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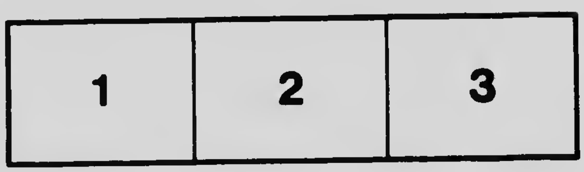
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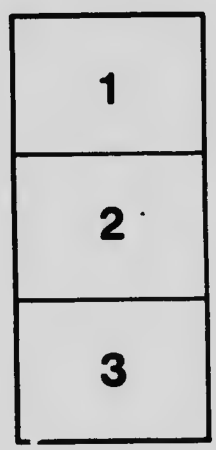
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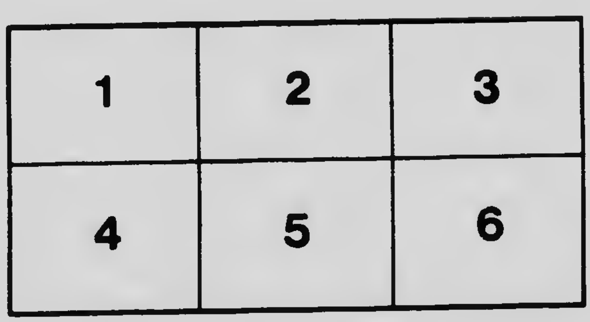
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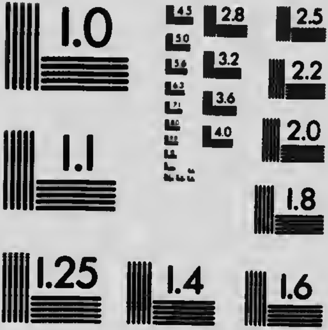

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GEOLOGICAL SERIES, No. 15 JUNE 19, 1914

## SUPPOSED EVIDENCES OF SUBSIDENCE OF THE COAST OF NEW BRUNSWICK WITHIN MODERN TIME

by

J. W. Goldthwait



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## GEOLOGICAL SERIES, No. 15

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*III.—Supposed Evidences of Subsidence of the Coast of New Brunswick within Modern Time.*

By J. W. Goldthwait.

## INTRODUCTION.

While engaged in 1910 in a study of the records of late Pleistocene marine submergence in Quebec and New Brunswick, I was impressed by the need for giving greater attention to the more recent of the post-Glacial movements which this region, in common with New England, has suffered. Accordingly, in July and August, 1911, during the continuance of work on the several problems of post-Glacial changes of level in southeastern Quebec and New Brunswick, I visited a number of localities where so-called evidences of modern subsidence are to be seen. Before entering upon this phase of the work, a conference was held with Professor Douglas Wilson Johnson of Harvard University, under whom an exhaustive investigation of the question of modern stability of the coasts on both sides of the North Atlantic was already in progress. A co-operative plan was arranged, between the Geological Survey, Canada, and the Shaler Memorial Investigation, which will find full expression in a later publication. The present paper merely outlines the conclusions reached by the writer during the field season of 1911.

From Professor Johnson have come many helpful suggestions, which it is a pleasure to acknowledge. Thanks are due also to Professor W. F. Ganong, of Smith College, whose published

writings on the botany, physiography, cartography, and history of New Brunswick constitute a most valuable guide in that Province for the naturalist, the antiquarian, and the traveller; and who kindly suggested to me, in personal correspondence, several localities particularly worth visiting, in my search for evidences of modern coastal subsidence.

## MODERN VERSUS LATE PLEISTOCENE MOVEMENTS.

The elevated beaches, deltas, and sea-floor deposits which are found along the coast of the Maritime Provinces bear witness to a differential emergence of this region from the sea, in post-Glacial time. Judging from the strength of certain strands, especially along the north coast of Gaspe peninsula, this emergence was not steady, but consisted of two or three periods of uplift, separated by periods of stabillty or of subsidence. In the lower Saint Lawrence, one shore-line, in particular, which forms a wide shelf only twenty feet above the modern sea-level, and a great sea-cliff, records an interval of stability or of subsidence which must have lasted for a considerable length of time, and was followed by an uplift of approximately twenty feet.[1] Recent observations around the coast of Gaspe peninsula point to the probability that this recent upward movement of the lower Saint Lawrence region was attended by a downward movement of the more southerly coast of Gaspe and New Brunswick. It is not known whether the upward movement is still in progress along the lower Saint Lawrence, or not. From New Brunswick, however, a number of phenomena have been adduced as evidence that the more southerly coast is still subsiding. That there has been coastal subsidence, locally, if not over a wide region, since the last Glacial epoch, and presumably since the great Champlain emergence, is shown by the famous submerged forest at Fort Lawrence, Nova Scotia. The supposed evidences of a modern continuance of the subsidence, however, are open to question. On this account, it is important to discriminate

[1] J. W. Goldthwait: The twenty-foot terrace and sea-cliff of the Lower Saint Lawrence, Amer. Journ. Sci., vol. XXXII, 1911, pp. 291–317.

at the outset between modern movements and those which, so far as can be seen, may have been completed some time ago. To avoid any misunderstanding that might arise from the use of the term "recent"[1] for the period covered approximately by the twenty centuries of the Christian era, the term "modern" will here be used.

Among the supposed evidences of modern subsidence of the coast in New Brunswick, those to which attention is here invited are:—

(1) A rapid recession of the coastline now in progress;

(2) The presence of drowned valleys;

(3) The presence of barrier beaches;

(4) Recurved hooks, dipping beneath lagoons;

(5) Trees dying because of an invasion by high tides;

(6) Peat bogs whose bottoms lie below high tide mark;

(7) Old beaches on prograding shores, whose crests are lower than the crests of more modern beaches outside of them.

Such a varied list of evidences would seem to constitute a strong argument for the commonly accepted view that the New Brunswick coast is now sinking. An examination of the several lines of evidence, however, seems to show that convincing proof of modern subsidence here, is yet to be discovered; while, on the other hand, as some writers have maintained, there are some indications that the coast for several centuries has been nearly, if not perfectly stable.

## SUPPOSED EVIDENCES OF SUBSIDENCE.

*Recession of the Coastline.*—As all who live on exposed portions of the New Brunswick coast are aware, and as Professor Ganong has pointed out in several of his physiographic and historical papers, the coast is being cut back at a rapid rate. Among the hundreds of illustrations which might be given, are the sites of the old French establishments at Fort Nipisiguit, Fort Moncton, and Little Shippigan, which have been more or less completely

[1] Which, according to the best usage, is synonymous with the "human" or "post-Glacial" period.

washed away, during the last two centuries and a half.[1] Lobster factories near Miscou point, Point Escuminac, and other places have been swept away by the recession of the cliffs, and rebuilt, farther inland, over and over again. According to Mr. Kenneth McClellan, lightkeeper at Point Escuminac, the lighthouse originally stood about 500 feet seaward from its present position, and was moved inland about eighty years ago, because of the rapid encroachment of the waves against the low cliffs of sandstone at that point. Since that time, the sea has advanced about 100 yards, and is now threatening to demolish a building where the fog horn is installed, unless the Government takes prompt measures to protect it. There is no doubt that along most of the open coast of New Brunswick, the sea is now advancing upon the land.

It does not follow, however, that because the shore-line is moving inland, the coast is sinking. In a brief note on "Evidences of sinking of the coast of New Brunswick"[2] Professor Ganong explains that the washing of the sea through the gateway of old Fort Moncton, described by Gesner,[3] must be accounted for by a washing away of the coast, rather than by an actual sinking of the ground beneath the sea. Ganong, nevertheless, argues that the rapid cliff recession thus recorded, which measures over 70 yards in a century and a half, is an evidence of subsidence. "This washing away of the upland can only be explained by a marked sinking of the coast, though the amount of the sinking is not thereby determined."[4] Were it not for the fact that this idea of a necessary connexion between cliff recession and coastal subsidence has been widely circulated, it would seem hardly worth while to point out the possibility that all this encroachment can be accounted for by the horizontal cutting of waves against the foot of cliffs, attended, as it is, by the scouring down of the inclined shelf which lies below, and without any downward movement of the coast whatsoever.

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[1] W. F. Ganong: Proceedings and Transactions of the Royal Society of Canada, second series, vol. 12, 1906, p. 133, also in his translation of Nicholas Denys' History of Acadia, published by the Champlain Society, 1908, p. 202.

[2] W. F. Ganong. Evidences of the sinking of the coast of New Brunswick. Natural History Society of New Brunswick, Bull., vol. XIX, 1901, pp. 339–340.

[3] Abraham Gesner: On elevations and depressions of the earth in North America. Quarterly Journal of the Geol. Soc. London, vol. 17, 1861, pp. 381–388.

[4] Op. cit., p. 340.

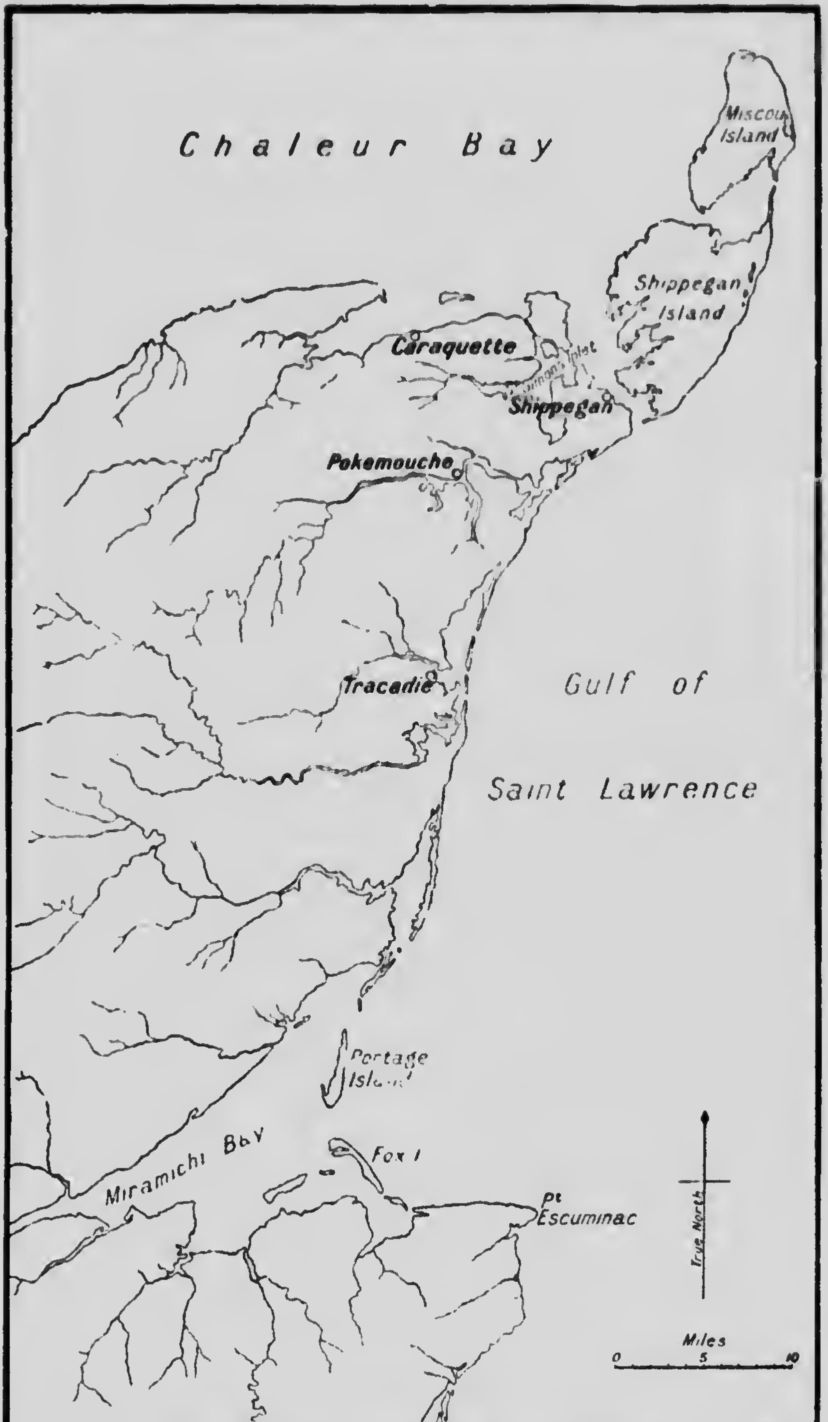


Fig. 5. Map of the coast of northeastern New Brunswick.

Cliff recession is indeed accelerated by coastal subsidence; but it takes place on any fully matured shore-line, as a part of the normal sequence of changes, and even on young shore-lines where the initial slope is steep.

That rapid cliff recession does not *necessarily* indicate that subsidence is in progress is seen in the case of the west shore of Lake Michigan, between Milwaukee and Chicago. According to Dr. Edmund Andrews,[1] the average rate of recession of this cliffed coast, prior to 1870, was over five feet a year. In other words, although the cliffs along the west shore of Lake Michigan are higher than those on the northeast coast of New Brunswick, their average rate of retreat is faster. Locally, cliff recession as fast as thirty or forty feet has been observed on the Wisconsin shore.[2] This destruction of cliffs by the waves of Lake Michigan cannot be attributed to a rise in level of the water on the shore; for the surveys cover a long period of years, during which the changes of level of the lakes have been slight, and as often downward as upward.[3]

*Drowned Valleys.*—In a letter in Science,[4] discussing the question of modern stability of the Atlantic coast, Mr. T. L. Casey points to the well-known estuarine coast of Maryland as "positive evidence of progressive subsidence . . . in recent times." If the drowned valleys of Chesapeake bay can thus be appealed to as evidence that the coast of Maryland is now sinking, the same argument could be applied to the equally typical dendritic estuaries of Gloucester, Cumberland, and Kent counties, in New Brunswick. It seems necessary, therefore, to anticipate the use—or, more accurately, the misuse—of such evidence, by pointing out the fallacy in it. Drowned valleys simply indicate that the land once stood higher than now; they do not indicate the date of the drowning, and do not prove that

[1] Edmund Andrews: The North American Lakes considered as Chronometers of Post-glacial time. Transactions of the Chicago Academy of Sciences, vol. 2, 1870, pp. 1-23.

[2] J. W. Goldthwait: Abandoned shore-lines of eastern Wisconsin. Wisconsin Geological and Natural History Survey, Bull. No. 17, 1907, pp. 58-59.

[3] For similar testimony from the shore of Lake Huron, and information as to the fluctuations in level of the Great Lakes, see A. C. Lane: Geological report on Huron County, Michigan. Geol. Survey of Michigan, vol. 7, 1900, pp. 78-85, and Plate 5.

[4] T. L. Casey: Subsidence of the Atlantic shore-line. Science, vol. 34, 1911, pp. 80-81.

the sinking of the land has continued down to present time. Indeed, in the case of New Brunswick, there is positive evidence, in the raised beaches, fossiliferous clays, and associated deposits, that at the close of the Ice Age this coast was very much farther under the sea than now; and that an elevation of from 100 to 200 feet has taken place, nearly but not quite restoring the region to its former position. Since the elevation of this coast is of later date than the stage of widespread submergence, it is more logical to conclude that the movement now in progress, if any, is upward, rather than downward. In any case, drowned valleys do not necessarily show what is the nature of the *latest* movement in a region.

*Barrier Beaches.*—During the past few years, there seems to have been a growing opinion, on the part of experts in plant physiology and ecology, that barrier beaches like those of New Jersey and New Brunswick are evidences of coastal subsidence. While, so far as I am aware, this opinion has been expressed in print by only one author, it is entertained by others.[1] It is hard to see the reason for this view, unless it is that barrier beaches are commonly associated with salt marsh deposits, and that these are believed, upon botanical grounds, to testify to a modern progressive subsidence. The only attempt to outline a theory for the origin of barrier beaches, based upon subsidence, so far as I have learned, appears in Professor Ganong's notes on the origin of Portage and Fox islands.[2] Referring to the long, broken barriers across the mouths of the Miramichi and neighbouring estuaries, he says: "Originally . . . they no doubt formed against the margin of the flat upland as ordinary shore beaches. But the steadily progressing subsidence carried the land beneath the sea faster than the beaches, whose rate of inward movement is determined by the erosion of the protecting headlands, could follow; hence the lagoons were formed. The coast is still sinking, and the beaches are still travelling

[1] C. A. Davis and David White, in oral discussion of the question of modern coastal subsidence, at the eleventh annual New England Intercollegiate Geological Excursion, at Tufts College, Oct. 13, 1911.

[2] W. F. Ganong: On the physical geography of the north shore sand islands. Bulletin of the Natural History Society of New Brunswick, vol. 6, 1908, pp. 6-13; and, On the physiographic characteristics of Portage and Fox islands, Miramichi. In the same volume, pp. 1-6.

inward."[1] As concrete illustrations of successive stages in this development of barrier beaches, Professor Ganong presents, among other cases, the following:—

(*a*) Three short beaches, just south of Point Escuminac, which connect headlands, and which enclose very narrow lagoons. "These are of especial interest as showing the mode of origin of the greater beaches, for in the case of the first two, while they are still shore beaches, lagoons are forming inside them." Likewise, Chockpish beach, which "extends from the rocky Richibucto head in an inbowed curve south to a rocky point just north of Buctouche beach, encloses mostly bog and marsh, but with rudimentary lagoons. It is thus another forming beach."[2]

(*b*) The long barriers or sand reefs which shut off from the sea the wide estuaries of Pokemouche, Little Tracadie, and other rivers. According to Professor Ganong's theory, the lagoons have been broadened by progressive subsidence faster than they have been narrowed by the inland migration of the sand reefs. In other words, the vertical subsidence has been more effective, here, than the horizontal advance of the barrier towards the land—an advance which is accomplished mainly through the drifting of sand along the exposed shore and the scattering of the sand through the gulleys into the lagoons.

(*c*) The more detached fragments of sand reefs, like Portage and Fox islands, at the mouth of the Miramichi. These are conceived to have passed through the stages already described, and to have become disconnected from their original anchorage as subsidence converted the mainland border into a submerged shoal, or as the protecting ledges at the headlands were drowned and their places were taken by easily eroded cliffs of peat, whose destruction let the sea through the barrier, at points where there was no longer a supply of sand for the beach. In short, "both Portage and Fox islands . . . appear to have been formed as true beach plains against the neighbouring upland. . . . Their separation from the upland is due to subsidence of the land, admitting the sea to flow over their

[1] Op. cit., pp. 12-13.
[2] Op. cit., p. 9.

oldest and, therefore, lowest parts, while their outer parts have been more or less eroded by the advancing ocean."[1] Thus it is conceived that barrier beaches originate as true beaches at the mouths of rivers on a low coast; that as this coast sinks beneath the sea, the river mouths are drowned to form lagoons, while the beaches, being tied to headlands at either end, remain relatively fixed in position; that as soon as the subsidence allows the sea a better opportunity to cut the beach away from its supporting headlands, there is a rapid widening of gullies, and a conversion of the reef into a broken chain of sand islands.

It will be noticed, by those familiar with the commonly accepted principles of shore-line morphology[2] that the first or "rudimentary stage, as outlined above, is the final stage, according to the accepted theory. Barrier beaches along coasts like that of New Brunswick are commonly believed to owe their origin to a rapid accumulation of shore drift along the concave line of breakers between headlands, and to follow these retreating headlands in their shoreward migration, narrowing the lagoons as they go, until at last they reach the mainland, and the lagoons vanish, so that the barrier passes into a true beach. In other words, the small beaches which Professor Ganong regards as "*forming*" would be regarded by most physiographers as *disappearing* barrier beaches. It is perhaps sufficient reason for the rejection of this theory of subsidence in favour of the commonly accepted one, that long bars or barriers of this kind occur between headlands on lakes whose level has been unvarying. Moreover, since both the headlands and the beaches, on the New Brunswick coast, are known to have been rapidly retreating, during the last few centuries, at least, this horizontal shifting, alone, of the sand reefs towards the shore, is competent to account for the several stages of development noted, if the long barriers which bridge the greater re-entrants are taken as the more youthful type, and the short beaches at the mouths of streams on the most exposed headlands mark the end of the life history of the barriers. Here, as in the case of the rapid recession of sea-cliffs, we find no necessity for progressive coastal subsidence.

[1] Op. cit., p. 5.
[2] See, for instance, W. M. Davis: Physical Geography. Boston. 1899, pp. 353-354.

*Re-curved, Hooked Spits, Dipping Beneath Lagoons.*—In his description of Portage and Fox islands, already referred to, Professor Ganong shows that they are detached remnants of long, re-curved hooks, now being cut away at one end, and built forward at the other. "Portage island is composed of a series of approximately concentric, low dune beaches with intermediate shallow hollows, a series of sand swells or billows. . . . Near its northern end the beaches, bearing the oldest woods, are parallel with the axis of the island, and here they are being cut away, together with the covering woods, by the sea. Farther south these same beaches curve around to the westward and finally sink gradually beneath the waves of the Inner bay, their summits projecting as points, while their intermediate hollows form coves of salt marsh. These beach lines, as may be seen at many points, form only above the reach of the highest tides, and their gradual disappearance beneath the waters of the Inner bay forms one of the very best evidences we possess of progressive subsidence in this region, evidence still further strengthened by the occurrence near the north end of the island, of peat in situ on the beach below high water mark."[1]

Contrary to this statement, it may be pointed out that the hooked terminations of long sand spits are commonly inferior in height to the crestline of a main storm beach, whether the latter is covered with dune sand or not. On such a hook, the crest of the beach always descends to sea-level and extends out under water. This is due in part to the decreasing supply of sand towards the end of the hook and in part to the fact that the storm waves around the bend of the hook are weaker than on the fully exposed straight beach which faces the sea, and so do not cast beach material up so high. In this case of Portage island, therefore, there is nothing abnormal about the dipping of the extremities of the hooks beneath the surface of the sheltered lagoon. Not only is this feature seen on hooked spits of the Atlantic coast generally, but it occurs on hooked spits in such lakes as Lake Michigan, where no subsidence of the coast has taken place during the period of construction of

[1] Op. cit., p. 2.

the hooks. So far as the occurrence of the peat bed below high tide mark on the outer beach of Portage island is concerned—evidence of quite another kind—this is a common feature in retreating barrier beaches, and can be explained without appeal to coastal subsidence.[1]

*Trees Killed by High Tides.*—In a short paper in his "Notes on the Natural history and physiography of New Brunswick," Professor Ganong says that on the low shores of the South river, near Pokemouche, "in places the dead forest trees still standing with their roots immersed by the highest tides afford striking evidence of the rapid subsidence this coast is undergoing."[2] An examination of this estuary in 1911, with the expectation of finding convincing proof that the tides at that place rise higher than they formerly did, proved a disappointment to me. It is quite possible that I failed to find the precise place to which Professor Ganong refers, although my search for it was rather thorough. Here and there, near the creek are patches of trees whose death, like that of groves farther back on the upland, seems to have been due to fire rather than to tides. Where the road from Lower Pokemouche to Tracadie crosses the upper end of South river, a number of dead spruces and firs occur near the river bank; but they stand in a bog which is clothed with characteristic freshwater vegetation. At one point where the highway between Six Roads and Pokemouche crosses the head of a short creek, about a mile south of Upper Pokemouche, there are obscure signs of an increasing submergence by the tides. At the water's edge, where salt marsh grasses of the genus *Spartina* and meadow plants like *Daucus Carota* and *Eupatorium purpureum* are curiously mingled, are a few tall birch trees, now dead. According to farmers in this vicinity, the trees have been killed by salt water, brought up during occasional spring tides. Even if we grant that this explanation is correct, in this instance, we cannot safely argue from it that the killing of the trees registers more than the

[1]D. W. Johnson: Fixité de la Côte Atlantique de l'Amérique du Nord," Ann. de Geographie, vol. 21, 1912, pp. 193–212 (particularly pp. 201–204).

[2]W. F. Ganong: On the physiographic characteristics of the Pokemouche and St. Simon rivers. Bulletin of the Natural History Society of New Brunswick, vol. 5, 1906, pp. 524–526.

injury received from an unusual succession of high tides, due, perhaps, to a series of storms of very great severity. If a downward movement of the coast is now in progress, and is so rapid as to be recorded during the short lifetime of a tree, we might reasonably expect to find, in a situation like this one, trees in all stages of destruction and of burial by the advancing salt marsh.

In one other place, of those which I visited in 1911, is there perhaps a record of forest destruction through submergence. At the head of the southeast branch of Saint Simon inlet, near the railway that runs to Shippigan, the low upland bordering the salt marsh is occupied by many stumps and dead trees. The suggestion of subsidence here in modern time is strengthened by the discovery of a number of stumps farther out on the marsh itself, entirely surrounded by *Spartina* and other halophilous plants, and of a black stratum of leaf mould or swamp deposit containing birch bark, beneath three feet of salt marsh material, near the edge of the creek, about 300 feet out from the margin of the upland. Some of the stumps are charred, as if by fire. Most of them, however, bear axe marks, as if the forest had been cut while living; for there is no apparent reason why a tide-killed forest should have been visited by the woodsman in a district where standing timber is abundant and little fuel is used. The encroachment of the salt marsh upon the forest border, therefore, must have taken place within the two centuries or so of occupation of the district by the French. A series of borings indicates that the buried stratum of leaf mould, at its greatest depth, is not more than four and a half feet below the surface of the marsh. As Professor Johnson points out, there are a number of ways to account for slight submergence without subsidence. The local high tide surface may creep up over a low upland border and bury it with a few feet of salt marsh in a district, for instance, where the widening and deepening of passageways across barrier beaches allows a constantly increasing play of the tides, or where the same result is accomplished in a single great storm, as at Marshfield, Massachusetts, in 1898.[1] On a rapidly retrograding coast like

[1] D. W. Johnson: Botanical evidence of coastal subsidence. Science, vol. 33, 1911, pp. 300-302.

that of New Brunswick, where the sea has cut back half-way to the heads of the estuaries, an increase of three or four feet in local high tide level might reasonably be expected. It does not appear, therefore, that the destruction of trees at the localities noted constitutes valid evidence of coastal subsidence.

On the other hand, as Professor Johnson suggested to me before field work was commenced, if the coast is now going down at a rate fast enough to be registered within the lifetime of trees of moderate size, the destruction of bordering forests should be seen in all parts of the area where submergence is in progress. An inspection of a number of estuaries along the drowned coast of New Brunswick, between Bathurst and Point du Chene, leads to the opinion that as a rule the forests surrounding salt creeks and marshes are not suffering from their proximity to the sea. The fringe of dead trees which we should expect to see is missing.

*Forest Beds and Peat Bogs Reaching to Depths Below High Tide Level.*—At a number of places along the coast of New Brunswick, peat bogs composed of fresh-water plants and containing roots of trees have been reported to extend to depths several feet below high-tide mark. Bogs of this type, composed of sphagnum and other swamp-loving plants, but generally treeless, cover vast areas on the lowlands near the coast, and are known as the "barrens." Their height is often not more than fifteen or twenty feet above sea-level. Since soundings have been known to penetrate them to a depth of over twenty feet, the impression has arisen that the bottoms of the bogs are so far below tide level as to indicate a subsidence of the coast. Among those who have studied the bogs and reported in detail upon them, the late Dr. Chalmers has published the largest amount of information. Criticism of his evidence naturally follows two lines: (*a*) Chalmers' statements of observation are so qualified as to admit of some doubt whether the peat actually does extend below sea-level; and (*b*) in case it does extend to that depth, the question arises whether it may not be explained in other ways than by supposing that the coast has gone down. In order to test both the facts and the interpretation of them as records of modern subsidence, I visited a few of the most typical barrens, including one on Miscou island, one at the head of Saint Simon inlet, and one near Point Escuminac. Natural cross sections of these bogs, cut by the sea, were inspected, and many soundings were made with a Davis peat sampler, with the expectation that the deposits would prove to extend to a considerable depth.

On Miscou island, half a mile inland from Miscou point, at a place where the surface of the barren is about ten feet above high tide mark, the sounding instrument penetrated decayed sphagnum to a depth of thirteen feet, where it struck something hard. Another group of borings 150 feet away from the first one, at the edge of a tidal "pond," gave the following section:—

Surface; typical salt marsh, with *Juncus gerardi* (?) the dominant grass; at mean high tide.
0 to 6 inches; brown, spongy peat, containing very little sediment, with many vertical fibres (salt marsh).
6 to 12 inches; brown, very compact, woody peat, without sediment; splits horizontally.
12 to 18 inches; reddish brown, very soft, fibrous peat (sphagnum).
18 to 24 inches; no core (frequently the case in boring through soft sphagnum deposits).
24 to 30 inches; same rotten, reddish brown peat.
30 to 36 inches; stiffer, rather firm, reddish-brown peat.
36 to 42 inches; brown, slippery, muddy peat in upper two inches, followed below by watery mud.
42 to 48 inches; muddy brown sand, with hard, gritty sand below, through which the sounder could not be driven.

The significant points about this section are: (*a*) that the salt marsh is merely a thin veneer over the bog peat. This agrees with the physiographic evidence that this "pond" is one of the numerous fresh-water pools on the barren, which has very recently been invaded by an advance of the sea, cutting back the cliffs into one end of it; (*b*) that the sphagnum deposit extends to a depth of only three feet and a half below mean high tide. This much submergence does not prove coastal subsidence. The bog may have grown up in a basin whose floor, although below high tide mark, was above mean tide level, and whose water, consequently, was fresh, and supported fresh-water vegetation. Later, as the sea cut its way into the pond and flooded it to high tide mark, opportunity came for a salt marsh deposit to form on top of the fresh peat, around the border of the pond.

A condition of things similar to this was found in the peat bog which lies at the head of the Saint Simon inlet, southwest of Shippigan. Here a low sea-cliff exposes the peat in cross section to a depth of not more than four feet below high tide mark, where the underlying structure, deeply decayed sandstone, is seen. Spongy brown sphagnum, in layers, alternates with tougher, blacker layers of woody peat, in which erect stumps and prostrate logs are rather abundant. The peat is exactly the sort of deposit now in process of formation on the surface of the quaking bog, where stunted spruces in scattered groups relieve the monotony of the low-bushed carpet that conceals the soft sphagnum. There seems to be a greater compactness of the basal layers of the peat, as if considerable settling of the mass had occurred. The rotten character of the moss, likewise, points to a considerable loss of volume. The very distinct stratification evidently marks recurrent cycles of wet and dry climate, in which forests encroached upon the barrens during dry periods, only to be overwhelmed by sphagnum when more humid conditions returned. The fact that the peat reaches down about to mean-tide level, but not below it, seems significant and will presently be discussed.

Of the bogs cited by Chalmers as evidence of coastal subsidence, perhaps the most notable is the one at Point Escuminac, near the mouth of the Miramichi. Ells stated, in 1880, that this bog has a maximum depth of more than thirty feet.[1] Chalmers, after mentioning the convexity of the bog, says: "From the examination made about its margin, it seems to occupy a basin . . . the central part of which is below high tide level. This gives it a thickness of twenty feet or upwards. Mr. Phillips, the lighthouse keeper at Point Escuminac, informed me that he found it twenty-four feet deep in one place."[2] Again, Chalmers remarks that "the bottom of these deposits seems to be at least ten or fifteen feet below high tide level in some places."[3]

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[1] R. W. Ells: Geological Survey of Canada, Report for 1879-80, Part D, p. 43.
[2] R. M. Chalmers: Geological Survey of Canada, Annual Report, 1887, Part N, p. 24.
[3] Op. cit., p. 25.

A study of the peat exposed in receding cliffs west of the Point Escuminac lighthouse, accompanied by borings to determine the depth of the deposit, convinces me that there is little if any evidence of coastal subsidence. Behind the soft peat cliff, which rises from 5 to 15 feet above the beach, the surface of the bog ascends rapidly inland, attaining nearly 30 feet altitude in the central part. It is quite apparent that the convexity of the barren at its periphery is due mainly to loss of water near the cliffs, where the water-table descends to the level of the beach. In the first quarter mile west of the lighthouse, the freshly cut cliff shows the floor of the bog—a smooth surface of decayed sandstone, gradually descending to the high tide mark. A series of borings along the foot of the peat cliffs in the next quarter mile, taken at intervals of 200 feet, show the depth of the floor of the peat bog below high tide mark, as follows: zero; zero; 6 inches; 12 inches; zero. Half a mile from the lighthouse, where the peat cliff attains its maximum height, 13 feet, a boring through the beach reached the sandy floor of the bog at a depth of less than 24 inches below high tide mark. Since the upward slope carries the surface of the bog to an altitude of fully 26 feet (as measured by hand-level and rod) above high tide mark, it is probable that the peat here is 28 feet thick. The sounding instrument used was limited to a depth of 21 feet. The 24-foot sounding reported by Chalmers may, therefore, have been entirely above high tide mark. In the half mile between this point and Herring cove, a few borings, at wider intervals, struck sand beneath the peat at depths below high tide mark, successively, of 24, 18, and 6 inches. It appears, therefore, that the Point Escuminac peat bog occupies a rather flat basin, whose floor is close to high tide mark over a wide area, yet rarely as much as two feet below that mark. In this respect it seems to agree with the peat bogs at Miscou island and Shippigan. This I am inclined to regard as significant. If there had been a subsidence of the coast of New Brunswick in very recent times, while the bog was under construction, we should expect to find the fresh-water peat extending down to greater depths; for sphagnum would have accumulated in basins whose floors, in some places, were barely above mean tide level, and thus just above the influence of the tides; and the subsidence of several centuries would probably drown these bog floors to depths distinctly below mean tide level. If, on the other hand, there has been no vertical movement of the coast for several centuries, while peat has been accumulating in these bogs, we can see why the fresh-water structures approach, but seem in no place to exceed mean tide level.[1] The latest evidence from the peat bogs of New Brunswick, therefore, argues rather for modern stability than for modern subsidence.

*Old Beaches on Prograding Shores, with Crestlines Lower than the Present Beach.*—A few places on the coast of New Brunswick, where, instead of retrogression, there has been for centuries a forward construction of the beach, offer opportunity to test the hypothesis of modern subsidence by a comparison of the crestline altitudes of the older beaches with the newer.[2] Of two such localities described by Professor Ganong—Miscou Grande Plaine and Portage island, the former was selected for a visit, partly because of the interest aroused by Professor Ganong's report on the plant ecology[3] and partly because the age of the beaches on Grande Plaine can be estimated with some approach to accuracy.

As both Chalmers and Ganong have stated, Grande Plaine is a long triangular tract of sands at the northwest side of Miscou island. Hither for centuries have been swept the beach sands and gravels that drift northward along the east side of the island. Rounding Miscou point, the shore drift comes to rest on the more sheltered beach of the Grande Plaine. Each successive storm of the first magnitude causes the construction of a new beach, a little outside of the former one. Thus there has grown up a sandy terrace which is over a mile wide, and is corrugated with ridges and swales. The outer, newer ridges are very

[1] A larger amount of testimony on this point is, of course, desirable, before drawing definite conclusions. The value of this evidence depends also upon the assumption that the sphagnum deposits have had a continuous upward growth, rather than a horizontal growth out over the surface of pools, in the form of a mat, which might sink to the floor of the basin, after a time, in the manner suggested by Professor Johnson. I am unable to say how far the latter process has entered into the formation of the peat deposits here described.

[2] D. W. Johnson: The stability of the Atlantic coast. Bulletin of the Geological Society of America, vol. 23, 1912, p. 740.

[3] W. F. Ganong: The nascent forest of the Miscou Beach plain. Botanical Gazette, vol. 42, 1906, pp. 81-106.

sandy and have rather pronounced back slopes. Their crest-lines, which commonly stand four or five feet above the inter-

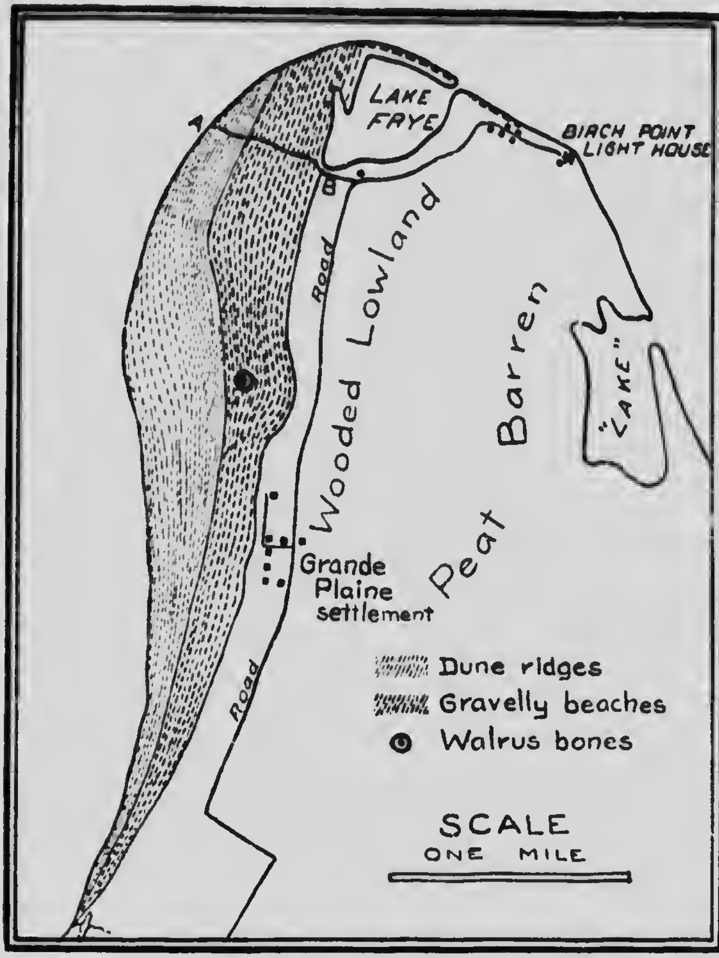


FIG. 6. Map of the northwest part of Miscou island, showing the old beaches of Grande Plaine (with slight modifications from W. F. Ganong).

vening hollows, are surprisingly uniform for dune ridges. Measurements along the crest of the outermost or newest ridge, in

August, 1911, gave altitudes of 8·37, 7·71, 8·81, 8·97, 9·77, and 10·63 feet above high tide mark. In the hollows, well within the vertical range of storm waves, gravels are common. The ridges themselves, however, so far as they exceed the altitude reached by the present storm waves (5·65 feet above the high tide mark) appear to be of æolian origin. Passing inland across this zone of dune ridges, which on the old trail to Lake Frye consists of twelve distinct members, one finds behind them a large number of flatter ridges, formerly well clothed with forest, now to a large extent laid bare by the lumberman. As Professor Ganong has pointed out,[1] the crests of these inner ridges are somewhat lower than those near the shore. Herein lies what appears to be evidence of coastal subsidence. That the inner beaches are at least a few centuries old is inferred from the presence on them of bones of walrus, which were hunted here in great numbers by the early French settlers, and exterminated shortly before the close of the eighteenth century.[2] Professor Ganong's walrus bone locality is about half a mile in from the sea, on the outer members of the inner group of beaches. From the published descriptions one would be led to suspect that enough subsidence of the coast had taken place, in the century and a half since the slaying of the walrus, to give the crests of these old beaches a perceptibly lower altitude than the crest of the present beach.

In considering first the testimony of these walrus bones with reference to the age of the beaches on which they occur, we may accept without hesitation the view that the inner beach ridges were formed prior to the close of the eighteenth century. Furthermore, the absence of such bones from the outer ridges seems to show that these have been built since the days of walrus hunting, or since the beginning of the nineteenth century. However, it is possible that the ridges which have furnished the bones are of much earlier date than the walrus hunting period, since, as Dr. John M. Clarke has pointed out to me, con-

[1] W. F. Ganong: On the physical geography of Miscou. Bulletin of the Natural History Society of New Brunswick, vol. 5, 1905, p. 459.

[2] W. F. Ganong: The walrus in New Brunswick. Bulletin of the Natural History Society of New Brunswick, vol. 5, 1903, pp. 240–241. Also, R. M. Chalmers: Geological Survey of Canada, Annual Report, 1887, Part N, p. 27.

temporary accounts of walrus hunting tell of the practice of driving the beasts from the waters or the floe ice up on to the low shore platforms and even into the woods, where they were shot at leisure. Possibly, then, some of the outer, barren beaches were already in existence when the walrus were slain in the woods close behind them, and the fossiliferous ridges are, therefore, older than we have assumed. Keeping this possibility in mind, we may say that the ridges in question date back at least to 1775. If, now, we assume that the growth of the beach plain, in the long run, has been steady, we may estimate that the age of the innermost beaches, which are as far behind the bone-bearing ridges as these are behind the modern beach, is probably not less than 300 years.

Lines of levels were run from the shore across the plain to Lake Frye, to determine what difference in height, if any, exists among the beach ridges. The measurements follow:—

| | | | |
|---|---|---|---|
| Last high tide mark on the beach, on August 3, 1911, at 9 a.m. | | | Zero. |
| Cut at upper reach of storm waves | | | 5·64 feet |
| Crest of first or outermost ridge, | | sandy | 9·04 " |
| " second | " | " | 8·91 " |
| " third | " | " | 6·70 " |
| " fourth | " | " | 5·89 " |
| " fifth | " | " | 8·12 " |
| " sixth | " | " | 5·54 " |
| " seventh | " | " | 5·07 " |
| " eighth | " | " | 3·91 " |
| " ninth | " | " | 7·81 " |
| " tenth | " | " | 5·50 " |
| " eleventh | " | " | 6·09 " |
| " twelfth | " | " | 7·44 " |
| " thirteenth | " | gravelly | 4·36 " |
| " fourteenth | " | " | 3·70 " |
| " fifteenth | " | " | 3·61 " |
| " sixteenth | " | " | 3·56 " |
| " seventeenth | " | " | 4·60 " |
| " eighteenth | " | " | 4·64 " |
| " nineteenth | " | " | 3·97 " |
| " twentieth | " | " | 3·92 " |
| " twenty-first | " | " | 4·25 " |
| " twenty-second | " | " | 3·04 " |
| " twenty-third | " | " | 3·26 " |
| " twenty-fourth | " | " | 3·25 " |
| " twenty-fifth | " | " | 3·21 " |
| " twenty-sixth | " | " | 3·43 " |
| " twenty-seventh | " | sandy | 4·14 " |
| " twenty-eighth | " | " | 4·19 " |

As the measurements show, the outer ridges, from the first to the twelfth, are on the average nearly three feet higher than the inner ridges, from the thirteenth to the twenty-eighth. This decrease in altitude, however, is by no means uniform. Indeed, there is a rather sharp distinction between an outer, higher, and more variable group, and an inner, lower, and more uniform one. Of the ridges numbered from thirteen to twenty-eight, the extreme crestline measurements are 3·04 and 4·64 feet—a difference of scarcely 18 inches among them. There is also a close approach to perfect horizontality in the crestline of any single ridge of this group. As Professor Ganong remarks, the difference between the vegetation of the outer and the inner ridges is very great.[1] There is an equally striking difference in their structure. Ridges one to twelve inclusive are dune ridges, of unusual linear uniformity and symmetry, to be sure, but built throughout of wind-swept sand. In the hollows between them, gravel frequently appears; but in no place, so far as I could see, above the altitude which is reached by storm waves on the present beach, *i.e.*, 5·64 feet above high tide mark. Ridges thirteen to twenty-six, on the other hand, are gravelly, with pebbles of good size on the very surface. Many of them are typical shingle beaches. Ridges twenty-seven and twenty-eight have a veneer of sand, perhaps a foot thick, above the gravelly foundation. As a record of the former sea-level, therefore, ridges thirteen to twenty-six are as valuable as a modern storm beach; while ridges one to twelve, being dune ridges, have relatively little significance. They are, on the average, about three feet higher than the older ridges, *not because the coast has subsided about three feet since the older ones were built, but because the wind has heaped up sands on top of the outer gravel beaches to an average depth of three feet.* Any conclusion regarding modern subsidence here must rest upon a comparison of the gravel beaches with each other and with the gravel beaches along the present shore. As already stated, the gravel ridges thirteen to twenty-six are practically equal in height; and such small differences as are brought out by the measurements are distributed unsystematically through the group. All the crests are vertically within the range of storm waves of to-day—5·64 feet above the high tide mark on the present beach. The most significant comparison is that of the old ridges with a modern

[1] W. F. Ganong: Op. cit. *Botanical Gazette*, vol. 42, 1906, p. 95.

storm beach which encloses Lake Frye at its northern end. This beach has a crestline altitude, determined by instrumental levelling, of just 4 feet above high tide—the old ridges from thirteen to twenty-six have an average crestline altitude of 3·82 feet. If the facts on Miscou Grande Plaine can be used as evidence in this disputed question, therefore, they testify that in the last three centuries or so, there has been no measurable subsidence nor elevation of the coast.

## CONCLUSION.

Summing up the several lines of physiographic evidence which have been presented by earlier writers, in support of the view that subsidence is now in progress on the coast of New Brunswick, we may draw the following conclusions:—

(1) The rapid recession of cliffs and beaches along the coast at the present time proves nothing either for or against modern subsidence. If the coast had been stable for centuries, the same cliff-cutting would be expected as has been described by investigators of the cartography and history of this coast.

(2) The presence of estuaries of the drowned valley type proves that there has been submergence, and, in view of the depth of the drowning over a wide area, coastal subsidence, at some time in the past. It proves nothing about modern or very recent movements of the coast. In fact, the valleys in question seem to be products of pre-Glacial or interglacial stream erosion, drowned very deeply during the Champlain submergence, and only partially lifted out again by the subsequent upwarping of the region.

(3) Barrier beaches are not evidence of coastal subsidence. They are normal features in the simplification of a shore-line which is initially irregular, whatever the cause of that irregularity may be. It is as natural to interpret the lagoons behind them as bays, shut off by reefs which have grown up between headlands, as it is to regard them as river mouths which have been drowned since the barriers were formed. Indeed, the former explanation is the more natural one, since it involves only those processes of shore drift and deposition which can be seen actually in

progress, while the latter supposes a downward movement of the land which demands further demonstration. Inasmuch as barriers are known to have been constructed on the shores of lakes in which no relative subsidence has occurred, and the processes of shore drift, working alone, are competent to account for them, the assumption that where such barriers occur the coast has been subsiding is entirely gratuitous.

(4) The disappearance of the hooked ends of re-curved spits beneath the surface of lagoons is not an evidence of coastal subsidence. On the contrary, this is the form which hooks necessarily assume on shores where no change of level is in progress.

(5) An examination of localities where trees have been said to be dying from invasion by high tides does not afford as good evidence as one might expect. If, as one may fairly question, the dead trees at Pokemouche and Saint Simon rivers register a submergence of the low upland border by salt water, this submergence may be due to recent increase in range of tide, which in some estuaries might be considerable. On the other hand, if this coast were subsiding fast enough to kill the trees, this sort of evidence should be apparent in favourable situations throughout the region—which is distinctly not the case.

(6) The peat bogs or barrens of sphagnum and associated fresh-water plants, whose bottoms have been reported to reach ten or fifteen feet depth below high tide mark, appear to extend only two or three feet, at most, below that level. Inasmuch as these bogs seem to have grown up in enclosed inland basins before the sea encroached upon them, it is not impossible that the basin floors, originally a few feet below high tide level, but not below mean tide level, were covered with fresh water. The fact that, so far as observed, and measured, the bog deposits approximate but do not exceed the depth of mean tide level is itself reason for favouring the view that neither subsidence nor elevation has taken place during their growth.

(7) A detailed survey of the beaches on Grande Plaine, Miscou island, which seem to register a period of at least three hundred years, indicates that so far as these are true wave-built beaches they testify to coastal stability rather than coastal subsidence.

The first number of the Museum Bulletin was entitled, *Victoria Memorial Museum Bulletin Number 1.*

The following articles of the Geological Series of Museum Bulletins have been issued.

*Geological Series.*

1. The Trenton crinoid, Ottawacrinus, W. R. Billings; by F. A. Bather.
2. Note on Merocrinus, Walcott; by F. A. Bather.
3. The occurrence of Helodont teeth at Roche Miette and vicinity, Alberta; by L. M. Lambe.
4. Notes on Cyclocystoides; by P. E. Raymond.
5. Notes on some new and old Trilobites in the Victoria Memorial Museum; by P. E. Raymond.
6. Description of some ne[illegible]idae; by P. E. Raymond.
7. Two new species of [illegible]adium; by P. E. Raymond.
8. Revision of the species which have been referred to the genus Bathyurus (preliminary paper); by P. E. Raymond.
9. A new Brachiopod from the base of the Utica; by A. E. Wilson.
10. A new genus of dicotyledonous plant from the Tertiary of Kettle river, British Columbia; by W. J. Wilson.
11. A new species of Lepidostrobus; by W. J. Wilson.
12. Prehnite from Adams sound, Admiralty inlet, Baffin island, Franklin; by R. A. A. Johnston.
13. The origin of granite (micropegmatite) in the Purcell sills; by S. J. Schofield.
14. Columnar structure in limestone; by E. M. Kindle.