenwood and Deer Lake, for example, record only a fraction of the amount of snowfall, as compared with adjacent localities, which suggests some discrepancy. These two places have, therefore, been absorbed within the areas indicated as having a high snowfall, in the light of overwhelming evidence to that effect from other sources.

There are occasional years with very heavy snowfalls on the Avalon Peninsula; one year there was over nine feet of snow at St. John's in February alone, but in some years there is only a few feet for the whole winter season. The average snowfall for the year at St. John's is nine feet.

There is no snow from June to September in southern or southeastern Newfoundland, but the northern districts and the mountainous areas have received measurable amounts in July and August.

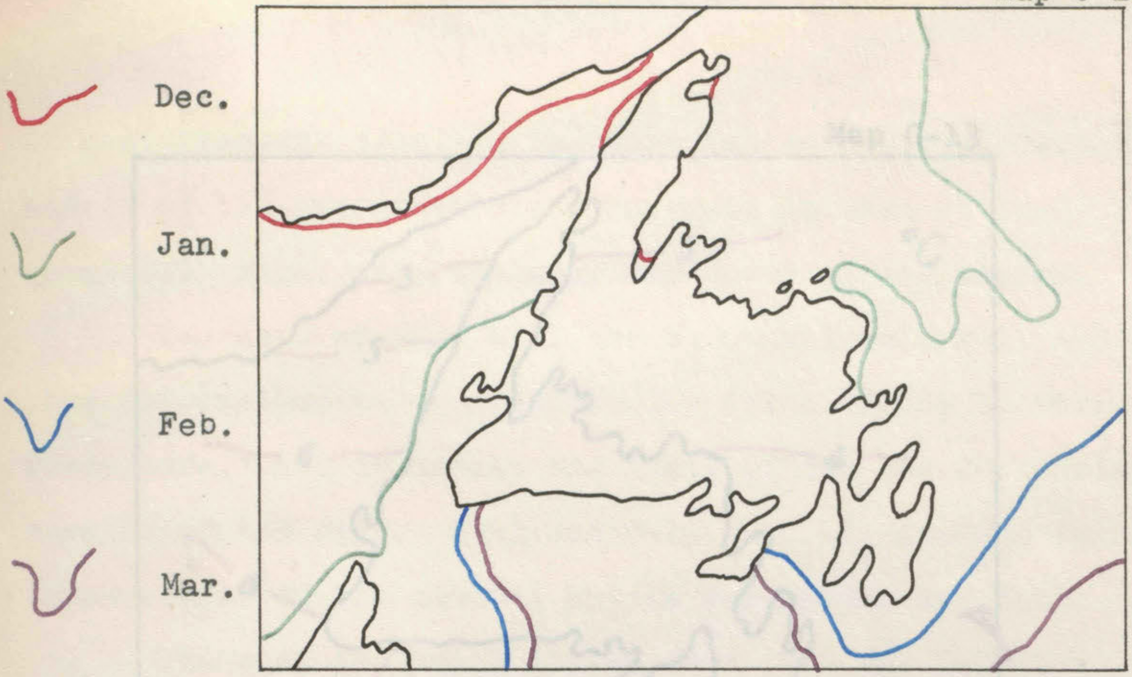
VIII. COASTAL FOGS AND THE INFLUENCE OF COASTAL CURRENTS

The meeting of the Labrador Current and the Gulf Stream off the southeast coast of Newfoundland is the cause of frequent advection fogs. The warm waters of the Gulf Stream produce warm moist air currents which upon mixing with the cooler air from the chilly and often ice laden waters of the Labrador Current produce in turn areas of fog which are almost continually present over the Grand Banks. Newfoundland, however, is not as subject to fogs as is universally supposed. St. John's has an average of only 40.8 foggy days a year as compared with an average of 54 days for Halifax on the eastern shores of Nova Scotia.

These fogs affect Newfoundland mainly in its southern and eastern coastal regions. There are far fewer foggy days on the western and northern coasts and in the interior than there are along the south coast and on certain sections of the Avalon Peninsula. Even the interior of the Avalon area is decidedly less foggy than its coast. Cape Race, which juts well out towards the Grand Banks, is the foggiest region known on the island, for here it is foggy approximately 32 per cent of the time, as compared to 14 per cent of the time at St. John's. In one June month the amazing figure of 400 hours of fog was recorded for Cape Race.

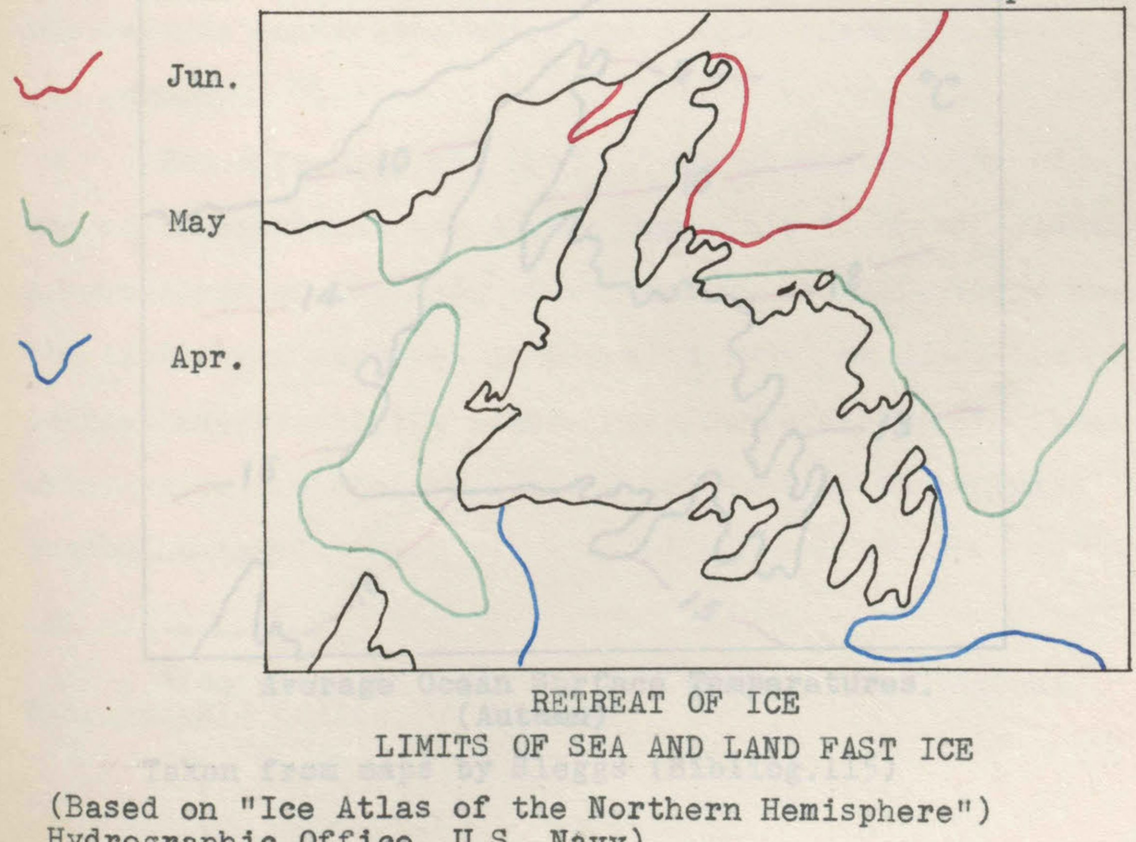
Were it not for these coastal fogs the average temperatures in most of the Avalon Peninsula would probably be much higher. They reduce the percentage of sunshine, and the northeast, east and southeast winds that bring them are exceedingly cold and can make the months of May and June unpleasantly cool. Spring and early summer are the periods

Map C-11



ADVANCE OF ICE

Map C-12

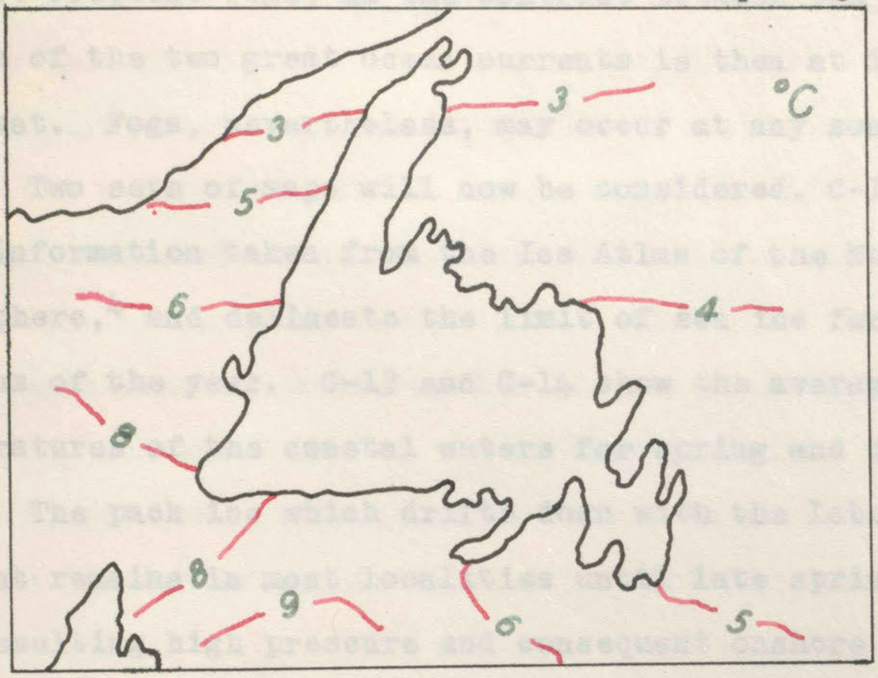


RETREAT OF ICE

LIMITS OF SEA AND LAND FAST ICE

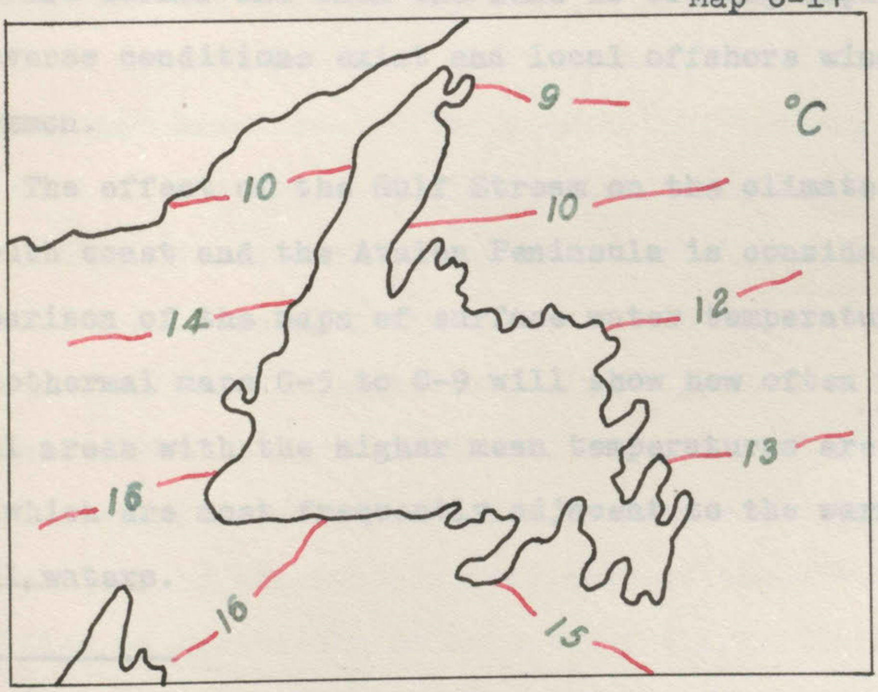
(Based on "Ice Atlas of the Northern Hemisphere")
Hydrographic Office, U.S. Navy)

Map C-13



Average Ocean Surface Temperatures.
(Spring)

Map C-14



Average Ocean Surface Temperatures.
(Autumn)

Taken from maps by Sleggs (Bibliog.115)

of most frequent fogs, as the contrast between the temperatures of the two great ocean currents is then at its greatest. Fogs, nevertheless, may occur at any season.

Two sets of maps will now be considered. C-11 and C-12 show information taken from the Ice Atlas of the Northern Hemisphere,[4] and delineate the limit of sea ice for various seasons of the year. C-13 and C-14 show the average surface temperatures of the coastal waters for spring and fall.

The pack ice which drifts down with the Labrador Current remains in most localities until late spring. The resulting high pressure and consequent onshore winds have already been described. In autumn when the coastal waters are warmer and when the land is cooling rapidly, the reverse conditions exist and local offshore winds are common.

The effect of the Gulf Stream on the climate of the south coast and the Avalon Peninsula is considerable. A comparison of the maps of surface water temperature and the isothermal maps C-5 to C-9 will show how often the coastal areas with the higher mean temperatures are those areas which are most frequently adjacent to the warmest coastal waters.

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[4]Ice Atlas of Northern Hemisphere. (Washington: Hydrographic Office, U. S. Navy).

IX. CLIMATE AND OCCUPANCE

There are no great extremes in the climate of the Avalon Peninsula; the winter season is cold but sunshine is abundant and storms are of but short duration. The polar air which dominates in this season is clear, dry and healthy. Summers in general are warm and pleasant with night-time temperature always cool. Spring is the most unpleasant season because of the frequency of damp, cold and foggy weather. Autumn can be very pleasant, although it is always cool, but occasional years favour it with an "Indian Summer" giving delightful summer-like days well into October.

The great variety of weather types, although disagreeable in some cases, continues to produce in Avalon, as well as in most parts of Newfoundland, a climate that is certainly not monotonous. The stimulating and invigorating effect of the frequent changes is an important factor in promoting an industrious and resourceful people, capable of pursuing successfully the arduous occupations which are the principal means of livelihood in this area. The Newfoundland fisherfolk, woodsmen and farmers, being a sturdy and industrious race, have become accustomed to the changeability of the weather, and have adjusted their activities to derive the maximum benefit from it through years of experience.

Agriculture on a large scale in Newfoundland is often a very hazardous venture unless undertaken in the proximity of ready markets. On the Avalon Peninsula, considerable success has been attained at dairy and vegetable farming because of the existing market in the larger centres of population that are found in this area. Not only do economic conditions favour agriculture on the Avalon Peninsula, but there is also a favourable climatic factor. Table V in Appendix A gives the average interval between the first daily maximum of 43 degrees in spring and the last in fall, or the period of daytime growth. Table VI gives the average interval between the last daily minimum of 43 degrees in spring and the first in fall, or the period of 24 hour growth. This data shows a considerable difference in the duration of growth periods for various districts which thus have different agricultural possibilities, at least as far as climate is concerned. The statement is, of course, very general, and does not always compare with actual conditions. Also, the local topography in some areas is such as to make these readings of maximum and minimum temperatures very different from those which might apply to adjacent areas. The general inferences to be drawn, however, are that the southeast and southwest coasts have the longest growing periods, with the central Avalon and Grand Bank areas especially favoured, also, that the interior has slightly fewer growing days, and the northern sections considerably fewer. One special advantage to the Newfoundland farmer in the Avalon area is that the season between killing frosts is much longer than in the interior.

The section on precipitation shows that adequate moisture is available for crops throughout Newfoundland. Drought-like summers are rare, but they can mean failure for a hay crop or a reduced yield in vegetable growth. Conversely, a summer with too much rain or cloudy weather may present difficulty in hay drying.

The crops which succeed best on the Avalon Peninsula are potatoes, turnips, cabbage, carrots and several varieties of cattle feed. With the assistance of hotbeds for early starting, success has been attained with tomatoes, cucumbers, celery and similar plants. The Newfoundland climate is favourable in most places to some type of farming, and the problems presented to the agriculturist are mostly those of soil type or economic factors.

The climate is of great importance to the fishermen who inhabit the numerous coves and inlets along the coast. Most of the shore fishery is prosecuted in clement weather, and use is made of the available sunshine in drying fish. The fisherman usually relies on a small vegetable garden to provide a fair percentage of his food. In wintertime, he makes use of the deep snow, which enables him to bring out his firewood and lumber from the inland forests.

Climatic conditions in summertime are often the cause of great economic loss to timbered areas through forest fires. When temperatures and winds are above normal, and there is subnormal precipitation and humidity, the forest fire hazard is great. The forest litter and mosses become tinder dry and the smallest spark can launch a tremendous conflagration. Human agencies are responsible for starting most fires, but occasionally a fire is set off by lightning.

X. CONCLUSION

This analysis of climatic conditions throughout Newfoundland has shown that there is an appreciable difference between the climate of the Avalon Peninsula and that of the other sections of the island. These differences are due, mainly, to the greater marine controls in this area and to the more frequent visits of maritime tropical air. Rainfall is high, temperatures are a little different from those elsewhere in the island, and extremes are more noticeably modified. Also, the coastal areas are subjected to frequent envelopment by advection fogs formed at sea.

CHAPTER VII

ECONOMIC ASPECTS

I. HISTORICAL SKETCH

After the discovery of Newfoundland in 1497 by John Cabot, who sailed under the English flag, a long period elapsed before any exploration was carried out on the island, and for a time the Avalon Peninsula was the only section to be settled. Fishing vessels from Portugal, France and England, were early engaged in reaping a plentiful harvest from the new found waters which were teeming with fish. During the sixteenth and seventeenth centuries, these fishermen sheltered in the harbours of Avalon in the summer months and returned to Europe in wintertime.

Little attempt at colonization was made, and in fact, settlement was discouraged by the English Government under the influence of fish merchants, who were anxious to monopolize the fishing industry in these parts. In spite of this opposition an increasing number of people managed to evade the laws and make their permanent homes in this part of the Western World. In the eighteenth century, many tiny villages were established along the eastern coasts of Avalon and in Conception and Placentia Bays. These earliest settlements grew in places that were advantageous to the fisherman, in sheltered harbours, or near superior fishing grounds.

The long narrow fiord-like bays of the east coast and the "ria" coastline of Conception Bay were amongst the first places chosen.

These pioneer settlers were primarily fishermen. They occupied themselves in the summer months catching cod in the shallow waters off the coast, and in winter, they trapped small fur-bearing animals inland, or sought the caribou, which roamed on the moss-barrens of the highlands. They lived a truly pioneer existence, relying mostly on the resources of the land and surrounding seas for their survival. Their only contact with the outside world was through vessels that called occasionally to trade, exchanging for the fish and furs, food and clothing, along with other supplies that the settlers were not otherwise able to procure.

In these days, the sparse population demanded little from the country's resources. The products of the forests were employed only for limited building purposes, and for fuel. Each year, a few caribou were killed to supply meat, but thousands still remained unmolested in the interior. Cultivation of the land was almost non-existent and the whole general aspect of the terrain was probably quite different from that presented today.

As settlement increased, so occupations changed, and the fishermen found time to clear the forests near their homes in order that they might grow rather than buy their vegetables and cattle feed.

Some left their boats altogether and sought a livelihood in the forests or in the towns. St. John's became a centre of the fishing industry as well as the Island's capital and created opportunity for further industries. Other towns developed as centres of activity in Conception Bay, amongst which Carbonear and Harbour Grace were the largest. In these areas too, other means of livelihood were sought by the growing population. The exploitation of the iron ore deposits of Bell Island brought about the development of a town, now known as Wabana, on the northwestern corner of this island. Practically all settlements developed were in the coastal areas, with the exception of Whitbourne, in the interior south of Trinity Bay, which started as a railway maintenance station, and the villages of the inland farming areas west of St. John's.

Slowly, frontiers were pushed back, forests were cut to the ground, and timber was sought further and further from the coast. Public services increased and a network of roads and railroads covered the Peninsula. Population rose to over 100,000, or one third that of all Newfoundland, and today there is no corner of Avalon that does not show the trace of man's activities in one form or another. Even the most barren section of the highlands and the most remote regions of the timbered areas contain paths or clearings made by the hunter or the woodsman in the search for game or timber.

East and southeast of the Avalon Peninsula are the famous Banks of Newfoundland. A great proportion of the fishery which is a vital part of Newfoundland's economy is carried out on those Banks. These underwater ridges are the meeting place of the two great ocean Currents, the Gulf Stream and the Labrador Current.

The mixing of two bodies of water with different characteristics seems to stimulate the growth of planktonic life. These tiny plants and animals are the principal food of the codfish. With the return of sunshine and increased surface temperatures during spring, there is a phenomenal outburst of planktonic growth in the seas over the Banks as well as on the surface of coastal waters. A brown-green colour is imparted to the shallow waters during these periods of planktonic growth, but the deeper waters in places where plankton are at a minimum remain blue. The factors controlling the growth of plankton are largely unknown, but sunlight and water circulation are believed to be of great importance.

On the Avalon Peninsula, the majority of fishermen confine their activities to coastal waters. Here, fishing is carried out in the early summer months from small open boats in the icy waters off the bays and headlands, or over minor banks that provide favourable fishing grounds. The principal product is the cod, but in some localities herring, mackerel salmon and lobster are sought. These fish are caught by many different methods, the cod with bait on hooks, or by nets, salmon and mackerel by trapping in nets, and lobsters by placing wooden traps on the sea floor in shallow places. The bait used in the codfishery is usually one of two small fish, caplin or squid, both of which are plentiful in coastal waters in spring and early summer.

When the cod is caught, it is split, salted and dried. Several different methods are employed for drying this fish. Usually the split and salted cod are placed on stages or "flakes" which are crude platforms, covered with boughs and thin sticks. The combined sunshine and circulation of air around the fish serve well to complete the drying process. In case of rain, however, the fish must be covered and piled together. Some fishermen dry the cod on the cobblestone beaches. These stones radiate considerable heat on a sunny summer day, and they lie together loosely enough to allow ample aeration.

The individual fisherman usually sells his dried fish to a local merchant, who in turn ships it to St. John's, or one of the other larger ports for export mainly to Latin countries in the Eastern and Western Hemispheres. In a few places, a more modern method designed to produce fresh frozen fish for the American market has been established and the product of this method has become increasingly important.

The fishermen lead an arduous existence. Their homes, which must be near the fishing grounds, are often in isolated, bleak and barren localities, although sometimes the inlets or coves which were chosen primarily for the shelter they afforded from the sea, are also situated at the mouths of large rivers, and in such cases, the soil may be good, and arable land extensive. The submerged coastal regions present dangerous waters for navigation. Shoals and submarine rocks are hazardous in stormy weather and coastal fogs sometimes limit visibility for days. Changes in water currents or in climatic factors affecting the supply of fish may mean financial ruin for the fishermen and the necessity of seeking relief from the Government. Their occupation is indeed a hazardous one and the wisdom of its pursuance under such arduous conditions can sometimes be questioned.

The fishermen usually undertake some part time farming in order to grow their own garden vegetables, but the growth qualities of the soil and their inexperience of agricultural methods often result in a pitiful return in exchange for the labour expended. There are, of course, exceptions to this, as suggested above. Some fishing settlements have developed excellent hay fields and vegetable gardens. The fisher-farmers in the vicinity of Torbay, north of St. John's, have some splendid farms, capable of producing more than enough for their own needs. The surplus produce finds a ready market in the City, which is approximately ten miles to the south.

The inland fisheries or those prosecuted in the larger rivers and ponds, are of economic importance, especially to the tourist industry. In the spring and early summer, salmon travel up the larger streams to spawn. If the rainfall is below normal at this time of year, these rivers may become too shallow to permit the fish to travel to the head waters with ease, and salmon will consequently be scarce in the pools where they are normally found. However, this condition is infrequent, occurring perhaps once in every ten years. Other serious obstacles to the passage of salmon upstream are the numerous waterfalls and rapids on all the major rivers. In places salmon ladders have been erected by the Department of Inland Fisheries, to by-pass the highest and most difficult of these falls. The number of salmon taken yearly is not great, but the tourist trade which this sport attracts is of considerable economic importance.

Most of the ponds and lakes on the Avalon Peninsula are well stocked with trout, and these are caught in great quantities both for sport and domestic consumption. During the winter months, many trout are taken through holes cut in the ice on the surface of the ponds and lakes.

The inland trout fishery is an indirect benefit derived from the glaciation of the Avalon terrain. The widespread deposition of glacial drift and the gouging of the bedrock has formed the thousands of lakes and ponds in which these trout abound. Also, the drowned shoreline, brought about by the depression of the land under the weight of the ice masses, forms many excellent harbours, which are of great benefit to the coastal fishing industry.

III. FORESTRY

The widespread mantle of glacial drift on the Avalon Peninsula has created a terrain that is topographically suited to the production of forests in many areas. Though these forests have been exploited for many centuries and have suffered tremendous loss from fires, there are still many stands of good virgin timber as well as extensive areas of later growths. The best timber is now confined to a few areas removed from the centres of population, but there is still adequate forest growth near most settled localities to provide the inhabitants with fuel and other limited needs.

The lumber industry was once very important on the Avalon Peninsula, but the depleted supply of sizeable timber and competition from other sources, with the advent of improved transportation, has diminished it to a few large lumber yards and a small number of privately owned saw mills. Most of this lumber is sold as building material on the Peninsula. There is a large market, as practically all the houses in the area are built of wood. The timber is cut mostly from the forests of the Moraine Plain in central Avalon, although there are small mills which cut their supplies on the St. John's Peninsula and in the Salmonier region. The Forestry Division of the Department of Natural Resources carries on an active campaign in promoting plans for the preservation and improvement of forest growth on the Peninsula. The experiments in thinning operations have already been mentioned and the use of systems of correct cutting procedure is encouraged. An active and efficient forest fire patrol is employed in all timber areas and observation towers have been erected in several places.

Surveys are conducted to ascertain the extent of damage to forests by insect pests such as the Spruce Bud Worm and the Larch Saw Fly, which have brought about serious damage to certain areas.

IV. AGRICULTURE

The Avalon Peninsula is not naturally an agricultural area, but some farming ventures have developed successfully chiefly because of existing economic factors. Fishermen usually live in isolated communities separated from the larger centres of population by long and arduous routes. A large proportion of the cultivated land on the Peninsula lies in or about these small fishing communities, mainly because it is less expensive for the fishermen to grow their own garden vegetables and cattle feed than it is for them to purchase such commodities from the distant markets.

Unfortunately, the fishermen are not keenly interested in such factors as soil erosion or deterioration, but they manage with their own crude agricultural methods to force enough vegetable growth each summer to meet the needs of the following winter. In many localities, a more intelligent use of the soil and a knowledge of scientific agricultural methods would result in a greatly increased yield.

Apart from the numerous small areas of cultivated land in the fishing communities, there are four large areas devoted to agriculture, much of which exists under a different economy. These lie within the following areas marked in yellow on Map NV-1; near Whitbourne in central Avalon, on the west and east sides of Conception Bay, and in the St. John's district. With the exception of the land near Whitbourne these areas of cultivated land are all situated near the larger centres of population. The farm practice is usually a mixture of vegetable and dairy farming. Some of the fields are utilized for pasture, but generally the cattle are allowed to forage on the marshes and roadsides. The majority of the fields are set out in hay or oats which, when cut, are stored for winter feed. This, however, is rarely adequate and must be supplemented with imported feeds.

Some of the farmers in this group are making the most of the poor soils available. The addition of lime and fertilizers as well as composting material made from peat and stable manure or fish remains has produced in some areas an excellent soil. An effective system of crop rotation is also occasionally used. However, this scientific treatment of the soil is costly, and although there is a ready market for fresh vegetables and dairy products the competition from imported products is often great enough to reduce returns below the level which would compensate the farmer for his efforts. Thus, even farming of this nature is a hazardous undertaking, from an economic standpoint alone. Other factors, such as adverse climatic conditions and destruction of crops by insects or fungus growth, have also to be contended with. The ruination of a crop may be brought about by unseasonable frost, gales or torrential rains in spring when the plants are young, and in the summertime growth can be retarded seriously by droughts, or long periods of foggy or cloudy weather.

Encouragement is being given the farmers to modify the present agricultural system. Experts have classed the soil as best suited for the growth of rich pastures. Yields from the Government Experimental Farm, situated on an average soil, have borne this out. There are many forested areas of fair soil which are, however, littered with boulders of glacial origin. It is suggested that if these areas be cleared of the forest growth and seeded with grasses, they could be successfully utilized for rough pasture of sheep, cattle or goats. The presently cultivated and more arable lands could then be devoted exclusively to the production of crops suitable for storage, thus eliminating the necessity of importing expensive feeds for winter use. The task of enlightening and convincing farmers along these lines is not easy, but if agriculture is ever to develop on a large scale a trend will have to be established in this direction, or in that of some other suitable plan designed to increase the soil yield as well as to preserve its fertility.

Some localities possess small herds of sheep. These are fed with local grown and imported feeds for about five months during the winter season, but find enough nourishment from the natural vegetation throughout the rest of the year to thrive reasonably well. The wool is utilized in small carding industries for the manufacture of homespun clothing and in some areas the sheep are slaughtered for the market.

V. WILD LIFE

Wild life, which was once abundant on the Avalon Peninsula, has greatly diminished during the past hundred years. The caribou, which feed on the sphagnum mosses are rarely seen, though efforts to preserve them have been initiated in the establishment of a deer park and the enforcement of laws limiting the number which may be killed by any individual during a year.

Some other mammals of minor importance include the rabbit, which is taken in great numbers for domestic consumption, and several species of fur-bearing animals, some of which are trapped for the value of their pelts. The latter include the fox, otter, beaver and muskrat.

VI. WATER POWER AND WATER SUPPLY

The position of the majority of the larger lakes and ponds in the upland regions of the Avalon Peninsula presents excellent opportunities for water power development. Six hydro-electric stations with a combined development of some 30,000 H.P. have already been established, and an estimation of available horse power, taken from the major rivers only, gives a potential development of a further 18,000 H.P.

The lakes now utilized for water power development are on the Carbonear and St. John's Peninsulas and the output from the power stations serves the various towns and villages in these districts. The system employed by the companies supplying this power is to dam off a series of large lakes in a drainage system. Small dams are used and the water level is generally raised only a few feet, but the total volume of water thus stored provides many additional gallons of water, and an adequate supply is always assured. A flume is constructed to lead from the upland lake with the lowest elevation to the power house which contains the turbine generators on the adjacent lowland.

The thousands of ponds situated on the highlands or on the highest parts of the lowlands also present an ideal water supply for the populated areas. An example is Windsor Lake, situated west of St. John's at an elevation of 600 feet, which supplies this city with some ten million gallons of water daily. This water is naturally pure and the addition of chemicals is not necessary. Furthermore, because of the high yearly rainfall, there is always assurance of continual supply.

VII. COMMUNICATIONS

The habit of settlement in rugged coastal areas and the uneven topography between most communities presented difficulties for many years in road building, and communication was usually established by boat. Cost of road building on such a terrain was at first prohibitive, but as the population increased, a network of roads slowly developed. Most coastal settlements are now connected, and there are a few roads through the interior of the Peninsula. Material for road building is abundant in the glacial drift, and the problems presented are usually ones of grade, or of bridging large rivers, or crossing boggy lands. Heavy snows in winter block off most of these roads, and only the more important highroads can be kept open with snow plows. This leaves many communities isolated except for communication by sea and this is infrequent in wintertime.

A railroad runs from St. John's westward through central Avalon and thence northwest through the Isthmus, to other points in Newfoundland. There are two branch railway lines, one to Argentia in Placentia Bay, and the other to Carbonear in Conception Bay. In the construction of this railroad use was often made of level country near the shoreline in the lowlands, but in some regions very circuitous routes were necessary in order to reduce the grade to a minimum. Such winding routes are noticeable in the scarp country of the Carbonear Peninsula.

Coastal communications are hazardous at most seasons, but many small vessels ply between the major ports along the shoreline, trading in fish, lumber or general supplies. The frequency of storms, the coastal submarine topography, and the prevalence of fogs make this mode of travel difficult at most seasons, and prohibitive during winter when land-fast or pack ice is widespread.

Communication by air has become increasingly important. There are two major airports, one at Torbay and one at Argentia, and the numerous lakes and sheltered harbours are utilized by small amphibious aircraft in summertime and by ski-equipped aircraft in wintertime.

VIII. NATURAL VEGETATION

Utilization of certain useful products of the natural vegetation has created some important small industries. The moss-barrens, bogs and burnt forests support many edible berries which are gathered and packed for local consumption and for export. Blueberries are the most important of these. The yearly crop is large but only a fraction of the yield is gathered. The bakeapple, partridge berry, and wild currant, raspberry and strawberry, are also extensively consumed by the local population.

IX. SUMMARY

The basic economy of the Avalon Peninsula lies in the shore and Bank fishery. Settlement has been established in places suitable to the more successful prosecution of the fisheries, and agriculture in these areas is incidental. Some land devoted purely to agriculture is under cultivation. However, its economy is not sound, and a change in the land utilization policy would perhaps bring more stable returns.

The widespread storage of water in lakes and ponds has enabled development of hydro-electric power sufficient for present requirements and a substantial reserve is still available.

Small timber on the Peninsula is used mostly for domestic purposes, but wood cut from the areas with the mature forest stands is employed in small lumber industry. This resource has been seriously depleted in certain areas, but methods of reafforestation are being developed.

Some of the wild berries found on the bogs and barren lands find a local and foreign market and there are possibilities for more extensive development, especially in the blueberry crop.

The Grand Banks and the coastal waters, with their abundant fishing grounds, have influenced the whole pattern of settlement on the Peninsula. All subsequent development of other industries or occupations has been largely dependent on the fishing industry. It is highly problematical if they could exist alone.

CHAPTER VIII

SUMMARY

I. INTRODUCTION

In summarizing the foregoing observations it is intended to stress the inter-relationship of the topics discussed in each section. Each of the physiographic divisions described in Chapter II, is taken and treated separately, and an attempt is made to show the inter-relationship in each between rock type, surface forms, soils, vegetation, climate, the traces of glaciation and the economic aspects.

II. HIGHLANDS

The Highlands on the Avalon Peninsula are formed on bedrock consisting of granitic, volcanic, or resistant sedimentary rocks. The topography in these areas is sometimes rough, but mostly the uplands have a plateau-like surface, being the remains of old erosion levels. Glaciation has denuded the surface of all pre-existing soils, but has deposited in their place a coating of drift that is often very thin, and which supports only a barren or boggy vegetation. The combination of glacial scouring and damming by glacial drift has caused the formation of thousands of lakes and ponds. The vegetation consists primarily of mosses, grasses and small woody plants, and it is limited not only by soil type and poor drainage, but also by exposure to the elements, and the effects of the lower mean temperatures due to the high elevation. The economic significance of these Highlands lies in their potential source of water power, and the fact that small berries of commercial value abound.

III. LOWLANDS

The Lowlands are usually situated on areas of soft sedimentary rocks. The topography is rugged in a few places, but is mostly gently rolling. Here there is a combination of well drained and poorly drained land. Glaciation has deposited a thick mantle of drift, derived in general from the underlying rock formation, but sometimes containing numerous boulders from the Highlands. The vegetation is primarily a forest cover with inter-spaced bogs. The coastal regions of the Lowlands are usually the most rugged, due to a submerged shore line. The climate is fairly equal throughout, with the exception of certain areas near the sea which have frequent fogs. Soils formed on the glacial drift are typical podzols, and can be made productive with the addition of lime and fertilizers. The economy of the Lowlands centres in the fisheries in the coastal areas, the agriculture near all communities and to a certain extent the exploitation of the forests.

IV. LOW-LYING PLAIN COASTS

Two areas have been included in this classification; each is situated in a region underlain by soft pre-Cambrian rocks. They possess a relatively level topography. Glacial drift is thick, and soils are generally better than those in the Lowlands. The natural vegetation is primarily forest, but a great deal of this has been cleared, and the land is now given over extensively to agriculture. Vegetable production, dairy farming and sheep raising are the most important occupations. Both these Plains lie in areas where there is a relatively low percentage frequency of fog.

V. ESCARPMENTS

The escarpments on the Peninsula occur in regions of alternate soft or resistant tilted sedimentary strata. The topography is very rough, and the coast line frequently indented. Usually the hilltops are barren, but the inter-scarp valleys are filled with glacial drift, on which fair soils have developed. The natural vegetation of the valleys is forest, but since this scarp country is well populated much of the forest has been cleared or burnt. The "ria" coastline resulting from the structural trend and glacial deepening of existing valleys has provided these localities with excellent harbours. The principal occupation is a mixture of fishing and farming, although several large towns, which have developed as centres of fishing activities, provide other means of livelihood.

VI. MORAINE PLAIN

The bedrock underlying the Moraine Plain in the centre of the Avalon Peninsula consists mostly of soft sediments, but these have been covered thickly by the glacial deposits. The topography of this area is gently rolling, consisting of ridges and hummocks, alternating with bogs that now fill the depressions in the glacial drift. Drainage on the higher land is free and deep, and some soils superior to those found elsewhere on the Peninsula have been developed. The vegetation consists of many good stands of mature timber, usually found on the ridges, and many areas of bogs and marshes on lower ground. This area possesses a slightly warmer climate than the coastal regions. Timber cutting for lumber and a small amount of agriculture are carried out. The area has great potentialities but it is situated rather too far from markets for successful development.

VII. CONCLUSION

The Avalon Peninsula differs mainly from the rest of Newfoundland in its climate and economic structure, but resembles the rest of the Island in its soils, vegetation and glacial features. However, within the Peninsula itself, five physiographic divisions are found, each containing striking differences, not only in physical structure, soil type and vegetation, but also in the economy under which the inhabitants of each exists.

Photo 1. River valley near Cape Broyle showing extensive cutting on valley slopes and cultivation on the river flats.

Photo 2. Islands of submerged coast-
line off the east coast of Avalon.

Photo 3. Gently rolling topography of the Moraine Plain near Whitbourne in central Avalon.

Photo 4. Low Lying Plain Coast near Topsail in Conception Bay, developed on soft Cambrian strata. Cobblestone beach in background.

Photo 5. Peat bog in depressions of thick glacial drift on the coastline.

Photo 6. Thick peat deposit supporting a woody plant vegetation.

Photo 7. Highland topography in the uplands west of Renews. Forest vegetation on better drained sites.

Photo 8. Scattered larch trees on barren country of the Highland west of Renews.

Photo 9. Climax forest on ridge top of the Moraine Plain near Whitbourne.

Photo 10. Early stage of recovery after devastation by forest fire.

Photo 11. Late stage of recovery after forest fire. Predominantly bushy hardwoods with young conifers interspaced.

Photo 12. Tilted strata on the east coast of the Peninsula. Exposed headlands are usually barren.

Photo 13. Roche moutonnee on hilltop of the Highland west of Renews. Alternate forest and bog on the Lowland in the background.

Photo 14. Barren vegetation on the flat Lowland north of Trepassey.

Photo 15. Bushy vegetation on river flats.
Thick glacial drift in the background.

Photo 16. Rocky forest site, recently devastated by fire.

Photo 17. Highland glacial drift in foreground. Bog in the background filling depression.

Photo 18. Barren country on the Highland of the Carbonear Peninsula.

Photo 19. Near Brigus, Conception Bay.
Fence made from glacial boulders cleared
to permit cultivation of the land. Scarp
country in the background.

Photo 20. Glacial till lying on bedrock near seashore. Rounded cobblestones in foreground.

Photo 21. Two hundred foot cliff of glacial drift on coastline.

Photo 22. Glacial drift showing old vegetation layer two feet below the surface.

Photo 23. Esker west of Renews on the east coast of Avalon.

Photo 24. Climax forest on thick glacial drift.

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APPENDIX A

CLIMATOLOGICAL TABLES

TABLE I

PERCENTAGE FREQUENCIES OF WEATHER TYPES REPRESENTATIVE OF NEWFOUNDLAND (Koeppe)

	St. John's	
	Winter	Summer
Cold	79	0
Cool	21	23
Moderate	0	67
Hot	0	10
Fair	49	58
Windy	26	5
Cold;Snowy;Quiet	18	0
Cold;Fair;Windy	9	0
Cold;Fair;Quiet	36	0
Cold;Snowy;Windy	15	0
Cool;Rainy	17	13
Cool;Fair;Windy	2	0
Cool;Fair;Quiet	2	10
Moderate;Rainy	0	27
Moderate;Fair;Windy	0	4
Moderate;Fair;Quiet	0	35
Hot;Rainy	0	1
Hot;Fair;Quiet	0	8

TABLE II a

EXTREME HIGHEST TEMPERATURES ON RECORD

	Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Belle Isle	40	40	43	56	59	69	70	71	69	58	52	40	71
Burin	50	48	52	58	64	76	80	80	80	68	60	54	80
Cape Race	51	44	48	60	68	78	80	78	76	72	58	54	80
Fogo	52	52	56	59	74	82	86	86	78	70	63	60	86
Grand Bank	51	46	50	54	67	74	77	82	75	69	62	54	82
Millertown	46	47	58	59	75	84	86	88	80	73	63	50	88
St. George's	56	52	63	70	77	83	87	86	87	74	67	58	87
St. John's	59	56	67	72	81	87	90	89	84	87	66	60	90

TABLE II b

EXTREME LOWEST TEMPERATURES ON RECORD

	Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Belle Isle	-31	-30	-20	-10	9	19	25	29	27	12	-6	-30	-31
Burin	-6	-10	0	10	24	34	40	40	34	28	11	10	-10
Cape Race	-12	-15	-5	7	15	21	35	33	30	14	7	-6	-15
Fogo	-10	-18	-15	6	10	20	30	32	10	23	8	0	-18
Grand Bank	-4	-2	-1	15	22	33	40	40	34	26	16	10	-4
Millertown	-26	-26	-27	-2	21	27	31	32	29	17	-1	-11	-27
St. George's	-16	-24	-21	-9	20	23	39	35	29	20	8	-4	-24
St. John's	-19	-19	-10	8	20	28	35	32	29	22	9	0	-19

TABLE III

SEASONAL PRECIPITATION EXPRESSED AS PERCENTAGE OF YEARLY PRECIPITATION

	Summer	Spring	Autumn	Winter	Wettest Season
Cape Norman	23	23	25	29	W
Belle Isle	20	33	31	16	Sp.
Fogo	22	22	27	29	W
Bonavista	25	17	33	25	A
Shoal Harbour	21	22	35	22	A
St. John's	23	20	28	29	W
Cape Race	24	23	25	28	W
Grand Bank	22	19	33	26	A
Burgeo	24	19	32	25	A
Channel	21	25	28	26	A
St. George's	17	23	33	27	A
Corner Brook	18	24	32	26	A
Point Riche	21	27	28	24	A
Deer Lake	19	32	34	15	A
Howley	20	23	30	27	A
Buchans	20	29	32	19	A
Millertown	22	26	28	24	A
Grand Falls	21	26	28	25	A
Glenwood	22	27	34	17	A
Gander	21	22	28	29	W

The underlined sets of figures indicate the wettest half year.

The letters in the last column, indicating the wettest season, are abbreviated to: W (Winter), Sp. (Spring), and A (Autumn).

TABLE IV

TOTAL PRECIPITATION IN DRIEST AND WETTEST YEARS

	Driest Year		Wettest Year	
Belle Isle	22.27	1917	52.69	1939
Burin	43.97	1930	81.67	1915
Cape Race	44.05	1927	63.99	1935
Fogo	24.78	1918	46.26	1923
Port-aux-Basques	44.72	1920	66.59	1925
St. George's	14.14	1918	44.11	1938
St. John's	45.59	1932	62.82	1935

TABLE V

AVERAGE INTERVAL BETWEEN FIRST DAILY MAXIMUM OF 43 DEGREES FAHRENHEIT IN SPRING AND LAST DAILY MAXIMUM OF 43 DEGREES FAHRENHEIT IN AUTUMN

	First Date	Day of Year	Last Date	Day of Year	Period of Daytime Growth
Belle Isle	May 31	151	Oct.10	283	132
Bonavista	Apl.26	116	Nov.20	324	208
Buchans	Apl.23	113	Nov. 2	306	193
Burin	Apl.21	111	Nov.15	319	208
Cape Race	May 1	121	Nov.20	324	203
Channel	May 3	123	Nov. 9	313	190
Corner Brook	Apl.12	102	Nov.11	315	213
Deer Lake	Apl.14	104	Nov. 9	313	209
Fogo	May 1	121	Nov. 7	311	190
Glenwood	Apl.16	106	Nov.10	314	208
Grand Bank	Apl.24	114	Nov.21	325	211
Grand Falls	Apl.20	110	Nov. 7	311	201
Howley	Apl.23	113	Nov. 6	310	197
Millertown	Apl.23	113	Nov. 5	309	196
Gander	Apl.22	112	Nov. 4	308	196
Ramea	May 13	133	Nov. 7	311	178
St. George's	Apl.18	108	Nov.12	316	208
St. John's	Apl.21	111	Nov.13	317	206
Shoal Harbour	Apl.14	104	Nov.22	326	222

TABLE VI

AVERAGE INTERVAL BETWEEN LAST DAILY MINIMUM OF 43 DEGREES FAHRENHEIT IN SPRING AND FIRST DAILY MINIMUM OF 43 DEGREES FAHRENHEIT IN AUTUMN

	First Date	Last Date	Period of twenty-four hour growth
Belle Isle	Jul.30	Aug.29	30
Bonavista	Jun.10	Sep.28	110
Buchans	Jun.20	Sep.17	89
Burin	Jun.14	Oct. 6	114
Cape Race	Jun.26	Oct. 2	98
Channel	Jun.17	Oct. 3	108
Corner Brook	Jun.20	Sep.14	86
Deer Lake	Jun. 9	Sep.18	101
Fogo	Jun.18	Sep.29	103
Glenwood	Jun.13	Sep.17	96
Grand Bank	Jun. 6	Oct. 8	124
Grand Falls	Jun.13	Sep.22	101
Howley	Jun. 9	Sep.30	113
Millertown	Jun.13	Sep.15	94
Gander	Jun. 9	Sep.28	111
Ramea	Jun.14	Oct. 3	111
St. George's	Jun.10	Sep.29	111
St. John's	Jun.12	Oct. 4	114
Shoal Harbour	Jun. 6	Sep.21	107

APPENDIX B

POPULAR AND BOTANICAL NAMES USED FOR IDENTIFICATION OF SITE-TYPES.

POPULAR NAME	BOTANICAL NAME
Alder	Alnus crispa
Bakeapple	Rubus chamaemorus
Balsam fir	Abies balsamia
Black birch	Betula lenta
Black spruce	Picea mariana
Blueberry	Vaccinium tenellum
Bush honeysuckle	Lonicera coerulua
Cotton grass	Eriophorum tenellum
Crackerberry	Cornus Canadensis
Crowberry	Empetrum nigrum
Dogberry	Pyrus Americana
False lily of the valley	Maianthemum Canadense
Gold thread	Cornus Captus
Labrador tea	Ledum Groenlandricum
Larch	Larix Americana
Leather leaf	Chamaedaphne calyculuta
Lily	Clintonia borealis
Paper birch	Betula papyrifera
Partridge berry	Vaccinium Viti-Idaea
Pitcher plant	Sarracenia purpurea
Rhodora	Rhododendron Canadense
Sheep laurel	Kalmia augustifolia

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