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THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

WITH THE

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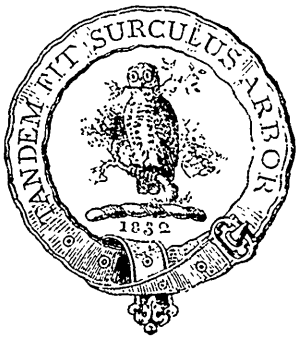

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THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

ON THE PRE-GLACIAL GEOGRAPHY OF THE REGION OF THE GREAT LAKES.

By E. W. Claypole, B.A., F. Sc. (London), Antioch College, Ohio.

The alliance of Geology with Physical Geography is not of long standing. Each science had separately done good work before by combining their forces they attempted yet greater undertakings. When Geology discovered and published the fact that the present outlines of the earth's surface had not always existed Physical Geography demanded the reproduction of the outlines passed away. The sister sciences thereupon joined hands, and set themselves to the task of reconstructing what we may call Extinct Geography. Long and arduous as it is, their efforts have already been crowned with no small measure of success—a success the greater, as might be expected, in proportion as the date is more recent. Quaternary maps are more full and correct than Tertiary, and Tertiary than Secondary; while the palæozoic coast survey has hardly yet begun.

The following attempt to reconstruct the early Quaternary Geography of the great American Lake District is offered as a small contribution to this department of science. The region is one of the most interesting upon the continent, both to the geologist and the physical geographer. Speculations have been made on the origin of these great inland sheets of water, but the

writer has not met with any connected or detailed investigation into the physical cause of the basins in which they lie, and which determine their existence. Until lately no proposition at all tenable had been promulgated; but since Professor A. Ramsay's strong advocacy of a glacial origin for the basins of certain European lakes, there seems to have been a tacit extension of this theory, so that according to some it explains the formation of almost all lakes in the North Temperate Zone, and were it not for the existence of several great inland seas in Equatorial Africa, it would, we think, be accepted by not a few as the sole and sufficient cause of all lake basins on the surface of the globe.

The merits of this theory we do not propose now to examine. Our purpose is merely to test its application to the case of the great North American lakes. The publications of the Geological Survey of Ohio have shown that opinion is yet divided upon this point. Dr. Newberry, its director, is apparently himself in doubt, as we infer from expressions in different parts of the work. For instance, we read in the volume for 1869, p. 28:

"Lake Erie in the glacial era was not a lake but an excavated valley into which the streams of Northern Ohio flowed."

But in the volume for 1873, Dr. Newberry says:

"It is doubtless known to some who may be readers of this volume, but probably is realized by few, that the basin of Lake Erie in all its length and breadth—as well as the smaller and yet deeper one of Lake Ontario, and the broader and far deeper ones of Lakes Michigan and Huron—has been excavated by mechanical force from the solid rock. . . . They are plainly basins of excavation dug out of sheets of rock which were continuous over all the area they occupy. . . . Any one who will stand on the cliffs which overlook the lake in North Eastern Ohio, 750 feet above the water, and will look over the sea-like expanse toward the Canadian shore, will get some realizing sense of the vastness of the mechanical effect which has been produced here. . . . The agents were unquestionably the same that have produced all the great monuments of erosion seen elsewhere—*water* and *ice*; and of the two that which was by far the most potent and that which alone could excavate broad boat-like basins such as these was ICE." p. 49.

Again we read in the volume for 1874, p. 77:

"Previously to the glacial period the elevation of this portion of the continent was considerably greater than now, and it was

drained by a river system which flowed at a much lower level than at present. At that time our chain of Lakes—Huron Erie, and Ontario—apparently formed portions of the valley of a river which subsequently became the St. Lawrence, but which then flowed between the Adirondacks and the Appalachians in the line of the deeply buried channel of the Mohawk, passing through the trough of the Hudson. . . . Lake Michigan was apparently then a part of a river course which drained Lake Superior and emptied itself into the Mississippi."

It is somewhat difficult to reconcile this with the next paragraph, which is as follows:

"With the approach of the cold period, local glaciers formed on the Laurentian mountains, and as they increased in size gradually crept down, and began to excavate the plateau which bordered them on the west and south. *The excavation of our lake basins was begun and perhaps in large part effected in this epoch.* The extent of the erosion produced *in the epoch under consideration* will be best appreciated by one who will stand on the cut edges of the great series of rocks exposed on the southern slopes of Lake Erie and Lake Ontario, and in imagination fill the vast vacuity which separates him from the base of the Laurentian hills."

On a previous page (72) we read the following:

"All our great lakes are probably very ancient," and "their formation may have begun during the coal measure epoch."

And on p. 74:

"There can be no doubt that the basin of each of the great lakes has been produced by a local glacier. . . Our lake basins must have been formed before or after the continental glacier, or both before and after."

And once more we find in the volume for 1873, p. 172, when speaking of the buried river channels, of which mention will be made presently, Dr. Newberry says:

"They were formed at a time when Lake Erie did not exist as a lake but was represented by a river flowing through some portion of the basin it occupies, and receiving the Cuyahoga, Rocky River, the Chagrin, Grand River, &c., as tributaries, at a level 200 feet below the present mouths of these streams. This was anterior to the first epoch of the drift period."

The view expressed in the last extract appears to be the only one now tenable, and the object of this paper is to support and to extend it to other parts of the region of the great lakes.

No fact has been more clearly brought to light during the Geological Surveys of New York and Ohio than that the present rivers are not flowing, in all cases, where they flowed during the Tertiary age. When the ice advanced southward it obliterated the rivers then existing, and on retiring left their channels filled with stones and clay. These beds of drift, as they are called, remained after the ice had disappeared, and when the rivers began again to flow, they failed, in many cases, to find their ancient beds. These ancient channels remained filled with clay stones and sand, and have only been discovered by borings and cuttings made generally for economical purposes. A good instance of this will be found in the volume of the Geological Survey of Ohio for 1873. Prof. Orton writes in his account of Clarke County—p. 460:

"An old valley of Mad River is disclosed in the heavy cut of the Atlantic and Great Western Railway, a few miles west of Springfield. The tongue of land that occupies a bend in the river has an elevation of 100 to 125 feet above the level of the stream, and gives no hint in its contour of any break in the rocky floor underlying it. The Sandusky railroad, which was first in construction, cuts across the tongue. A considerable portion of this cut is wrought in solid rock, the maximum depth of the stone cutting being 18 feet. With these facts before them, the Atlantic and Great Western Company, whose line crosses the river half a mile higher and on a grade of ten feet below the first road, expected also to find rock, and made arrangements for tunnelling the hill. The road that they selected however, chanced to be a buried channel of the river, which allowed an open cut of 65 feet through clay and sand. Soundings that have since been made from the track to the level of the river, show drift material throughout the whole extent."

In the north of the State, near Cleveland, where the Cuyahoga River enters the lake, is another of these buried channels. Borings have revealed the fact that the Cuyahoga now flows over a bed of clay and sand, 220 feet in depth, filling an older channel in the same or nearly the same place, whose rocky bottom lies 210 feet below the level of the lake. Ten miles west of Cleveland the Rocky River also enters the lake by a deep channel with precipitous walls. But two miles to the west is found its ancient channel filled like that of the Cuyahoga with clay, the Erie clay—"which here as at Cleveland extends far below the lake level." 1873, p. 172.

Now a river cannot excavate its bed below the bottom of the valley or lake into which it flows, and as Lake Erie does not much exceed 200 feet in depth, it follows of necessity that the bottom of the channel of the Cuyahoga and the bottom of the lake are nearly on the same level. It is impossible therefore to doubt that at the time when this older Cuyahoga flowed along its now buried channel the Erie valley had been excavated *to its full depth*, and that whatever was the agent we cannot attribute the erosion to the ice of the glacial era, since both valley and river equally belong to pre-glacial times.

Another argument may also be founded on the facts above given concerning the Cuyahoga. It is frequently affirmed that enormous erosion occurred over the face of the country during the ice age, and that, even if we grant the existence of an excavation where Lake Erie now lies, yet that excavation must have been deepened and widened under the action of the continental ice sheet. But no one will maintain that the ice deepened the gorge of the Cuyahoga from Cleveland to Boston, fifteen miles back from the lake, and it is equally impossible to maintain that the Erie basin which lies at nearly the same level can have been much deepened during the glacial era. The higher parts of the country may have been somewhat worn down, and the basin of the lake slightly eroded, but there is absolutely no evidence proving any perceptible change in the outline and depth of the Erie valley since early Quaternary days.

Yet a third inference may be drawn from the relative conditions of the Cuyahoga and the Erie Valley at the time now under consideration. There is no reason to believe that the river at Cleveland was much larger than now while it is absolutely certain that it flowed at least 200 feet below its present level, or nearly on the bottom of the present lake. We may hence safely conclude that the lake had no existence, and that the bed of the Cuyahoga continued into the wide open vale of Erie without meeting any such inland sea as that into which it now falls, and emptied itself into some larger stream then flowing eastward through the valley.

The same was also in all probability true of the Rocky River, and of other streams now tributary to the lake. For example: "Borings at Toledo show that the old bed of the Maumee is at least 140 feet below its present surface level." Geological Survey of Ohio, 1874, p. 15. The instances given are however sufficient for our purpose, and we pass on.

The establishment of this conclusion is however only the first step. If it is proved that the Erie valley existed not as a lake but as a valley at the time in question, other changes must follow. We quote again from the Survey of Ohio:

"An old excavated and now filled channel connects the basins of Lake Huron and Lake Erie. At Detroit the rock surface is 130 feet below the city. In the oil regions of Enniskillen and Bothwell, on the opposite side of Detroit river, from 50 to 200 feet of clay overlie the rock where the land surface is but little above the level of Lake Huron. The greatest depth of this channel is unknown."

The existence of this old and buried chanel at Detroit is another link in the chain. It enables us to extend our inferences from the valley of Erie to the basin of Lake Huron. It is evident that if the former in pre-glacial times contained no lake, and was connected with the latter by this channel 200 feet in depth, now filled with drift, the latter must also have been an open valley, and not, as now, the bed of an inland sea. The water collected upon its slopes must have flowed down to the mid-channel and thence through the deep gorge at Detroit into the Erie valley, forming the river previously mentioned.*

Turning now to the other end of Lake Erie, let us consider the physical condition of the Ontarian valley at the time in question. The greatest depth of Lake Ontario is 450 feet, with a surface level of 235 feet above the sea. Between the two lakes lie, as is well known, the falls of Niagara, which with the rapids below and above them, cause a descent of 330 feet. We have shown above that the valley of Erie cannot have been in early Quaternary times the bed of a lake, and it is therefore necessary to find some means of accounting for the escape of the

* It may be well in this connection to mention that the often expressed conception of these lakes as profound depressions is quite incorrect. They are excavations insignificant in depth when we consider their area. Lake Erie, with an average breadth of about 40 miles and a depth of 200 feet, lies on a bed whose sides slope only 10 feet in a mile. To the eye such a slope would appear an absolute level, and when we consider that a railway incline sometimes rises as much as 80 feet in a mile, the flatness of this valley to the eye will be more apparent. A similar calculation applied to Lake Huron shows that its bed slopes on an average not more than 16 feet in the mile, and like results may be obtained for all the others in the chain

waters. In the present state of our knowledge of the geology of the region it is impossible to point out the exact position of this channel, but the following extract will indicate its probable situation. After citing and discussing numerous instances of buried river-channels of pre-glacial age in different States, and relying on his experience and his knowledge of the geology of the country, Dr. Newberry says:

"I ventured to predict to General Warren that an old filled up channel would be found passing round the Mississippi rapids, and his examinations have confirmed the prophecy. I will venture still farther, and predict the discovery of buried channels of communication between Lake Superior and Lake Michigan, probably somewhere near and east of the Grand Sable, at least between the pictured rocks and St. Mary's river, *between Lake Erie and Lake Ontario through Canada*, between Lake Ontario and the Hudson by the valley of the Mohawk, and between Lake Michigan and the Mississippi somewhere along the line I have indicated before." Geology of Ohio, 1874, p. 19.

Of these the first, the channel between Lake Superior and Lake Michigan had already been announced in 1871 by Mr. N. H. Winchell, then a member of the Michigan Geological Survey, in the American Journal of Science and Arts for July of that year. This paper is noticed by Dr. Newberry in the volume just quoted, page 13.

The existence of a buried channel therefore between Lakes Erie and Ontario, though not actually proved by boring as in the former case, yet rests on evidence not to be estimated lightly. The opinion of one so well acquainted with the country as Dr. Newberry, deserves great confidence, and as in other cases, so here, it is likely that further investigation will reveal the buried channel somewhere near the line of the Welland Canal.*

The condition of the Ontarian valley at the time in question

* It would be conducive to the interest of science, and might at the same time repay the expenditure of the public money if the Government of the Dominion would set on foot a systematic examination of the region before completing the section of the new Welland Canal that passes through it. If such a buried channel could be found through the great Upper Silurian escarpment which forms so striking a feature in the landscape between St. Catharines and Niagara and the excavation carried through it, the cost would certainly be less than that of a rock cutting.

now claims consideration. In the passage above quoted from the Geology of Ohio, mention is made of the existence of a buried channel between Lake Ontario and the Hudson River through the valley of the Mohawk. Many years ago, in the course of the Geological Survey of New York, the facts were discovered on which this opinion is based. They prove the existence of a deep drift-filled and therefore pre-glacial channel near Syracuse, in the course of which channel lies Lake Onondaga.

"Onondaga Lake is the remains of an ancient and deep excavation in the Onondaga salt group, of which Onondaga valley forms the southern part, all of which has been filled up with sand and gravel except the part occupied by the lake." Geology of New York, Third District, p. 241.

Professor Newberry says: "The long level of the Erie canal between Utica and Rome lies in the old partially filled valley of the Mohawk." Geology of Ohio, 1874, p. 16.

In this channel are bored the Salina salt wells, the deepest of which extends 414 feet below the level of the lake, and it is not certain that the rock was reached in this.*

Dr. Newberry says: "The rocky bottom of the valley of the Mohawk is far below the surface—how far is not known, *as it has never been reached.*"

These figures warrant the conclusion that there exists a buried channel leading south-east from some point in the Ontarian valley near Oswego to Lake Onondaga and thence eastward towards Rome and Utica in the valley of the Mohawk. Beyond this point it has not been investigated, but there can be little doubt of its communicating by the valley of the Mohawk with that of the Hudson somewhere near Albany. It is also reasonable to

* Geology of Ohio, Vol. II, p. 16. Here by an error the surface of the lake is put at 274 feet above the Atlantic. But as the survey of New York shews a fall of 66 feet in the upper Niagara rapids, 160 feet at the Falls, and 104 feet in the lower rapids, or 330 feet in all, it is evident that the surface of Lake Ontario must be 235 feet only above the ocean. The Survey of Canada also (1863, p. 10) gives the fall from the Lake to the Atlantic 232 feet, a discrepancy of only 3 feet. By another error we are here told that at 414 feet below the lake-level, we are only 50 feet below the sea-level, whereas if 234 be subtracted from 414, the difference shews that we must be 180 feet below the surface of the Atlantic. It is difficult to discover which of the given data is wrong—the depth below the lake or that below the ocean.

infer that its bottom lies nearly or quite as low as that of the lake, so that in the later Tertiary age before it was filled with clay and sand, the waters of the Ontarian valley must have found their way by Oswego, Syracuse, Rome, Utica and Albany to the sea. The present lake basin, therefore, like those of Lakes Erie and Huron, must have formed an open valley drained by the river whose upper course was pointed out above, and which, considering its lower course, we may well christen the "Pre-Glacial Mohawk."

An objection will here be raised which must be met. The bed of Lake Ontario lies 215 feet below the present level of the Atlantic, while the bed of Lake Erie is 330 feet* above it, consequently, while there is no obstacle to the flow of this ancient Mohawk from the Erie to the Ontarian valley, it will be impossible to explain its course from the latter to the sea. A like difficul'y is found in establishing the flow of the river from the Huron basin into that of Lake Erie, the bed of the former lying 230 feet below the Atlantic level, while that of the latter is 330 feet above it, giving an *ascent* of more than 500 feet. If the relative levels of sea and land were then as they are now, such a course for this pre-glacial river was impossible. But there is much reason to believe that *before* the coming on of the great ice age the present relative levels of land and sea did not exist. It is the opinion of many geologists, among whom we may mention Professor Dana, that the glacial era was a time of continental elevation in high northern latitudes, and that this elevation became less and less towards the equator. But whatever may have been the case at and before its commencement, it is more probable that during the ice age the land to the north underwent depression in relation to the sea, whether the result of a rise in the ocean waters or not may be left for the present undetermined. Be this however as it may, most geologists are agreed that *before* the ice age, during the later Tertiary and early Quaternary eras, the northern part of the continent was more elevated than now.

"The Atlantic coast of North America to the north of Cape Cod was higher than now during the Cretaceous and *Tertiary* eras, as is shown by the absence of sea-shore deposits of these eras." Dana's Manual, 1874, p. 540.

* In these figures no account is taken of the recent deposits in the beds of the lakes.

It will be necessary therefore to consider the bearings of this fact on the course of the pre-glacial Mohawk. It is difficult, perhaps impossible at present, to arrive at exact conclusions in regard to its amount or its rate of increase northwards, but a consideration of the phenomena presented by European and American geology inclines us to assume that it was not excessive, and that a rate of about three feet in a mile would not vary much from the truth. With this estimate then we must now calculate the effect of such an elevation on the various parts of the bed of the river, and in so doing it will be sufficient for our purpose to start from the mouth of the present Hudson River in the harbour of New York in north latitude 40½°. The change would place the western end of the Erie valley 645 feet above the present Atlantic level, or 315 feet higher than now. But the same change would elevate the Huron valley in lat. 45° to a position 720 feet above the same level, and give a fall of rather less than 100 feet from the latter to the former, making the flow of the Mohawk not only possible but necessary.

In the next place the bed of Lake Ontario lies nearly 500 feet below that of Lake Erie, and as the change now in view would not lessen this amount by more than 150 feet, it is evident that no difficulty will be introduced to prevent the flow of the river from the latter into the former, and it only remains therefore to consider the relative levels at that day of the Ontarian valley and New York harbour. The deepest part of the Ontarian valley in lat. 43½° now lies, as we have said, at more than 200 feet below the surface of the Atlantic. The three degrees of latitude between the two points correspond to an elevation of 630 feet. This would place the Ontarian valley about 400 feet above the mouth of the Hudson, and supply ample fall for the river in its course of about 400 miles between the two points.

It must not be supposed that the figures above given are strictly accurate, accuracy being unattainable in the present state of our knowledge. They are only intended to show that there is no difficulty, when all the facts and probabilities are taken into account, in maintaining that in later Tertiary times a pre-glacial Mohawk, greater than the present river, drained the Huron valley and flowed through the gorge of Detroit into the vale of Erie. Taking its course to the north-east it received tributaries, among them the Maumee, the Rocky River, and the Cuyahoga, and passed through a chasm not far from the present

Niagara, probably forming a series of Rapids into the Ontarian plain. After traversing this from west to east, it escaped through the buried channel at Oswego, which it followed along the course of the present Mohawk until it reached the Hudson, then perhaps the smaller stream, and both united entered the Atlantic at some point south-east of where New York now stands.

One other point deserves a passing notice, but, for want of exact knowledge, it can only be at present an indication of probability. A striking feature in the geology of Canada is the great Silurian escarpment, as it is called. It consists of a range of cliffs, in some places two or three hundred feet high, commencing on the west bank of the Hudson, and forming the southern boundary of the valley of the Mohawk. Thence extending nearly due west to Niagara it sweeps round the western end of Lake Ontario to Cabot's Head, the Manitoulin Isles and Mackinaw, and skirts the western shore of Lake Michigan.*

This escarpment faces the north, and forms, at present, an imperfect division between Lake Huron and the Georgian vale. But when elevated, as in the later Tertiary age, it must have formed a water-shed between the Huronian valley and that in which now lie the waters of the Georgian Bay; and the question arises, in what direction did the waters of the Georgian valley then flow? A study of the geography of the country leads to the suspicion that they may have found their way to the eastward by the valleys of the present Severn and Trent and the Bay of Quinté. Sir William Logan, writing on this subject in the Geology of Canada, 1863, pp. 12, 13, describes a ridge of drift material running nearly east and west, at a short distance from Lake Ontario, and dividing the Lake Basin from the valley of the Trent or Ottonnabee. "Between the Holland and the Humber, Mr. Tully in his report on the proposed Georgian Bay canal, states the height of the ridge to be 904 feet above the sea. To the east of this it is crossed by the Toronto and Simcoe

* It appears as if geologists who advocate the excavation of the basins of the great lakes by the action of northern ice flowing off the Laurentian highlands, are somewhat oblivious of the existence of this escarpment. If the ice possessed the enormous eroding power on rocks and cliffs so often attributed to it, it must certainly have cut away and destroyed this gigantic barrier to its advance before proceeding to scoop out deep basins to the southward.

railroad, while to the west where it abuts against the Upper Silurian escarpment, and separates the Humber from the Nottawasaga, its height is 950 feet."

"Lake Simcoe is a tributary to Lake Huron, and lies 704 feet above the sea, but the depression in which it is situated is a continuation of the valley of the Trent, which can thus be traced from the Georgian Bay to Kingston."

"If the palæozoic rock surface beneath the drift ridge presents the same character as it does in other parts of the plain, it seems probable that it rises with a pretty even slope from the exposures on the lake to those north of it in the latitude of Peterborough, and that a depression accompanies the softer deposits from the Georgian Bay to Lake Ontario. This would give a probable depth of 400 feet to the drift along the chief part of the ridge, and a still greater depth over the depression."

Now Lake Simcoe, lying 704 feet above the sea, is only 130 feet above the level of Lake Huron, and if, as Sir Wm. Logan supposes, the rock lies more than 400 feet below the surface, it is evident that before the deposition of the drift, the waters of the Georgian valley may have flowed eastward along the depression where now lies the chain of Lakes Simcoe, Balsam, Cameron, Sturgeon, Mud, Salmon Trout, and Rice, and the present river Trent into the Bay of Quinté, at the eastern end of which they may have entered the Ontarian valley, and the pre-glacial Ottonnabee may have been a tributary of the pre-glacial Mohawk.

These are some of the changes which the elevation of the northern part of the continent before the deposition of the drift, probably implied, but we can trace them somewhat further. Three-fifths of the great system of fresh water lakes have already disappeared from our Tertiary geography, and it is evident that the same elevation will efface the most beautiful river of the continent, the St. Lawrence.

The St. Lawrence, at Quebec, is much farther to the north than Lake Ontario. The elevation due to its latitude, at the same rate as before, must have placed it at the time in question about 1300 feet above the Atlantic, while Montreal and Kingston were nearly 1000 feet above the same level. Instead therefore of flowing to the north-east the drainage of the waters of the district must have taken a south-westerly direction, and in all probability passed by some channel across the great plain between the St. Lawrence and the Green Mountains, not far it

may be from the course of the present Richelieu, into the valley of Lake Champlain and thence into the Hudson River, at that time a tributary to the Mohawk. At the present day the distance between the Hudson and the Lake is only "20 miles, with a height of land between them only 120 feet above the sea." Geology of Canada, 1863, p. 8.

Without taking into account therefore the layer of superficial deposits of which this height of land in part consists, it is easy to see that the course here suggested was then a more probable outlet for the Canadian waters from the north-east than that which they now follow. Those to the west of Montreal may have taken a course to the westward, and have entered the Ontarian valley near its eastern end, and become tributary to the Mohawk before it entered the Oswego chasm.

In order to show that the phenomena of the adjoining lakes, Michigan and Superior do not conflict with the results that we have thus far obtained, it may be well to refer to them for a moment. The bed of Lake Superior now lies about 200 feet below the Atlantic. It must therefore at the time and with the elevation in question have been more than 1300 feet above it. Moreover the researches of the Michigan Geological Survey have disclosed the existence of an old channel now filled with drift-clay and sand reaching southward from the south shore of the lake. The facts connected with the discovery are thus given by Mr. N. H. Winchell in a paper on the glacial features of Green Bay in the Am. Journal of Science and Arts for July, 1871:

"If we examine the south shore of Lake Superior we find that in a line directly north of little Bay de Noc occurs the only break in the otherwise continuous rocky barrier."

"From the mouth of the Chocolate River, six or eight miles east of Marquette to a point one mile and a half east of the mouth of the Train River, the shore is low and occupied by drift deposits, the usual rocky barrier of sandstone being interrupted or entirely wanting. Both to the east and to the west from this interval the shore of the lake is formed by the rocky ramparts either of the Lake Superior sandstone on the east or of the Huronian and other Eozoic rocks upon the west."

"In relation to the country between the head of little Bay de Noc and the shore of Lake Superior, we may infer that a valley exists or did exist connecting Lake Superior with Lake Michigan through little Bay de Noc, and that the present outlet of

Lake Superior is of comparatively recent date. Not only do the descriptions of this tract by Messrs. Foster and Whitney confirm this inference, but examinations of the district since made by Mr. Wadsworth of the Michigan Geological Survey, almost directly demonstrate the former outlet of Lake Superior to have been through the White Fish valley." "It appears that the outlet of Lake Superior was through little Bay de Noc up to the close of the Tertiary age." Of course we are as yet unable to give the depth of this channel, but considering the change of elevation it is not improbable that we have here the pre-glacial outlet from the valley, and that Lake Superior then existed as a vast, open, almost level plain, through which flowed a river to the southward. We incline however to think that instead of leading into the valley of Lake Michigan, as Mr. Winchell supposes, this river flowed more to the south-westward, through Lake Winnebago and Lake Horicon by the valley of Rock River, and met the Mississippi near where Rock Island now lies. In confirmation of this view we cite the following:

"The State of Wisconsin is traversed by a remarkable valley. Commencing north of Lake Michigan, near Lake Superior, this depression runs south west, and contains in its northern part the waters of Green Bay, and in its southern portion those of Rock River. It pursues an almost straight course for 400 miles and terminates on the Mississippi, where Rock River flows into it. From the northwest the country descends by a gentle slope into the valley, but from the south-west it breaks down suddenly and often by a perpendicular precipice. A rocky ridge, the Upper Silurian escarpment spoken of above, or rather an elevated region of Silurian rock, some 300 feet in height, separates this valley from Lake Michigan." E. Andrews, M.D., in Am. Journal of Science and Arts for September, 1869.*

The condition of the Michigan valley during the same era was similar to that of the valley of Lake Superior. In the geology of Ohio (Vol. 2, p. 13), we read: "An excavated trough runs northward" (*southward*) "from Lake Michigan to the north line of Iroquois county, Illinois, thence south-west through

* We may mention here that Mr. G. M. Dawson in his recent report on the geology of part of the region near the 49th parallel, states his belief that in pre-glacial times Lake Winnipeg also had a southern outlet.

Champagne county, beyond which it has not been traced. Its western margin is sharply marked at Chatsworth in Livingstone county, where it has a depth of 200 feet, and reaches the Cincinnati group. Farther north, its boundary walls are composed of Niagara limestone, and terminate in buried cliffs on the Calumet and Kankakee Rivers. At Bloomington this trough has a depth of 230 feet. . . . Where penetrated in other localities the depth of this channel is from 75 to 200 feet."

This channel leaves the basin of Lake Michigan near Chicago, where the land is now but few feet above the level of the lake, and its course appears to be marked out by a remarkable chain of forest oases in the prairies of Illinois, extending along the line indicated above. Whether, however, it reached the Mississippi directly, or indirectly through the valleys of the Wabash and Ohio, is not easy at present to determine. Further investigation along the line of the buried channel, can alone set at rest this uncertainty.

The depth of Lake Michigan may be set down at about 900 feet, and if we assume this and the greatest known depth of the buried channel at Bloomington as data, we find that, with the rate of elevation previously employed, the bed of the lake was 170 feet above the bottom of the buried channel. Here therefore we have an outlet by which the waters of the Michigan valley escaped into the great midland plain, and reached its draining stream, the Mississippi. In that event there was a river which may be named for the present the pre-glacial Michigan, traversing the long vale of the same name, narrower and deeper than those before described, and yet with sides sloping only about twenty-five feet in a mile.

Reviewing the results thus obtained, the early Quaternary Geography of the North American continent presents to the eye an appearance very different from that of the present day. The great river of the north-east was not the St. Lawrence but the Mohawk. Rising in the slopes of the wide and open Huron valley, it passed thence through the gorge at Detroit into the vale of Erie receiving tributaries on both banks. Thence it found its way through a similar gorge not very far from Niagara into the Ontarian valley, receiving on its way the waters of the Genessee, the Ottonnabee, and perhaps also of the Ottawa. It passed onwards through the deep and drift-filled channel under Lake Onondaga and the valley of the present Mohawk to the

valley of the present Hudson, and reached the Atlantic somewhere to the south-east of New York harbour, after a course of nearly 1000 miles, while its former tributary, the Hudson, appears to have drained the district whose waters now find an outlet to the Lower St. Lawrence. In the west the broad open vales of Superior and Michigan poured forth their waters to the south to meet the great Midland River of the Continent, the Mississippi, while the waters of the Georgian Bay instead of communicating, as at present, with Lake Huron, flowed directly into the Ontarian valley somewhere along the line of the present Ottonnabee.

From the position maintained in the present paper, several facts otherwise difficult of explanation, become consistent with one another, and are, in fact, necessary consequences of the principle here laid down. The great depth of the lakes to the northward is a result of the previous elevation and subsequent depression, which we have assumed as the basis of our reasoning. The almost uniform descent in the channel of the pre-glacial Mohawk from the valley of Lake Huron to New York harbour would be restored if elevation to the same amount should again take place and the accumulation of drift be removed. The shallowness of Lake Erie at its western end is a consequence of its southerly position which lessened the depression it has since undergone. It increases in depth to the north-east. Ontario is deeper than Erie, while the three upper lakes extending much farther to the north are also considerably deeper, because of the greater subsidence their basins have since experienced.*

Another fact which this principle explains is the excavation of many part of these channels below the level of the sea. The bottoms of lakes Superior, Michigan, Huron and Ontario, are all more than 200 feet below the surface of the Atlantic. The same is true of the buried channel under Lake Onondaga, and also to a less degree of several places in the present Hudson River.

There is no evidence that cataracts ever existed to scoop out these basins, and with one exception no other agent has ever been brought forward to explain their formation. That agent is ice, and to it some writers are disposed to attribute effects which the evidence fails to support. We have already alluded to the

* A similar explanation may be given of the great depth of the bed of the Saguenay and the lower St. Lawrence.

opinions of Dr. Newberry as expressed in the volumes of the Ohio Survey. It seems necessary, however, to dwell on this point somewhat more fully in order to show that the theory of the origin of our lake basins here maintained is more consonant with facts than that which attributes it to the action of ice. Dr. Newberry says (1876, p. 74):

"There can be no doubt that the basin of each of the great lakes has been produced by a local glacier, and that the great ice-sheet which existed during the period of intensest cold, moving as a solid continuous mass of great thickness from north to south would have the effect to obliterate rather than to form such local troughs. Our lake basins must therefore have been formed before or after the continental glacier, or both before and after. Probably the latter is the true statement of the case."

The central and eastern portions of the bed of Lake Erie were once occupied by soft rocks. Of these more than 1000 feet in thickness were removed. To this enormous erosion by the ice, to which Dr. Newberry evidently ascribes the origin of the Erie valley, the following passage from the same volume suggests a serious objection: "An interesting fact was noticed by Mr. Gilbert, Mr. Winchell and myself, that in the north-west portion of the State, a series of glacial markings which have a nearly north and south bearing are obliterated (*nearly* obliterated ?) by the stronger, fresher, and more numerous grooves of which the bearing is nearly east and west."

The north and south grooves, to which Dr. Newberry here refers, are of course those attributed to the continental ice-sheet, while the east and west grooves of later date are those caused by the local glacier which followed it as the ice-sheet dwindled away. We cannot agree, however, with Dr. Newberry's reading of this natural palimpsest, for it appears highly improbable that the excavation of the lake basin was principally effected by this local east-west glacier, which was evidently unable to remove the superficial scratches left by its larger predecessor.

All will agree, we think, with Dr. Newberry that the effect of the great ice-sheet would be to obliterate rather than to form such local troughs. But even this planing effect seems greatly overrated. There is no proof that the great ice-sheet has removed more than an inconsiderable layer of the superficial rock of the region. Why then, we may ask, should a local glacier be supposed able to excavate so deeply rocks on which the great

continental glacier produced so small an effect? In short we have as yet no evidence that either local glaciers or a continental ice-sheet could excavate the basins of the great American lakes. The effect seems more justly attributable to the slow action of a river during part or the whole of the Secondary and Tertiary eras.

The three lakes, Huron, Erie and Ontario, are therefore on the view here maintained, only the broad portions of the valley of an ancient river, the narrow parts of whose channel were filled up with drift during the glacial era. A glance at the geology of the region confirms this view. The western end of Lake Erie lies on the hard Corniferous limestone, but the greater part of the lake basin is excavated out of the Hamilton and Erie shales, which are comparatively soft. At the eastern end of the lake the Upper Silurian ridge of Niagara limestone crosses the course of the river. The Ontarian basin also is cut out chiefly in the Hudson River shales, while hard rock again ensues between it and the sea. Accordingly we have the gorge at Detroit in the hard limestone, the broad open valleys of Erie and Ontario in the softer shales, and the channel at Niagara between them, worn in the Upper Silurian limestone. It is easy to see that the rate of erosion in the softer rocks must have been limited by the rate at which the hard limestone barriers could be cut down. The river meandered, as is usual with rivers, hither and thither over the wide plain, gradually excavating the valley by cutting down and carrying away the material as fast as the rocky bars were lowered. And when the length of time during which the work may have been in progress is considered, no one familiar with the phenomena of subaerial erosion will deem the cause insufficient. Let any one who doubts reflect on the examples to be found in other parts of the world. Let him turn to south-western Ohio, and see how the hard Niagara limestone has been swept away over a wide district, where existing outliers prove that it was formerly present, and by rivers of comparatively insignificant size—the two Miamis and their tributaries. Let him also realize how large a lake would be formed by damming back the Ohio at Cincinnati with a mole one or two hundred feet in height, and we think all difficulty will vanish in admitting the erosion which we here imply, vast as it is, during the time that elapsed from the Carboniferous to the Quaternary era—that is during the whole Secondary and Tertiary ages.

The scenery along such a river presented alternately the low wide landscape of the open plain and the deep contracted view of the narrow pass, each passing into the other, as the underlying rocks change from soft to hard or from hard to soft. The spread of drift-material over the face of the country left the narrow gorges completely choked. As the rivers began again to flow after the ice-age had passed away they were unable to find their ancient channels along these narrow chasms, and consequently the water accumulated in the valley until it rose sufficiently high to flow over the barrier at its lowest point, when it commenced anew the task of cutting a gorge through the same limestone ridge, first in the drift material on the surface, and then in the solid rock below. This process may now be seen going on at Niagara Falls.

The great American lakes therefore are nothing but mere drift-dammed pools, filling the wide portions of the channels of pre-glacial rivers, while the narrow chasms connecting them are concealed by superficial deposits of clay and sand. Should the present condition of things continue long enough, the rocky barrier between Erie and Ontario will be again cut down, and the present lake above the Falls converted again into the broad open plain of the later Tertiary age. New falls or rapids will be developed near Detroit as the excavation of the Erie basin proceeds, and the levels of lakes Huron and Michigan correspondingly lowered; while by the gradual wearing down of the rocky bars now forming the rapids on the St. Lawrence, as much of the water in Lake Ontario will be carried away as the relative levels of that lake and the Atlantic will allow. But neither Michigan, Huron, nor Ontario can ever be laid dry by this process, and their end can only come, catastrophes excepted, by the slow but steady process of silting up. The same process to some extent must occur in Lake Superior. The wearing down at the falls of St. Mary will lower its level, but the deposit from its tributary streams alone can entirely obliterate it.

One result of the Quaternary age has therefore been to transfer a great part of the basin of the pre-glacial Mohawk to the basin of the St. Lawrence, a younger and Quaternary river. But no great alteration in level would be required to change again the course of these northern waters. The sewers of Chicago now carry the water of Lake Michigan into the Mississippi valley, the watershed between the two being only 10 feet above the

lake, or about 23 feet above Lake Erie. Evidently, therefore, a very slight rise in the bed of Niagara river would raise the level of the three lakes and cause their waters to flow south-into the Mississippi rather than north-east into the Atlantic.

But great as these changes in the physical geography of the country appear, they are geologically trifling. The general surface was then as it is now. No new mountains have risen, and little progress has been made in the destruction of old ones. The great midland valley extended from the Alleghany Mountains westward, and was drained by the Mississippi, the Father of Waters in age not less than size. The Adirondacks, the Laurentides, the Green and White Mountains, the Catskills, and the Helderberg range then stood as now, while along the eastern border of the Continent the Alleghanies and the Blue Ridge formed its Atlantic frontier, their western slopes being drained by the Ohio and its tributaries, flowing at least a hundred feet below their present level.*

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* The substance of this paper was delivered before the Cincinnati Natural History Society in January, 1875, and illustrated by a map which is not reproduced here. The argument however appears intelligible without its aid.

NOTES ON THE APPEARANCE AND MIGRATIONS OF THE LOCUST IN MANITOBA AND THE NORTH-WEST TERRITORIES—SUMMER OF 1875.

By George M. Dawson, Assoc. R.S M., F.G.S.

From the reports now received from Manitoba and various portions of the North-west Territory, and published in abstract with these notes, it would appear that during the summer of 1875 two distinct elements were concerned in the locust manifestation. First, the insects hatching in the Province of Manitoba and surrounding regions from eggs left by the western and north-western invading swarms of the previous autumn; second, a distinct foreign host, moving, for the most part, from south to north. The locusts are known to have hatched in great numbers over almost the entire area of Manitoba, and westward at least as far as Fort Ellice on the Assineboine River (long. 101° 20′), and may probably have been produced, at least sporadically, in other portions of the central regions of the plains; though in the summer of 1874, this district was nearly emptied to recruit the swarms devastating Manitoba and the Western States, and there appears to have been little if any influx to supply their place. Still further west, on the plains along the base of the Rocky Mountains, from the 49th parallel to the Red Deer River, locusts are known to have hatched in considerable numbers—but of these more anon.

Hatching began in Manitoba and adjacent regions in favourable localities as early as May 7th, but does not seem to have become general till about the 15th of the month, and to have continued during the latter part of May and till the 15th of June; while, according to Mr. Gunn and others, in cold clayey land and where pools of water from the melting of the snow lay long, isolated colonies came out at still later dates. Mr. Gunn states that grasshoppers were even noticed to hatch in August and September, in spots which had been covered with water all summer, a fact showing the very persistent vitality of the eggs, and apparently negativing opinions which have been expressed as to their destruction by damp. The most northern locality at which locusts are reported to have been produced from the egg, is at Manitoba House, Manitoba Lake.

The destruction of crops by the growing insects, in all the settled regions was very great, and in many districts well nigh complete. The exodus of these broods began in the early part of July, but appears to have been most general during the middle and latter part of that month, and first of August. The direction taken on departure was, with very little exception, south-east or south. It is to be remarked, that as there does not seem to have been during this period any remarkable persistency of north-west or northerly winds, the insects must have selected those favouring their intended direction of migration, an instinct which has very generally been observed elsewhere. Though most of the parents, in 1874, came from the west and north-west, and Manitoba must have represented to those ending their flight there, the south-eastern limit of their range; the young insects of 1875 thus took a south-eastward direction, just as though starting from their usual breeding-grounds in the far north-west, and showed no disposition to return to the region whence their parents came. This direction of flight carried many of the insects at once into a country of thick woods, swamps, and lakes; and caused the repetition of the phenomenon of the appearance of grasshoppers in great numbers about the Lake of the Woods, a circumstance only once before noted—in the summer of 1857.* This previous occasion however differed from that of last year in being an extension of an invasion of Manitoba from the west or north-west, and not resulting from insects hatching in that province.

It is probable that most of the grasshopper swarms of Manitoba, thus entering the wooded country, were there harmlessly spent, for though some northern swarms reached the State of Minnesota, the invasion appears to have been comparatively unimportant. Northern swarms are noted to have passed over Crookston (Polk County, Minnesota), and Fort Totten, (Dakota); the greatest number appearing at the latter place July 19th. The locust swarms described by Mr. Riley † in the following paragraph, from information furnished to the *Chicago Tribune*, dated July 13th, probably also came from Manitoba: "The first foreign hoppers appeared on the Sioux City Road, alighting be-

* Not 1867 as erroniously printed in Notes for 1874.

† From Mr. Chas. V. Riley's very interesting Eighth Annual Report on the Noxious, Beneficial, and other Insects of the State of Missouri.

tween Lake Crystal and St. James on Wednesday last. A few days later they were observed at New Ulm flying south-east, and at noon of the same day struck the line of the road at Madelina, St. James, Fountain Lake, Windom, and Heron Lake, covering the track for about 50 miles of its length." It will be observed on referring to the summary on another page, that the insects produced in Minnesota itself flew south-west in the early part of July.

I have not been able to trace further the movements of these Manitoba broods, unless indeed it be supposed that some at least of the swarms which passed over central Illinois early in September, came from that quarter. These, however, Mr. Riley believes not to have been the true migratory locust—*Caloptenus spretus*.

Foreign swarms from the south crossed the 49th parallel with a wide front stretching from the 98th to the 108th meridian, and are quite distinguishable from those produced in the country, from the fact that many of them arrived before the latter were mature. These flights constituted the extreme northern part of the army returning northward and north-westward from the states ravaged in the autumn of 1874. They appeared at Fort Ellice on the 13th of June, and at Qu'Appelle Fort on the 17th of the same month, favoured much no doubt by the steady south and south-east winds, which according to the meteorological register at Winnipeg, prevailed on the 12th of June and for about a week thereafter. After their first appearance, however, their subsequent progress seems to have been comparatively slow, and their advancing border very irregular in outline. They are said to have reached Swan Lake House—the most northern point to which they are known to have attained—about July 10; while Fort Pelly, further west, and nearly a degree further south, was reached July 20th, and about seven days were occupied in the journey thence to Swan River Barracks, a distance of only ten miles. It is more than probable that the first southern swarms were followed by others, which mingled with them, or even, in parts of Manitoba and the country immediately west of it, with the indigenous brood. From a few localities only, in Manitoba—and those in its western portion—is the evidence pretty conclusive as to the arrival of foreign swarms from the south. Burnside, Westbourne, Portage La Prairie, Rockwood, and Pigeon Lake, may be mentioned as affording instances.

Many of the grasshoppers observed, according to reports received by Mr. Riley, in Dakota, at Fort Thompson, Yankton, Fort Sully, Springfield, Fort Randall, and Bismark, flying northward and north-westward at various dates in June and July, no doubt eventually found their way north of the 49th parallel. Those seen at Bismark about June 6th and 7th, probably belonged to the earliest southern bands above referred to, and judging from the dates given by Mr. Riley, may have been produced in Nebraska, or more probably even still further south. A portion of the southern and eastern army probably reached Montana, and may even have penetrated in diminished numbers into the districts in the vicinity of Bow River.

A considerable number of locusts appear to have hatched at about the same date as in Manitoba, near the extreme western margin of the plains, especially in the country near Bow River. Foreign swarms arrived at Fort McLeod from the south-west, depositing eggs; and most of those hatching near Bow River, and further north, seem to have gone south-eastward early in August. No very definite or wide spread movement of swarms appears, however, to have occurred during the summer of 1875 in this region, nor, if we may judge from the very meagre accounts received, in the corresponding portion of Montana.

The following notes, representing the condition of affairs in the Western States and Territories, south of the 49th parallel, are abstracts of the accounts in Mr. C. V. Riley's work, already referred to, and will serve as a basis of comparison:

Texas and Indian Territory. Hatched in large numbers early in spring in Texas and Indian Territory. Left in May, and early in June, going for the most part north

Kansas. Ravages confined to districts 150 miles long, 50 broad, along eastern border of State, this being the region where most eggs laid in 1874. Hatching from April 6th to May 10th. Flew north-west in latter part of May and first week in June.

Colorado. Hatched pretty generally over the territory, appearing from early in May till July, according to elevation. Prevalent direction of flight on departure south and south-east.

Nebraska. Hatching ground limited to districts bordering Missouri River. Insects produced early in May, and began to fly northward about June 7th. Several swarms from more southern regions passed north-westward over the State before those hatching here took wing.

Missouri. Hatched early in May, especially in the middle western counties. Began leaving early in June, the majority departing about the middle of the month. Main direction of flight, north-westward.

Iowa. Locusts hatched in a few localities near the south-west boundary of the State. From the 10th of June to the middle of July western counties suffered from swarms passing from south to north.

Minnesota. Hatched pretty generally throughout western part of State. Some appeared as early as April and were killed by cold and wet. The majority left early in July, and appear to have gone south-westward.

Dakota. Known to have hatched near the southern boundary of Manitoba. These insects, and those from further north, went southward early in August. During June, and in August, foreign swarms passed over the State going north-westward.

Montana. Some probably hatched here, and swarms from the east and south-east appeared during July.

During the summer of 1875, the conditions described in the Notes for 1874 as occurring in the region west of the 103rd meridian, were reproduced in Manitoba, and over a great area of the Western and South-western States, with results even more disastrous to the crops than those of the winged invasion of the previous year. We do not hear of any access of fresh swarms to Manitoba from the west or north-west, nor is it probable that any such occurred, notwithstanding the fact that in various parts of the province flights are reported to have passed over from north-west to south-east. From the dates and descriptions given, it seems certain, that these were only those from the more remote parts of the province itself, and in many cases the broods hatched in any locality mingled with those coming from a little distance, and departed at the same time.

The most remarkable and exceptional feature in connection with the appearance of the locusts in 1875, is the extensive invasion of the wooded region east of Manitoba by the swarms produced in the Province. This is the more noticeable when contrasted with the immunity enjoyed by Prince Albert on the Saskatchewan, alluded to in last year's Notes, which is owing to its separation from the general area of the plains by a belt of timber. On writing to Mr. Clarke of Carleton House on the subject, he informs me that this protecting belt of "fir timber"

is only four miles in width, and extends completely across between the north and south branches of the Saskatchewan. Judging from the above remarkable fact, and the known habits of the locust, I do not think that the incursion made into the forest country can be looked upon as anything but exceptional, and perhaps showing that the locusts had lost their reckoning. Nor do I believe that it should discourage the cultivation of belts of woodland, which promises to effect in time a general and permanent amelioration of the grasshopper plague.

Broadly sketched, the movements of the locust in 1875 conform to a general plan. All those hatching in Minnesota, Manitoba, northern Dakota, and in the high western region of the plains at least as far south as Colorado, on obtaining their wings went southward, and this in some instances regardless of the direction from which their parents had arrived in the previous year. Swarms produced in Nebraska, Missouri, Kansas, Texas, and Indian Territory, flew northward and north-westward, returning on the course of their parents, which had flown south-eastward from that quarter. This movement can be traced over an immense area, from the northern borders of Texas almost to the Saskatchewan River.

Evidence appears to be fast accumulating to show that the general and normal direction of flight for any brood, is to return toward the hatching grounds from which their parents came, and it would thus seem, that to complete the migration-cycle of the locust, two years are required. The tendency which the swarms show to migrate on reaching maturity cannot be wondered at, as it is so commonly met with in other animals, and may be assisted by the mere lack of food in the district which has for a long time supported the young locusts. The fact however—let us call it instinct or knowledge—that the young, while amenable to the migratory tendency, show a determination to exercise it in a direction exactly the opposite of the preceding generation, is most remarkable.

No panacea against the grasshopper appears yet to have been found, nor does it seem likely that any such will be discovered. The means of making war upon the young insects and winged swarms, with a degree of efficiency dependent largely on the determination of the people, and density of settlement in the afflicted districts, are now well known. Though it is to be hoped that Manitoba and the settled portions of the North-west may

long escape further trouble from these depredators, it is none the less a duty to prepare for a possible repetition of the scenes which have already been witnessed there. In various portions of the United States, the destruction of the young insects has been greatly encouraged by the payment of bounties for that purpose from the public treasuries, but with a plague so wide-spread as that of the locust, the means most likely to lead to permanent amelioration are those capable of general application. The movement in the Western States toward the appointment of a commission by the central government to investigate all the facts connected with the locust trouble, and suggest means for its relief, is in the right direction; and if such a commission is appointed, it would appear to be of the greatest importance that Canada should take similar action, and at the same time, for its western territory.

By such general measures as the cultivation and preservation of forest trees, the protection of the prairie grass till the appropriate time for destroying the young insects in their hatching grounds by fire, and the encouragement of all birds feeding on the young or fledged, insect, much may be done. The prairie chicken, and the various species of blackbirds, get the credit of devouring great numbers of the young grasshoppers, and if these were protected by more stringent laws, and even a small increase in safety to the crops resulted, the loss of the one as a game bird and the damage frequently done by the other in the cornfields, would be more than counterbalanced.

The point of prime importance however in the first instance, is to obtain a complete knowledge of the haunts and habits of the insect under discussion, and as a small contribution towards this end these notes are submitted.

Mr. G. M. Dodge of Glencoe County, Nebraska, has published a theory relative to the cause or motive of the migrations of the locust, in the *Canadian Entomologist* for 1875. Mr. Dodge has kindly favoured me with an explanation of this theory. He writes: "I find the insects to be double brooded, flying north in spring to rear a second brood in a region not already devastated. The resulting brood flies south late in autumn, and deposit eggs that lie over winter. This regular movement is complicated by the fact that if the insects of brood first, hatching as far north as this place, should fly north, their progeny might be destroyed by frost; consequently I find that all hatching here or further

north (of brood first) fly south to rear the brood second. I believe with yourself that their natural habitation is the plains east of the mountains, and think that their occasional invasion of the States is due to the prevailing winds." After giving several instances from Nebraska bearing on his theory, Mr. Dodge, referring to my Notes on the Locust Invasion of 1874, says: "In your items from various localities, I find a point that bears directly upon the double brooded character of the insect, but which may have escaped your notice. In the notes from Fort Ellice, Headingly, Rockwood, Scratching River, Winnipeg, Stone Fort, and St. Anne's, eggs are said to have hatched in autumn; and in *each case* grasshoppers are reported as coming from the *south* early in the season. These were of course of brood first; brood second coming always from a northerly direction would deposit eggs for the next spring's brood, and none of them would hatch in autumn."

I do not think Mr. Dodge's theory can be accepted in its entirety, though the locust may occasionally complete two generations in one season, when the circumstances would no doubt be as above supposed. Certain it is, however, that southern swarms seldom if ever reach the country north of the 49th parallel in time to allow a second brood to reach maturity, even if the eggs hatch in summer or autumn. The date of arrival of the first swarms in Manitoba in 1874 was considered exceptionally early, and yet it is believed that all their progeny hatching during the autumn were destroyed by frost.

The Hon. D. Gunn has favoured me with the following historical notes on the grasshopper, going back to the earliest settlement of the Red River country:

"The first appearance of the locusts in this land, of which we have any account, took place on the 18th of July, 1818, six years after the commencement of the colony. At that period of the season the wheat was well advanced towards maturity, and sufficiently strong to resist the voracious destroyers. But it fared otherwise with the barley. The locusts attacked the plants a few inches below the ear, and cut them off as neatly as if cut off by the hand of man with a pair of shears. However on this occasion nothing was lost; every ear that fell to the ground was carefully gathered up. The potatoes were injured to some extent, but all garden vegetables were devoured. Their eggs deposited, incited by instinct or pressed by hunger, they

departed. In the following spring the young locusts began to appear, and before the latter end of May, 1819, the whole country was literally covered with them, and the rising crops of every kind entirely devoured. These in due time left to invade some other region. The opinion of the settlers who were here at the time was that they flew to the north and were driven by a strong south wind into Lake Winnipeg and drowned in such great numbers that the waves heaped them up, in some parts of the western shore, to a depth of several feet. As soon as these had taken their flight, fresh swarms poured in from the south-west, but found nothing to devour but the stinted natural grasses of the plains, which their predecessors had eaten to the very roots. Notwithstanding the scantiness of their diet, they deposited their eggs in great numbers, which the warmth of the following spring ushered into life. At the usual time, the latter end of July and first week of August, they disappeared, and from 1820 to 1857 the country was free from the inroads of these formidable destroyers. In 1857 a considerable swarm of locusts visited the settlements on the lower Assiniboine in the latter end of July, but these did not extend in any considerable numbers towards lower Fort Garry. They deposited their eggs over what is now known as Headingly and White Horse Plain parishes, and in the spring of 1858 the young progeny destroyed the crops in the above-mentioned region, say a distance of twelve or fifteen miles. These after they attained their full growth, as usual left the country. In 1864 another invasion took place, great numbers of them fell on each side of the Assiniboine, and extended down to upper Fort Garry. On the 7th of July they flew in great numbers over the lower settlement. They were driven by a fresh breeze from the west, some of them appeared to be at a great height from the earth, the living mass extending downward to the height of a few feet from the surface. numbers of the lowermost falling continually to the ground. The foremost part of the cloud began to pass over this place at 10 a.m., and they continued flying for some time after 2 p.m., and during the time of their flight they had fallen in such numbers that from twelve to twenty were counted on a square foot of surface. After a short rest, those which had alighted on ploughed lands and on barren spots moved into corn-fields and began feeding on the leaves of the wheat plant, and according to their usual habit cut off the heads of the barley. Here I had an opportu-

nity of observing that, as a rule, they do not pass the night, under ordinary circumstances, on the ground, but climb upon pickets, fencing, and on every other object on which they can roost. On the tenth of July they were seen pairing and depositing their ova. In the first week of September they disappeared. In the beginning of May, 1865, the young ones began to appear. On the 9th of June, 1865, a swarm of locusts came from the south. They extended from the west side of Lake Manitoba to Fort Alexander on the east. They fell in great numbers in that lake and on its eastern shore, but were very sparsely scattered over the country to the east of the above body of water. However those which were hatched in the spring, and those that came in June did not seriously injure the growing crops, and the farmers reaped an abundant harvest. In 1867 the locusts made their appearance in very great numbers, but came about the beginning of August, and consequently did not do much injury to the wheat crops, but many of the farmers had hard work to save the barley and oats. These, according to their habit, deposited their eggs in great numbers, and departed to die in some other place, either to the east or south-east of this place. The river ice began to break up on the 24th of April, 1868, and on the 7th of May I took the following note: 'Grasshoppers moving about, color pale white, not much bigger than fleas.' On the 22nd of the same month their numbers had greatly increased, and some had become brown. They evidently continued coming out of the ground during the whole month of May, and a few perhaps during the first ten days of June. All the grain of every kind that was growing was eaten up by them before they took their departure, which was in the end of July and during the first week of August. After this none were seen until 1872, when on the 5th of August they appeared. By the 12th they had become very numerous, and on the 14th they were depositing their eggs. In the first week of September many of them had taken their departure, and all disappeared by the last of that month. Their offspring began to appear about the middle of May, and by the middle of June the whole country was literally covered with them, no grain had been sown, the potatoe vines had been consumed, and even the pasture on the plains suffered greatly from their ravages. However they left about the usual time. The next and last visitation we had from these living plagues was in July, 1874. On the 17th immense

swarms for some hours flew over the city of Winnipeg; at the same time thousands of them were coming to the ground. In a few days after they extended their excursion to Lake Winnipeg, but numbers of them left before they had deposited their eggs. Yet millions of eggs were deposited, but as the last spring, 1875, was very late, the ground kept cold during the most part of the month of May, the locusts were very late in being hatched; some made their appearance about the 10th of May, and others as late as the last week in that month. They were numerous in some places; however I am of opinion that if the people had made a combined effort to destroy them during the first and second weeks of their existence, could not have failed in destroying many of them, and would by so doing, had they sown or planted, have raised both wheat and potatoes. Most people however became discouraged, and could not be persuaded to make the least effort to rid the land of the plague."

I have to thank the various gentlemen who have kindly replied in answer to my circular asking information, and beg to suggest that in all cases of the appearance of the locust, careful notes be kept as to dates, directions of flight, &c.

In the subjoined digest of the more important items received from the various localities, the places are arranged in order from west to east.

Fort McLeod, North-west Territory. (R. B. Merritt, M.D.) No young insects observed. Foreign swarms arrived July 19th from the south-west, and continued passing, or on the ground—though most of them went on—till about August 25th; went north-westward. Eggs were deposited and some known to have hatched in the autumn. No cultivation here, but 25 per cent. of prairie grass eaten. Mr. Merritt adds: "In April, 1876, many young black hoppers seen around Fort McLeod. On my trip from Bow River, I saw a tract of country 70 miles wide covered with young grasshoppers. They appeared to be eating the grass, and only moving when disturbed."

Morleyville, Bow River, N. W. T. (J. Macdougall.) Produced here from the egg, hatching May 20th. Left in August going southward. A great swarm arrived on the wing from the northward about August 10th, the main body passed overhead

in about six hours going southward, while some remained several days on the ground. Some eggs deposited. Crops, represented by a small patch of potatoes, were not hurt.

Bow River, N. W. T. (J. Brown.) Produced here from the egg, hatching about the first of May; flew south-eastward from Oct. 1st to 15th. Winged swarms arrived late in July or about first of August, from the north and north-west, passing on for the most part, but depositing some eggs. The small quantity of crops put in were lost. Wild grasses in many places much injured, though bunch-grass of mountains untouched. Eggs hatched spring of 1876, and insects on July 25th almost ready to fly.

Plains between Fort McLeod and Edmonton, N.W.T. (Rev. Constantine Scollen.) Produced in large numbers from the egg, hatching about June 1st. Left toward the latter part of August, going north and north-east. Great swarms appeared on the wing from the south and south-west August 1st, some alighting and others continuing their flight. Continued arriving till August 15th, and departing north and north-east, those produced in the country accompanying them. Eggs deposited during latter part of August, none known to have hatched in autumn. Ma. Scollen adds: "I may remark that the grasshopper during the last four years it has visited this country, has always come from and gone on in the same direction. They have always stopped about 60 miles south of Edmonton, perhaps owing to the densely wooded country in that vicinity." No cultivation in this region.

Edmonton, N. W. T. (R. Hardisty.) The locust did not appear here. Mr. Hardisty writing from an experience of twenty years, states that he has never known the insect to appear at Edmonton, though he has often seen them in large numbers about fifty miles south of that place. Edmonton is about forty miles from the northern edge of the plains, and separated from them by country *well wooded* with small poplar and pine, and having many small lakes, and swamps with strong heavy grass.

Country between Battle and Red Deer Rivers, N.W.T. (W. McKay.) Grasshoppers did not appear in this region during the summer of 1875.

Bozeman, Montana. (J. Wright.) Not produced from the egg. Arrived on the wing, appearing first on the 8th of July, but continued passing overhead in large swarms from the east for some time.

Victoria, Saskatchewan, N.W.T. (Chas. Adams.) Did not appear here.

Carleton House, N.W.T. (L. Clarke.) Did not appear in this vicinity. Mr. Clarke writes: "From traders I have learned that grasshoppers appeared in great numbers about 130 miles to the south-west of Carleton. Again, they were seen to the south-east of Touchwood Hills as far east as Fort Pelly, destroying the crops at that station.

Touchwood Hills Post, N. W. T. (R. W. Ells, Geological Survey of Canada.) Not produced from the egg here, but arrived on the wing, flying north-west. Very numerous July 30. Mr. Ells did not see any grasshoppers west of the Touchwood Hills.

Fort Qu'Appelle, N.W.T. (W. J. McLean.) Not produced here from the egg. Full grown insects appeared in myriads, June 17th, coming from the south.

Fort Pelly, N. W. T. (A. McBeath.) Not hatched here. Swarms arrived on the wing, July 20th, from the south, and passed on northward. All crops destroyed. Eggs deposited, and none hatched in autumn. Mr. McBeath writes,—After the grasshoppers made their appearance here on the 20th of July, their progress was very slow. The Mounted Police barracks are some ten miles north of this place, yet they took two weeks to reach there. For a time it appeared that this place was the end of their journey, and they diminished very slowly. Many were killed by the frost. As far as I could learn they did not go further north than about 30 miles from here. Shortly after their arrival they began depositing their eggs, and dying, till the ground was covered with their dead bodies.

Swan River Barracks, Pelly, N.W.T. (lat. 51° 53′, long. 101° 59′. J. H. Kittson, M.D.) Not produced here, arrived on the wing July 27, from the south. Continued passing till Aug. 20, going in a direction north-west by north. Some remained, and eggs in considerable quantity deposited. Late in autumn insects remaining after depositing eggs were destroyed by small red parasites.

Fort Ellice, N.W.T. (A. McDonald and R. W. Ells.) Produced here from the egg, hatching about May 6th. By June 7th all growing crops destroyed. Left in the beginning of

August, going south-east. On June 13th swarms arrived on the wing from the south or south-east, and at once began to deposit eggs. The first that arrived did not remain long on the ground. A second swarm arrived on the 10th of July, and about two days afterwards a third lot appeared. These also deposited eggs, the last remaining till the beginning of September. All crops destroyed—oats and barley. No eggs hatched in autumn. Mr. Ells writes that eggs were deposited at Fort Ellice as early as the 20th of June.

Swan Lake House, N.W.T. (D. McDonald.) A few locusts observed to arrive on the wing about July 10th, coming from south by south-west. These appear to have deposited some eggs which hatching in September produced young insects which were either frozen, or took flight August first, in a direction between south and east. No crops destroyed, the locusts having arrived late and in small numbers.

Manitoba House, N. W. T. (J. Cowie, J. P.) Produced here from the egg, hatching about June 9th. Left about the end of July, going north. Swarms also arrived on the wing, some remaining on the ground, and some passing over. From the middle of June till the end of July they came with every south-east wind, the latest remaining altogether, the earlier swarms going north. Mr. Cowie writes: "The young before taking wing marched through the settlement from S. to N., and destroyed all the crops except potatoes. Some returned on foot going south, and some remained until able to fly."

Fort Totten, Dakota. (Dr. J. B. Ferguson.) No locusts hatched here. Foreign swarms appeared July 19, coming from the north, and departing finally about July 22 or 23; going southward. Little damage done to crops. No eggs deposited. Dr. Ferguson writes:—The 19th of July is the date when locusts first appeared here in large numbers and alighted on the ground. Swarms were seen passing over before this date, but no note made of the exact day. Those that came on the 19th remained 3 or 4 days, and then left. It rarely happens that a swarm passes without some coming down, while others already here appear to rise and join them in the air. In this way even after the great body of locusts has passed, considerable numbers remain behind, and do not entirely disappear for from 10 to 12 days, and sometimes even longer.

Woodside, Man. (Thos. Collins) Produced here from the egg, hatching from about the 20th of May till the end of June. Most took their departure about the middle of July, but a considerable number remained till the first week in August. Went south-eastward. A winged swarm arrived from west-north-west about the third week in July; remained a short time and departed south-eastward. Whole grain crop destroyed, estimated at 6,700 bushels for Woodside, Pine Creek, and Squirrel Creek. A few potatoes escaped. Very few eggs deposited.

Westbourne, Man. (P. Garriock.) Produced here from the egg, hatching from the 10th to the 15th of May. Began their departure about 1st of July, and continued leaving till some time in August, going south-east. Great swarms were observed at two or three different times, many alighting, while the rest passed on. These arrived about the first of July, coming as a rule from the north-west and going south-east. Disappeared during latter part of July and first of August. Grain crop would probably have amounted to 4000 or 5000 bushels. but all destroyed except about 50 bushels. Few eggs deposited. Mr. Garriock writes:—Some time in the beginning of June, if I remember rightly, great swarms of grasshoppers, quite different in colour and size from all that had ever visited this country, came from due south, and passed on to the north-west. Great numbers alighted, but after remaining but a few hours, they rose again, and followed the main body. They appeared to us to be a very peculiar species of the detestable grasshopper, in size at least one-third larger than the pest with which we have become too well acquainted, and of leaden colour.

Burnside, Man. (K. McKenzie.) Produced here from the egg, hatching from the 10th to the 24th of May on warm sandy ridges, from that date till the middle of June in heavier cold soils. Left from July 8th to about first week in August, disappearing gradually, but generally going east or north-east. Winged swarms arrived in July, and for the most part passed overhead. Came from west or south-west, and left generally eastward. A few arrived on the wing during the first week in June. In Palestine district whole crop destroyed. In Portage, High Bluff, and Poplar Point districts, about 40,000 bushels of grain harvested, probably about one-tenth of the crop. Potatoes gave about one-fourth crop. No eggs deposited here. Mr.

McKenzie says it is reported that eggs were deposited west of Manitoba Lake, about one hundred miles north-west of Burnside.

Portage la Prairie, Man. (C. Mair, J. Cowan, M.P.P.) Produced here from the egg, hatching from the middle of May to middle of June. Began to leave about middle of July, going south-east. Winged swarms passed overhead from the latter part of July till the middle of August, coming generally from the south-west and going south-east: few alighted. Two-thirds to four-fifths of crop destroyed. In Portage la Prairie, Electoral Division, about 12 miles square, the grain crop should have been 200,000 bushels; 40,000 bushels actually harvested. In High Bluff Electoral Division, loss greater in proportion, only 10,000 bushels of grain saved and a half crop of potatoes. Mr. Cowan writes that some winged swarms appeared from the south early in June, long before those hatched here could fly.

High Bluff, Man. (J. A. K. Drummond) Produced here from the egg, hatching May 15th to June 15th. Left about the middle of July, going for the most part south-east. A winged swarm arrived from the west July 19th, and swarms continued arriving from this direction, and departing, generally south-eastward till the latter part of August. Greater part of crops destroyed. No eggs deposited.

Gladstone, Man. (C. P. Brown.) Produced here from the egg, hatching June and July. Left about the last of August, going south-eastward. About July 17th a few winged swarms arrived from the west, leaving in same direction as those produced here. Crop, amounting to from 20,000 to 30,000 bushels destroyed. No eggs deposited.

Poplar Point, Man. (L. W. McLean.) Produced from the egg, hatching from the 20th of May till the 10th of June. Took flight about the 2nd of July, and continued flying till the 10th of August or thereabout; went south-east. Some swarms seen on the wing at dates above given were supposed to have hatched in the western and north-western parts of the province, or beyond the province line. These appear to have mingled with those produced in the locality itself, in their flight. Only crops planted, potatoes, which generally gave pretty good returns. No eggs deposited.

Oak Point, Manitoba Lake, Man. (J. Clarke.) Produced here from tho egg, hatching about June first. Left about the end of July, going south-west. No winged swarms observed to arrive. No grain sown. Potatoes and hay meadows considerably damaged. No eggs known to have been deposited.

Pigeon Lake, Man. (J. M. Haure.) Produced here from the egg, hatching from 15th of May till 15th of July. Commenced flying July 10th, and continued leaving till the middle of August, going south and south-east. Foreign swarms seen at various time—first on July 1st—passing overhead. These came from south and south-west, and went north-westward as a rule. No grain raised in Parish of François Xavier. No eggs known to have been deposited.

St. François Xavier West, Man. (F. Dauphenais.) Produced here from the egg, hatching early in May. Began to leave about the 10th of July, going south. Locusts arrived on the wing from the south-west about the 25th of July. Said to have kept coming and going, occasionally alighting. Left early in August, going south. Three-fourths of crop in the parish destroyed. No eggs deposited.

Headingly, Man. (J. Taylor.) Produced here from the egg, hatching obout the end of May. Left from the middle to the end of August, going southward. Winged swarms arrived from various directions, but more especially from the south. Myriads lit about the 20th of July. Eventually flew southward with those hatched here. Three-quarters of crop, or probably about 10,000 bushels destroyed. No eggs deposited.

St. Charles, Man. (A. Murray, M.P.P.) Produced here from the egg, hatching from about the 10th of May to July 1st in successive swarms. On arriving at maturity went south-east, ward. About July 10th winged swarms arrived from the west and left in the same direction as those produced here, the latter in many cases rising and mingling with them. Entire grain crop destroyed, and only a few inferior potatoes harvested. No eggs deposited.

Rockwood, Man. (J. Robinson.) Produced here from the egg, hatching about the middle of June. Left about the last of August, going south-east. Swarms passed overhead about July first, coming from the south. All crops destroyed.

West Lynne, Man. (H. G. Lewis.) Produced here from the egg, hatching about the 20th of May, and leaving southward toward the end of July. Swarms are said to have arrived from the south, and to have left again going southward, about the date last given. Two-thirds of crop destroyed. No eggs deposited.

Selkirk, Man. (A. A. Ross.) Produced here from the egg, hatching from the 10th of May, till the 10th of July. Left in latter part of July, going south-eastward. A few swarms arrived on the wing and alighted on the 29th of July. These left with those produced in the district. Scarcely any grain sown. Potatoes put in late, were harvested without much damage. No egg deposited.

Winnipeg, Man. (Wm. Hespeler, F. Cornish, C. Inkster.) Produced here from the egg, hatching during latter part of May and first of June. Began to leave in second week in July, going as a rule south and south-east. Winged swarms from the north-west observed about the middle of July; generally passing overhead without alighting. Flew in same direction with those hatched here. Little crop put in, and more than three-fourths of that destroyed. No eggs deposited.

St. Boniface, Man. (Hon. M. A. Girard) Produced here from the egg, beginning to appear in May. Left during August, going eastward. From the 15th of July to the 15th of August other swarms arrived from the south and west, and for the most part passed overhead going north and east. Few eggs deposited. Twenty-four twenty-fifths of crop destroyed.

St. Norbert, Man. (J. Lemay.) Produced here from the egg, hatching about the middle of May. Began leaving about the 22nd July, going west. Nine-tenths of crop, amounting to about 25,000 bushels, destroyed. No eggs deposited.

Parish of St. Vital, Man. (S. Hamilton.) Produced here from the egg, beginning to hatch out early in May. Left about the end of August, going south-south-east. Some swarms arrived on the wing about the 15th and 20th of June from the north-westward, and left at about the same time, and in the same direction, as those produced here. All crops, save a few fields of peas, destroyed. Eggs deposited during the summer but young insects hatched and destroyed by frost.

St. Vital, Man. (A. Gaudry) Locusts hatched here about about the first of June, and on obtaining their wings left, going north-east. Foreign swarms not mentioned.

Middle Church, Man. (J. Clouston.) Produced here from the egg, hatching from about May 15th till June 15th. Left in August, going south; all gone before August 15th. No foreign swarms mentioned. All crops sown were lost. No eggs deposited.

Little Britain, Man. (Hon. D. Gunn) Produced here from the egg, hatching from about May 7th till the middle of June, and a few even later. Some began to fly off about July 20th, others between that date and the 20th of August, and a few seen as late as the 8th or 10th of September. At first a few flew to the north, but returned, and all at length flew to the east and south-east. Very little grain sown, and all destroyed. No eggs deposited. Mr. Gunn writes that some eggs were deposited in the vicinity of Lake Winnipeg in the autumn of 1875.

Lower Fort Garry, Man. (Wm. Flett) Produced here from the egg, hatching during the greater part of the month of May. Most left during the latter part of July, though some still to be found till about middle of August; generally went south-east. No foreign swarms. No eggs deposited.

Springfield, Man. (F. Dick) Produced here from the egg, hatching May 15th to June 1st. Left during latter part of July and August, going south-east. About July 15th swarms appeared from west and north-west, and continued to pass over, alighting sometimes for the night, till about August 6th. In Electoral District of Springfield only about 700 acres sown. Crop saved on 25 acres only and even this much damaged.

Eagles Nest, Man. (J. Monkman.) Produced here from the egg, hatching from May 20th to July 15th. Left July 15th, going east-south-east. Winged swarms observed to pass overhead, some alighting. First noticed July 1st, and continued until August. Came from west-north-west, and went east-south-east. No eggs deposited.

Cook's Creek, Man. (G. Miller.) Produced here from the egg, hatching about the first of May. Departed about the first of August, going south-east. Swarms also passed overhead about August first, coming from the north-west, and going in the direction aforesaid. Total destruction of crops.

Crookston, Minn. (E. M. Walsh.) A few locusts produced here from the egg, hatching from May 15th to June 10th. Left July 15th, going south and south-east. These did little damage. Swarms appeared on the wing from the north, and passed south-eastward, about July 20th. Crops not injured. No eggs deposited.

North-West Angle, Lake of the Woods. (M. M. Thompson.) No locusts hatched here. Swarms arrived on the wing about August first from the north-west, and left again about the 20th of August, going south-east. Only crops put in potatoes, which were nearly all destroyed. No eggs or young insects observed in the autumn.

Mr. Thompson writes that these notes will apply equally to *Broken Head, White Mouth,* and *Birch River.* These are stations in the wooded district east of the Red River Prairie, and on the road between Winnipeg and Lake of the Woods.

NOTES ON SOME GEOLOGICAL FEATURES OF THE NORTH EASTERN COAST OF LABRADOR.

By Henry Youle Hind, M.A.

1. Area described.—2. Rock Cleavage.—3. Pan Ice,—4. Extent of Pan Ice Work. 5. Glacial Strim and Glacial Clays.—6. Icebergs.—7. Formation of Boulder Clays.—8. The Marine Climate of the Labrador Coast.—9. The Crystalline Limestones of the Laurentian Series.

1. Area Described.

The part of the North-eastern Coast of Labrador to which reference is made in these notes, extends from Sandwich Bay (Lat. 53° 45′ N.) to Ukkasiksalik or Freestone Point (Lat. 55° 55′ N.), a distance measured coastwise of about 230 miles. Freestone Point is 350 miles north-west of Belle Isle, and it takes its misleading name from the existence there of considerable pockets of the 'Ukkasik' or Potstone of the Esquimo.*

I am indebted to Francis Ellershausen, Esq., one of the proprietors of the already celebrated Betts Cove Copper Mine in Newfoundland, for the opportunities enjoyed last summer of visiting this little known part of British America, and of making the observations which form the subject of these brief notes.

The main body of Hamilton Inlet, and its South-westerly extension Lake Melville, penetrating 130 geographical miles into the interior, and receiving the waters of numerous large rivers, is well known in its general geographical features, but nothing has been published of its two great arms "The Double Mere" and "the Backway." The Double Mere is reported to be fifty miles deep, and the Backway is stated to extend near to Tub Harbour on the main coast. I conld not see the extremities of either of these deep arms from the deck of a schooner on a clear day when passing their entrances. The numerous and profound Fiords which indent the coast line beyond Cape Aillik (lat. 55° 11′, long. 59° 11′) are altogether undescribed. The Admiralty

* Ukkasik, the kettle; ukkasiksak, the stuff for the kettle; ukkasiksa-lik, supplied with that stuff for the kettle;—the k at the end of 'sak' being dropped for euphony.—The Rev. Brother Elsner, Missionary at Hopedale.

chart published on the 10th July, 1876, from partial surveys by Staff Commander Maxwell, R. N., is a great step in advance in the correct delineation of the north-eastern coast of Labrador, but merely the entrances to the most important Fiords are shown, with a note indicating there supposed depth inland.

Islands begin to be numerous a few miles to the east of Sandwich Bay. They form a belt or zone protecting the mainland all the way to Cape Chudleigh, at the entrance of Hudson Straits, about seven hundred nautical miles from Belle Isle. By means of the constant action of "Pan Ice" hereafter described, all exposed portions of these Islands have been polished with such uniformity that a perfect picture of their structure is exposed to view.

The farther to the north we advance, the more remarkable are the planed surfaces. The minutest detail of stratification, of undulation, dislocation, fold or vein is as clearly visible over many hundred acres on low islands, as if the wide expanse had been laboriously and carefully polished by artificial means.

The low lying surfaces are still annually submitted to a renewal of the polishing process by the never failing pan ice, and it is thus that in some favourable localities square miles of rock show the "grain" as clearly as a well kept mahogany table exhibits the grain of the wood.

Before alluding to the general structure of the area visited last summer, which by the way, is characterized by extraordinary regularity and symmetry, I shall briefly notice the means by which so much of the detail and arrangement of the strata is exposed to view. The abrading and polishing agent is, as already stated, pan ice, but this is assisted in a very marked degree by rock cleavage.

2.—Rock Cleavage.

The cleavage of the old Laurentian Rocks here is generally at right angles to the bedding, or nearly so, and whenever the strata incline towards the prevailing direction of the ice drift or thrust on the exposed coast, the wearing away is rapidly accomplished by the removal every year of large blocks, the resulting surface being left in a series of steps or terraces.

Some illustrations of these steps are seen near Hopedale, and especially in Tooktoosner Bay south of Hopedale. The steps are now polished and the edges neatly rounded; they may rise

120 feet above the present sea margin, each step being about four or more feet in altitude, such being the average thickness of the beds of gneiss. In Lake Melville, Hamilton Inlet, the process of breaking down the rock into steps, assisted by cleavage, is well seen on St. Patricks or Haines' Island, opposite to the mouth of English River. Here and at various other parts where a similar terrace or step disposition on the slope of the hills occurred, I was reminded of the "Gneiss Terraces" at the Level Portage, on Cold Water River, an affluent on the Moisie, which I described in 1862.*

The Gneiss Terraces there are about 800 feet above the sea level, and their aspect is similar to the steps in Tooktoosner Bay, leading to but one conclusion, that surface outline, where ice influence has prevailed, is largely due to the action of coast ice upon strata in which cleavage planes and joints readily assist denudation in the manner described.

The process of detaching and carrying away the blocks separated by cleavage planes and joints may go on until the strata exposed to this action are removed, or a change in the direction of the impinging masses of ice takes place, or until beds are reached in which cleavage planes and joints no longer facilitate the operation, when the rasping down, and finally, the polishing process begins, and a *roche moutonnée* results. These operations occur in the spring only, when the coast fringe of ice, which extends far out to sea, is broken up, and "pans" of ice are formed by the disruption.

3.—Pan Ice.

"Pan" ice is derived from Bay ice, floes and coast ice, varying from five to ten or twelve feet in thickness, all of which are broken up during spring storms. When the disruption of the ice sheet which seals the Fiords, the Island zone and the sea itself for many miles outside, continuously, is effected in June, the resulting "pans" as the fishermen term them, vary in size from a few square yards to many acres in extent. The uniform and unbroken mass of ice in the winter months, has no lateral motion, it rises and falls with the tide, but is unaffected by winds until the warmth of spring softens its hold on the

* Vide, Explorations in the Interior of the Labrador Peninsula—Longmans, London, 1863.

Islands to which it is keyed. When the pans are pressed on the coast by winds, they accommodate themselves to all the sinuosities of the shore line, and being pushed by the unfailing arctic current, which brings down a constant supply of floe ice, the pans rise over all the low lying parts of the Islands grinding and polishing exposed shores, and rasping those that are steep-to. The pans are shoved over the flat surfaces of the Islands and remove with irresistible force every obstacle which opposes their thrust, for the attacks are constantly renewed by the ceaseless ice stream from the north-west, and this goes on uninterruptedly for a month or more. Sometimes a change in the wind brings the endless sheet back again, and it is the middle of July before some of the Fiords are clear of ice. Hence boulders, shingle and beaches are rarely seen except in sheltered nooks and coves, and the masses *pushed* or torn from those surfaces where cleavage offers a chance of disruption, are urged into the sea and rounded into boulder form by the rasping and polishing pans.

Here too goes on the process, subsequently referred to, of manufacturing Boulder Clay, for the deep hollows and ravines at present under the sea—the records of former glacial work—are being filled with clay, sand, unworn and worn rock fragments, producing a counterpart of some varieties of Boulder Clay.

But this is not all of the work of pan ice. The bottom of the sea, to the depth of 12 or 15 feet, and at all less depths, is smoothed and planed by the drifting masses when they pile one on the other, and at depths less than eight feet when the pans are driven before the wind or carried by the currents. In sailing from Aillik to Nain or to Cape Mugford, the fishermen send a man aloft to look out for "White Rocks." These are prominences or swells in the general level of the sea bottom among the Islands, from which every particle of sea weed has been removed by pan ice.

The "White Rocks" are clearly visible in smooth water, and in rough weather "they break." Hence it is that pan ice is exerting an abrading action over a vast coastal and submarine area throughout the shallow seas which fringe the Labrador. It is pushing too the blocks of strata removed from the coast, backwards and forwards on the sea bottom, sometimes landing and leaving them on islands, and again in the following season push-

ing them into the sea, but each year causing them to assume more and more the boulder form. While clearing the ridges and planes on the sea floor it is piling or rather pushing the worn blocks into depressions and accumulating the debris in the shallow ocean valleys. In a word, it is doing before our eyes over a coast line many hundred miles in length, what has been done in earlier times over a vast area of the North American Continent, according as fresh surfaces by a rise or subsidence of the land were brought under the powerful and searching influence of pan ice aided by an Arctic current.

The influence of the Arctic Current shows itself throughout the Island zone, in a remarkable manner, giving rise with each change of the tide to ever varying eddies. Its speed through the Islands is greater than beyond their limits, where the fishermen estimate it at a knot to a knot and half an hour. Sailing among the Islands the fishermen going north-west generally count sixty miles sailing distance as equivalent to moving eighty miles through the water, on account of the current, which resembles that of a great river.

4.—Extent of Pan Ice Work.

The amount of work done by pan ice during the gradual rise of the land, is well shown by the polished surfaces and sides of hills many hundred feet above the sea level. I had no opportunity of testing by actual touch its abrading effects to a greater altitude than six hundred feet above the ocean, but I saw after rain the smooth glistening surfaces in great profusion over the steep sides of mountains at a much greater elevation. Erratics, and local rounded fragments of rock are not numerous until a height exceeding one thousand feet is attained, and even then, except perhaps in hollows, which I had no opportunity of examining, boulders and perched rocks are very much less numerous that at greater elevations in the far interior, where I saw them in countless multitudes in 1861. Below the level of perhaps twelve hundred feet they have been made and removed by pan and coast ice, and the country in this respect presents a counter part to the Upper Moisie Valley, where the "remarkable absence of erratics on the Moisie until an altitude of about 1000 feet is attained, may be explained by the supposition that they may have been carried away by icebergs and *coast ice*

during a period of submergence to the extent of about 1000 feet."*

The manner in which Ice blocks and pan ice acts as a powerful transporting and denuding agent in tidal estuaries and deep Bays is described with some detail in a paper on the "Ice Phenomena of the Bay of Fundy. †

Since my return from the Labrador I have had an opportunity of reading the excellent articles on "Ice and Ice Work in Newfoundland," by Mr. John Milne, F. G. S., published in the July, August, and September number of the Geological Magazine for 1876. At the time when the July number of this Magazine was passing through the press, I had an opportunity of seeing some hundreds of square miles of Floe Ice driven on the Coast of Notre Dame Bay, Newfoundland, by a north-easterly wind. Had this occurred in February or March when the temperature falls during the night many degrees below the freezing point, the "glueing" of large quantities of coast debris to the ice fringe, and its subsequent conveyance out to sea on a change of wind, in the manner so graphically described by Mr. Milne, would have occurred simultaneously over a coast line not less than fifty miles in length.

5.—Glacial Striæ and Glacial Clays.

Although the profound Fiords are doubtless the result of local glaciers, some of which are said still to exist beyond Hebron, yet a very careful search failed to reveal, except in one instance only, any glacial striæ, or indeed striæ of any description. In Tooktoosuer Bay close to Hopedale, I saw in a secluded and protected hollow, well marked, and deeply cut, grooves. They occupied a shallow cup-shaped basin, but all surrounding surfaces were smoothly polished, pan ice having removed every trace of groove or striæ. Glacial clays of considerable thickness are not uncommon in sheltered valleys opening into the Fiords. They were seen on English River, Lake Melville, also of precisely the same description in Tooktoosner Bay. Twenty feet in thickness of the clay was visible over the water of English River, but

* Vide—A Paper "On supposed Glacial Drift in the Labrador Peninsula, &c." by the author. Quarterly Journal of the Geological Society, London, 1864, page 124.

† "Ice Phenomena in the Bay of Fundy," by the author—published in the Canadian Monthly, September, 1875.

it was capped by an enormous deposit of stratified sandy drift, at least 70 feet in thickness. A portion of the pale bluish glacial clay was washed and found to contain numerous unworn and angular fragments of rock and a considerable quantity of black magnetic oxide of iron. The beds of stratified sandy drift were seen in many places, as for instance, at the narrows above Rigolette, at the mouth of English River, in Kebouka Bay or Fiord, &c. The highest terraces observed were fully 120 feet above the ocean. Remnants of gravelly beaches were found at levels below six hundred feet, occupying well sheltered nooks and coves. They were often seen beyond Aillik to exhibit a well defined terrace arrangement. One of the best examples of this succession of gravelly terraces was observed near Cape Aillik. On American Island, close to Cape Hurricane and 20 miles north of Hopedale, a beach was seen at an altitude of six hundred feet above the sea, and its aspect was so modern, that it looked as if the waves had left it but yesterday.

It is noteworthy that in this instance the situation was exposed, and it is difficult to imagine that this remnant of a beach could have been subjected to the action of pan ice without being not merely disarranged, but swept altogether away. Upon entering the deep Fiords, and proceeding beyond what may be termed the narrows, where pan ice has but little power, a lake shore aspect is at once visible. Sandy beaches, lines of boulders, remnants of terraces, and wooded slopes all tell of a period of repose, but scrape away the peat from rocky surfaces many feet above the present sea level and if the rock should be resisting gneiss, the polished surface reveals the universe action of pan ice. Showers of rain show glistening surfaces far up the steep sides of mountains where no moss or lichen has yet found a lodgment, though several feet in thickness of peat may occupy the terrace flats; and at the base of the slopes where a soil can accumulate there is a forest growth.

The aspect of portions of the terraces of stratified sand, gravel, shingle, and fine clay, now washed by salt water far up the deep Fiords, and sometimes resting on Glacial Blue Clay, suggest a different origin to that which gave rise to the unquestionably marine beds seen on the Southern Labrador Coast holding marine fossils. (Vide Packard.)*

* Canadian Geologist.

While we have evidence before our eyes of the subsidence of the entire country and its subsequent elevation, we can not reject the probable supposition that previous to the subsidence the whole country was far more upraised than it now is. A general upward movement of 1500 feet would cut off the Arctic Current, or reduce it to the dimensions of a river, both from Davis and Hudson Straits, these being the only existing channels between the Arctic and Atlantic on the American side.* This would produce a change in climate of a very marked character, and give rise probably to wide spreading areas of fresh water where now sea and land appear.

The Arctic or Labrador Current is the one great cause of the extreme climate of the Labrador Coast. It keeps the bays and Fiords on the whole North Eastern Coast closed by ice from December to June. It permits the formation of anchor or ground ice to an extraordinary extent at the commencement of winter. The sea bottom freezes in sixty and seventy feet of water, and fresh water flowing under the first ice formed, into the sea cooled by the Arctic Current, is instantly converted into spongy masses, and assists in choking the fiords. Seals taken in seal nets in November and early in December in 60 feet of water, are often found "frozen solid"; and fishermen several times put it to me as a problem passing solution, why frozen seals taken from a seal net sunk to the bottom in fifteen and even eighteen fathoms water, should thaw when kept for a few hours at the surface. The discoveries by Desprets have explained all this, but at the same time they have enlarged our views respecting the variety of ways in which ice can act as a geological agent when an arctic current is present to assist in its formation.

The differences between the condition of the Labrador and the Norwegian Fiords is remarkable; while the first named are closed by ice during at least six months of the year as a consequence of the Arctic Current flowing past them, the last named, according to Admiral Irminger, are kept open by a constant flow of warm water from the south-west, and the effect of this warm current is felt as far as Cape North. The cessation of the Labrador Arctic and Davis Strait Current by a general rise of the land between Greenland and Labrador would greatly

* Vide any good *recent* Map of the Arctic regions.

change oceanic circulation according to the views of Dr. Carpenter. That such a continental elevation has taken place during the last geological epoch there are strong reasons to believe, and I hope during the coming summer to obtain additional evidences from drift deposits, to support this view, as well as to establish the former existence here of wide spreading fresh-water lacustrine deposits.

6.—Ice-Bergs.

The climate of the Labrador Coast derives much of its low temperatures from sources extremely remote. The unceasing ice stream, in the form of ice-bergs, which sweeps past it, receives no inconsiderable portion of its material from the seas of Eastern Greenland, Iceland and even perhaps Spitzbergen, and if icebergs possessed the opportunities for transporting rock masses and other materials to the extent with which they have been credited, we might expect to see the shores of north-eastern Labrador strewed with blocks derived from East Greenland, as well as from West Greenland. But out of the thousands of ice-bergs I saw quite near at hand last summer, in one or two instances only did I detect any foreign material. The ice in *general* was stainless, though often well stratified on the exposed sides. Whatever might have been hidden in the holes and valleys on the upper portion of the bergs, was of course not visible from the deck of a passing vessel. I have attempted to show elsewhere* that infusorial life accompanies the ice-bergs to a remarkable extent, and that the great ice-stream from East Greenland seas, sweeping past Cape Farewell, thence northerly, north-westerly, westerly and southerly until it comes on the Labrador, is a vast distributing agent of fish ova and indirectly of fish food, but as to its geological work on the scale which has been assigned to it, there does not appear to be any evidence on the north eastern Labrador. It is no doubt adding a small amount of debris to the banks on which the bergs strand, and is deepening the water on the coasts which are steep-to, by the incessant rolling and grinding of the bergs with the swell of the sea.

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* 'Notes on the Northern Labrador Fishing Grounds'—Nov. 1876; also 'Notes on Anchor Ice,' Dec. 1876 and Jan. 1877.

Off the North-eastern Coast of Labrador, and generally on banks ten or fifteen miles from the outermost Islands, there is a loose fringe of stranded bergs for hundreds of miles. They are continually "foundering," that is breaking up during the summer. Sometimes they are grouped together, sometimes a mile a part, but still forming a continuous string as far as I saw them, for a hundred-and-fifty miles, north-west of Cape Harrison. Some years the fishermen say they are much more numerous than during other seasons, but I rarely counted fewer than thirty within view at the time from the deck of the Schooner, and often a much larger number. Outside of the stranded bergs the giant "Ice Islands" as they are locally termed, drift with the Arctic Current south-easterly. Very few bergs were seen among the Islands, or between the stranded bergs and the Islands. The shoals or banks "pick them up." In fact it is only small disrupted masses that one meets with; within the Islands Zone the water in general being too shallow to float a berg of considerable size.

7.—Formation of Boulder Clay.

During a period of subsidence the blocks of strata, boulders, mud, and sand, pushed to and fro on the shallow-sea-bottom by pan ice, ultimately accumulate in hollows and ravines below its action, and when the debris is pushed into profound submarine valleys such as exist on the Labrador Coast, (being probably due to former glacial action,) the mass will resemble Boulder Clays, and in a sinking marine area it will accumulate to a great thickness; in a rising area it would be liable to be remodelled by the action of the waves except in the case of very deep valleys. There are not many known narrow and profound submarine valleys on the north-eastern coast of Labrador, but those which are known offer precisely the conditions required for the accumulation of Boulder Clays or drift by the action of Pan Ice.

The seaward extension of Uksuktak Fiord, which lies a little to the south of Hopedale, affords an apt illustration. Commander Maxwell's soundings show a profound submarine ravine between clusters of Islands for upwards of eight miles, in which the depth reaches, 124, 126, 123, 106 and 130 fathoms. Between the Islands of Niatak and Paul, near Nain, the lead shows 71 fathoms. It is evident that the material torn from the sur-

rounding islands by Pan Ice and pushed along the bottom of the sea into these profound submarine valleys during a period of general submergence will be protected from the action of the waves, and the loose blocks and boulders will have a forced arrangement in the mud, as if they had been pushed over a bank, and thus produce the irregular disposition so frequently seen in boulder clay deposits. In such narrow and profound valleys as those instanced, the accumulation of Boulder Drift probably goes on at the present time, and may continue during a period of elevation, until large portions of the drift are raised above the sea level and beyond the influence of the waves, which will attack only its sea-front. But the agent which gives rise to this heterogeneous mass is Pan Ice, and the formation of Boulder Clay is very probably a part of its work over a vast area on the Labrador at the present day, throughout the labyrinth of Islands which fringe that coast to a depth of twenty miles seawards. If one examines the local deposits of Boulder Clay in various parts of Nova Scotia, with ice-worn gneissic rocks close at hand, or underlying the clays, the conclusion that pan ice has been instrumental in accumulating many of those deposits is irresistable. The pushing of blocks of strata by ice is graphically described by Dr. Dawson on page 65 of his Acadian Geology, 2nd Ed.

8.—The Marine Climate of the Labrador Coast.

It has been shown by Dr. Petermann and others that the difference between the coastal climate of Greenland and the Labrador is very great. The south-western Coast of Greenland is much milder than that of the Labrador in the same parallels.* A surface sheet of warm water, flowing from South to North, is determined on to the coast of Western Greenland by the rotation of the earth. A cold Arctic current ladened with ice from Davis and Hudson Straits flows from North to South and is determined on to the Labrador Coast by the rotation of the Earth. Hence the sea on the Labrador Coast is cooled sometimes in November and early in December to 29, and even 28 degrees, and the "Lolly" of the sealers, or Ice Speculæ, or Anchor Ice, forms rapidly during the first cold snap in November, along the entire

* Vide a paper entitled "Further Enquiries on Oceanic Circulation" by Dr. W. B. Carpenter, F.R.S., Proceedings of the Royal Geological Society, August, 1874.

coast line; and before Christmas, all the coastal waters within the zone of Islands are frozen in one solid sheet, so that no "Ice foot" is formed on the Labrador like the 'Ice foot" on the Greenland shores. In brief, it may be said that the stupendous work of Ice on the Labrador, apart from Glacial Sculpturing, appears to be almost altogether due to the periodical action of pan ice, deriving its power and constant opportunities, from the Arctic Current which presses continually on the Labrador Coast.

THE LAURENTIAN SERIES.

9.—Crystalline Limestones.

The occurrence of Upper Laurentian Rocks on the Labrador Coast has long been known, and their approximate limits are laid down on a map which was published some years since in Petermann's Mittheilungen, the data being chiefly derived from the observations of the Moravian Missionaries. The area occupied by the Upper Laurentian on this extensive coast is represented to be very considerable, and that it extends far back into the interior is probable from the fact that in 1861 I found Labradorite rocks on the Upper Moisie River, the locality being represented on Sir W. E. Logan's Geological Map published in 1864.*

During the last summer (1876) I met with a thin band of Crystalline Limestone about 35 feet in thickness in Hamilton Inlet, at the place called Mullen's Cove.

Mullen's Cove is situated eleven miles due East from Rigoulette, the Hudson Bay Company's Post, and its position is shown on the Admiralty Chart of Labrador by Commander Maxwell, R. N., published 10th July, 1876.

With a view to illustrate the regularity and variety of the strata in the vicinity of the Crystalline Limestones, the following section was roughly measured by my friend Mr. Colchester and myself in August last, across the strata.

The Series was well exposed on the Coast of Hamilton Inlet, and offered unusual facilities for examination in detail. It includes at the summit a band of limestone before noticed, also small bands of limestone from 4 feet to one inch in thickness in No. XI.

* Vide page XII. Geology of Canada, 1863.

Section in Hamilton Inlet.

Section No. I,—Ascending Order.

Dip S. 52 E. (True) angle 30°. Cleavage planes at right angles to dip. East side of Mullen's Cove.

Bed No.		*Thickness Feet.*
18	Grey weathering, finely banded, quartzose gneiss, with lenticular layers of micaceous schist. At the base the band becomes more micaceous until it passes into a compact dark grey mica schist, some of the layers garnetiferous	200
17	Finely banded gartnetiferous gneiss	50
16	Fine grained gneiss,—with coarse granitic Dyke cutting the strata at a low angle,—interstratified with garnetiferous, micaceous bands	37
15	Compact micaceous schist with small garnets	10
14	Finely banded gneiss, some layers garnetiferous	60
13	Garnetiferous gneiss	26
12	Very coarse quartzose gneiss with numerous patches and crystals of quartz	18
11	Banded gneiss in very thin layers with a bed of *calcareous conglomerate*, 13 inches thick; thin layers of crystalline limestone, from four feet to one inch in thickness, and thin layers of coarse gneiss, mica schist, and felspathic schist	120
10	Coarse banded gneiss	60
9	Coarse gneiss with bands of fine micaceous schist	6
8	Red Felspathic gneiss	6
7	Banded gneiss	25
6	Coarse quartzose gneiss	25
5	Dark colored micaceous gneiss	6
4	Band of garnetiferous gneiss	20
3	Fine banded micaceous gneiss	30
2	Coarse banded gneiss with granitic veins	18
1	Coarse gneiss	8
	Total thickness	727

Section No. II.

West side of Mullen's Cove, and between Mullen's Cove and Collingham Bight.

a.	Coarse felspathic gneiss, with small garnets distributed through the mass.....	
b.	*Crystalline Limestone*.....	35
c.	Coarse grey garnetiferous gneiss with large garnets distributed through the mass.....	
d.	Ferruginous gneiss containing Iron pyrites in thin bands.	

Both Series are regular, and garnets appear pretty generally distributed. In some of the beds crystals and grains of magnetite are visible. The Crystalline Limestone is white and saccharoidal in parts. It is seamed near its junction with the overlying gneiss, with thin lenticular bands of micaceous schist, and a thin band of felspathic gneiss. It contains near the gneiss crystals of magnetite and specks of carbonate of copper. Its colour is white to a pale yellowish tinge. Some bands are very pure and resemble coarse loaf sugar. When treated with hydrochloric acid the residue contains milk-white opaque grains and grains of light semi-transparent grass-green mineral, which in some parts appears to be disseminated through the mass.

Near the narrows of Kebouka Bay, 75 miles north-west of Mullen's Cove, two kinds of Crystalline limestone are found in the shingle, one white and compact, the other grey and coarse in structure, but the rock was not seen in place.

The structure of the strata as seen on the coast leads to the impression that the limestones are brought to the surface by undulations. The Moravian Missionary at Hopedale, showed me a slate of crystalline limestones which he had picked up near to that station.

NOTE ON SOME OF THE MORE RECENT CHANGES IN LEVEL OF THE COAST OF BRITISH COLUMBIA AND ADJACENT REGIONS.

By George M. Dawson, Assoc. R.S.M., F.G.S.

The elevation of the Cascade or Coast Range of British Columbia, and the parallel range of Vancouver Island, must have taken place to a great extent, though probably not entirely, in post cretaceous times. On the upturned and denuded edges of Cretaceous rocks, in the interior of British Columbia, rest nearly horizontal beds, which appear to be of Miocene age, and which pass upward into the great sheets of volcanic material, with which the whole interior plateau must at one time have been covered. The sedimentary Miocene beds seem to have been formed in fresh-water lakes, produced perhaps by interruption of the drainage by mountain elevation, which there is evidence to show, may have continued to some small extent even in post-miocene times. The country cannot have been so low at this period as to admit the sea to the interior plateau, but appears to have been depressed to a small extent, as marine tertiary beds, probably of this age, are found along the coast above the present sea-line. No Pliocene deposits have yet been recognised, and it was probably during this period, with the land standing at least 900 feet higher than at present, that the deep river valleys or canons now forming the remarkable system of fjords by which the coast is dissected, were cut out. These fjords are very generally in their sheltered upper reaches over 100 fathoms in depth, often over 150 fathoms, and probably in many cases over 200; though in most of them the actual depth has only been ascertained in a few places. When they open on the broader waterways, where the strong tides of the Pacific coast run with greater power, they are found to be silted up, and blocked with bars and banks; the water being generally shoalest where the water stretches are most extensive. This is especially noticeable on the west coast of Vancouver Island. The ice which can be shown to have filled these fjords during the glacial period, must have deepened them and altered their forms to some extent, but probably in a degree quite inconsiderable when compared with their pre-glacial excavation.

During the glacial period the country was submerged, but into the history of this epoch, and evidence of the very great extent of this submergence, I do not propose here to enter. In my Report on the Geology and Resources of the 49th Parallel, I have given the grounds which lead me to believe in a submergence at this time of at least 4,400 feet, on the eastern slopes of the Rocky Mountains. In the central portions of British Columbia, ice-bearing water must have stood at a level of 5,270 feet. I do not wish to insist that this must necessarily have been the sea, though that appears best to account for the facts.

Mr. George Gibbs states,* that the passages and inlets of Puget Sound, in the northern part of Washington Territory, are excavated in many places in drift deposits, which appear not only to form their present banks, but to underlie their beds. If this be correct, there is here pretty good evidence of a post-glacial elevation of the land to a height somewhat greater than the present; for the long river-like inlets, referred to, bear all the appearance of having been *formed* by river erosion and afterwards filled and widened only by the action of the sea and tidal currents.

No elevation or depression of the coast of the southern part of Vancouver Island is known to have taken place very recently, but the aspect of the shore is that of one gradually subsiding, and I had arrived at this conclusion from its examination before meeting with the statements of others, shortly to be mentioned. Near Victoria the low rocky substructure of the country, is partly enveloped in a somewhat irregular terrace, of which the average height may be about 40 feet. It is composed of clays, more or less arenaceous, holding boulders, and in some places also marine shells indicating pretty deep water. Cliffs of this clay are being rapidly wasted, along some parts of the shore, where the water may be seen during the higher winter tides actually removing this material from the polished and glaciated rock surfaces, wave by wave. The rocks about high water nearly all preserve very perfectly their glacial markings, which lower down are not so distinct; but in many places even where they receive the full force of the sea at every tide, they are much better preserved than would be the case if they had been for an indefinite number of years exposed to its action. In shallow bays, where the sloping pebbly beach is bordered land-

* Am. Journ. Geog. Soc. 1874, p. 308.

ward by a low perpendicular bank of the clays, I have seen the water during the high tides of winter actually above the stony beach, and beating against the clay, with which it was rendered turbid for some distance from the shore. In certain localities the old Indian shell heaps or kitchen-middens, which are abundant on this coast, are exposed in section by the sea in similar low banks, and the lower layers of some of these have been observed to be nearly a foot, in some places, below the high tide mark; showing I think that subsidence to a small extent has taken place since they were formed. The Indians would scarcely choose for camping a place liable to overflow, and if the shells were merely thrown there, they would have been scattered from time to time by the high tides, and would not have accumulated in heaps six to eight feet thick and very wide.

The land was probably at a somewhat lower level, when first inhabited by the Indians, for the upper layers of the pale clayey drift above referred to, merge in some places quite gradually into a darker coloured and more earthy material, from six inches to two feet, in thickness, which forms the soil of the cultivable tracts. This follows the slope of the surface and was probably deposited by the retreating waters, when for a time each level was an oozy sea margin, like that found at the heads of some of the present sheltered bays, in process of transition to land, and including in its mass much decomposed vegetable matter. In the very lowest layers of this darker material, I have noticed in one or two places, at heights of five to ten feet above the present beach line, burnt stones like those used by the Indians in cooking, and other signs of their presence.

There is no evidence to show that any movement greater in amount than a few feet, has taken place for a long time. The growth of very large trees near the present high water mark in the sheltered inlets, would seem to negative any great elevation. It would also seem probable that the movement of depression indicated in the extracts from Vancouver and Cooper, may have taken place rapidly, perhaps in connection with some of the small earthquake shocks by which this coast is visited from time to time. At the heads of all the inlets or fjords of the coast, a stretch of low, flat, and often marshy ground, shoaling very gradually seaward, and then in quarter or half a mile beyond the shore plunging steeply down into deep water, surrounds the mouths of the entering rivers. The position of these flats with

regard to the sea level is very much what we might expect from the action of the rivers and tides still in progress, though in some places they are probably a little higher than the present circumstances will explain. Had the coast permanently changed its elevation by as much as fifty feet in either direction, during many centuries, the aspect of affairs would no doubt be quite different.

Vancouver gives in the course of his relation, some singularly interesting statements bearing on the sinking of the coast. Of Port Chalmers, in Prince William's Sound (lat. 60° 16′) under date June, 1794, he writes* :—

"The shores are in general low, and as has already been observed, very swampy in many places, on which the sea appears to be making more rapid encroachments than I ever before saw or heard of. Many trees had been cut down since these regions were first visited by Europeans; this was evident from the visible effects of the axe and saw, which we concluded had been produced whilst Messrs. Portlock and Dixon were here, seven years before our arrival, as the stumps of the trees were still remaining on the earth where they had originally grown, but were now many feet below the high water mark even of neap tides. A narrow low projecting point of land behind which we rode, had not long since afforded support to some of the largest pine trees in the neighbourhood, but it was now overflowed by every tide, and excepting two of the trees which still put forth a few leaves, the whole were reduced to naked, dead white stumps, by the encroachment of the sea water to the roots; and some stumps of trees, with their roots still fast in the ground, were also found in no very advanced stage of decay nearly as low down as the low water of spring tides."

The place here spoken of by Vancouver, has it seems lately been called *Sinking Point* by the U. S. Coast Survey. It is mentioned under this name by Mr. Davidson in the Alaska Coast Pilot (1869) who however gives no description of its present appearance. Mr. Davidson suggests that the trees observed by Vancouver may have been felled by the Russians before Portlock and Dixon's visit, but as these commanders stayed here ten days, careening and overhauling their vessels,

* A Voyage of Discovery to the North Pacific Ocean and Round the World. London 1801. Vol. V., p. 335.

and yet make no mention of signs of previous visitors in their narrative,* it is probable that Vancouver was correct in his supposition. Mr. Dall, in the Coast Pilot (p. 193) shows pretty conclusively that the peninsular part of Alaska, west of the 150th meridian, is being, or has lately been elevated. Winrows of drift wood in various stages of decay are found above the highest levels ever now attained by the sea, and in the crevices of rocks, fifteen feet above high water, portions of the shelly covering of a species of barnacle are found *in situ*. He also refers to Sinking Point, but inclines to the belief that the subsidence there shown is merely local, which, in view of the other facts here cited it can scarcely be.

In detailing the observations of his sailing master, Mr. Whidbey, on another part of the coast, near Admiralty Island† (near lat. 58°,) more than four hundred miles eastward from Port Chalmers, Vancouver says:—

"He also states, that in his last excursions several places were seen, where the ocean was evidently encroaching very rapidly on the land, and that the low borders extending from the base of the mountains to the sea side, had, at no very remote period of time, produced tall and stately timber; as many of their dead trunks were found standing erect, and still rooted fast in the ground, in different stages of decay; those being the most perfect that had been the least subject to the influence of the salt water, by which they were surrounded at every flood tide: Such had been the encroachment of the ocean on these shores, that the shorter stumps in some instances at low water mark, were even with or below the surface of the sea. The same appearance had been noted before in Port Chalmers, and on this occasion Mr. Whidbey quotes other instances of similar encroachments, not only in Prince William's Sound, but also in Cook's Inlet, where he observed similar effects on the shores."

Dr. J. G. Cooper, in the Natural History of Washington Territory, makes the following note:—"On the tide meadows about Shoal Water Bay, dead trees of this species (*Thuja Gigantea*) only, are standing, sometimes in groves, whose age must be immense though impossible to tell accurately. They

* A Voyage Round the World, and to the North-West Coast of America. London, 1789.

† Op. cit. Vol. IV., p. 53.

evidently lived and grew when the surface was above high-water level, groves of this and other species still flourishing down to the very edge of inundation. But a gradual slow sinking of the land (which seems in places to be still progressing, and is perhaps caused by the undermining of quicksands) has caused the overflow of the tides, and thus killed the forests, of which the only remains now left are these cedars. This wood is perfectly sound, and so well seasoned as to be the very best of its kind. Continued and careful examination of such trees may afford important information as to the changes of level in these shores. That these have been numerous and great is further shown by alternating beds of marine shells, and of logs and stumps, often in their natural position, which form the cliffs above the bay to the height of 200 feet. But while these remains show that the changes took place in the latest periods of the Miocene tertiary epoch (?) there is no evidence in the gigantic forests still living on these cliffs, that any *sudden* or *violent* change has occurred since they began to grow—a period estimable rather by thousands than by hundreds of years."

The testimony of a small change toward depression within the last ninety or one hundred years appears concurrent.

The various Indian tribes of the coast and interior, like all peoples, have their stories, more or less unreal and grotesque, of deluges, or *the* deluge. The Okanagans, for instance, who inhabit the southern part of the interior, in a long rambling story relating their first arrival in the country which they now inhabit, are said to state* that, "after paddling day and night for many suns, they came to certain islands, whence steering through them, they came at last to where the mainland was, however much smaller than in these days *having grown much since*."

That they had been made familiar by tradition or experience with change of the sea level is apparent from the statement of Mr. Gibbs,† that on occasion of a slight earthquake shock, the Indians of Whidbey Island, in the Strait of Georgia, in reply to an enquiry if they knew what it was, said that the "earth was rising."

The most remarkable Indian tradition, however, quite equal in its way and in the circumstantiality of its details, to the

* Bancroft, Native Races of the Pacific States, Vol. III., p. 154.

† Loc. cit. p. 359.

Chaldean account of the deluge lately unearthed, has been found by Mr. J. G. Swan among the Makah Indians of Cape Flattery, the southern point at the entrance to Juan de Fuca's Strait. This, though no doubt much exaggerated, probably embalms the memory of some real event, either of the nature of an earthquake wave, or depression and reelevation due to the not yet wholly extinct volcanic forces of the coast.

Mr. Swan writes *:—"A long time ago," said my informant, "but not at a very remote period, the water of the Pacific flowed through what is now the swamp and prairie between Wäach Village and Neeah Bay, making an island of Cape Flattery. The water suddenly receded, leaving Neeah Bay perfectly dry. It was four days reaching its lowest ebb, and then rose again without any waves or breakers, till it had submerged the Cape, and in fact the whole country except the tops of the mountains at Clyoquot. The water on its rise became very warm, and as it came up to the houses, those who had canoes put their effects into them, and floated off with the current, which set very strongly to the north. Some drifted one way some another; and when the waters assumed their accustomed level, a portion of the tribe found themselves beyond Nootka, where their descendants now reside, and are known by the same name as the Makahs in Classet (Cape Flattery) or Kwenaitchechat. Many canoes came down in the trees and were destroyed, and numerous lives were lost. The water was four days regaining its accustomed level." The same story is preserved by the Kwilléyutes, who say that part of their tribe floated to the region near Port Townsend, where their descendants are known as the Chemakum Indians. The latter again claim to have originally sprung from the Kwilléyutes. Mr Swan adds:—"There is no doubt in my mind of the truth of this tradition. The Wäach prairie shows conclusively that the waters of the Pacific once flowed through it; and on cutting through the turf at any place between Neeah Bay and Wäach, the whole substratum is proved to be pure beach sand. In some places the turf is not over a foot thick; at others the alluvial deposit is two or three feet."

Leaving, however, the realms of tradition, the conclusions provisionally arrived at, as to the former levels of the coast, may thus be summed up.

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* Indians of Cape Flattery, 1869, p. 57.

Miocene Period.—Immediately succeeding considerable mountain upheaval, and closed by basalt flows of the interior. Coast at least during part of this period somewhat lower than at present.

Pliocene Period.—Land elevated at least about 900 feet above the present sea line for part or the whole of this period.

Glacial Period.—At one or more epochs during this period land much depressed; at one time probably over 5,000 feet.

The country considerably below the present level when the glacier of the Strait of Georgia finally retreated from the south-eastern part of Vancouver Island.

Post Glacial and Modern.—Reelevation to height probably 200 or 300 feet greater than at present, followed by depression to near the present level, with probably many changes of small amount, and perhaps one or more rather important movements as indicated by the Indian stories. Lastly, somewhat rapid depression of perhaps ten or fifteen feet during the latter part of last century, a movement which may still be slowly going on.

Subsequent examination of this part of the Pacific coast may enable us to add many details to this necessarily somewhat imperfect scheme.

MISCELLANEOUS.

A VERY RARE BIRD.—Yesterday Mr. Vennor was so fortunate as to purchase from a Canadian in the Bonsecœur Market, Montreal, a beautiful frozen specimen of the *dark variety* of the Gyrfalcon. This is a very rare bird, and one that is being at present much discussed by our leading American Ornithologists. Up to the present only two other specimens have been taken in Canada, so far as known, and these are in our Museum of Natural History. Apart from these, there is one specimen in the National Museum of Washington, one in the Boston Museum and two in the collection of Mr. Boardman of St. Stephen's. These, with Mr. Vennor's recently procured specimen, make a sum total of but seven individuals of this species known in collections in the whole of North America. Great enquiries have been made by United States naturalists for this bird *in the flesh*, as it is yet undecided whether it is a *valid* species or merely a dark stage of the ordinary form of Gyrfalcon of Iceland and Greenland. For these reasons Mr. Vennor has transmitted the bird entire to Boston, where such men as Brewer, Allan, Deane, Bailey and other leaders in American Ornithology will study its anatomy in detail, and probably arrive at some important conclusions. The specimen, however, is not to be lost to our Canadian collections, but when preserved and mounted by a skilful taxidermist will be returned to Montreal.—Ed. *Can. Nat.*

March 15th, 1877.

NOTE ON A SPECIMEN OF DIPLOXYLON, FROM THE COAL FORMATION OF NOVA SCOTIA.—By J. W. Dawson, LL.D., F.R.S., F.G.S.—The author described the occurrence in Coal-measure sandstone at the South Joggins of an erect stump of a Sigillarian tree 12 feet in length. It originated in a coaly seam 6 inches thick, and terminated below in spreading roots; below the coal seam was an under-clay 3 feet 4 inches thick, separating it from an underlying seam of coarse coal. The stem, which tapered from about $2\frac{1}{4}$ feet in diameter near the base to $1\frac{1}{4}$ foot at the broken end, was a sandstone cast, and exhibited an internal axis about 2 inches in diameter, consisting of a central pith cylinder, replaced by sandstone, about $\frac{2}{5}$ inch in diameter, and of two concentric coats of scalariform tissue, the inner one $\frac{1}{25}$ inch

in thickness, the outer constituting the remainder of the axis. The scalariform tissue of the latter was radially arranged, with the individual cells quadrangular in cross section. A few small radiating spaces partially filled with pyrites obscurely represented the medullary rays, which were but feebly developed; the radiating bundles, passing to the leaves, ran nearly horizontally, but their structure was very imperfectly preserved. The cross section when weathered, showed about twenty concentric rings; but these under the microscope appeared rather to be bands of compressed tissue than true lines of growth. The thick inner bark was replaced by sandstone, and the outer bark represented by structureless coal. On a small portion of one of the roots the author traced the remains of stigmarioid markings. From the above characters the author identified this tree with *Diploxylon* of Corda, and stated that it was the first well-characterized example of this type of Sigillarians hitherto found in Nova Scotia. The author compared the structure of this stem with that of other Sigillarians, and remarked that it seemed to come within the limits of the genus *Sigillaria*, but to belong to a low type of that genus approaching *Lepidodendron* in structure; those of the type of *S. elegans*, Br. and *S. spinulosa*, Renault, being higher in organization, and leading towards the still more elevated type described by him in 1870. He further discussed the supposed alliance of these trees with Gymnosperms, and the probability of the fruits known as *Trigonocarpa* being those of *Sigillaria*, and expressed the opinion that the known facts tend to show that there may be included in the genus *Sigillaria*, as originally founded, species widely differing in organization, and of both Gymnospermous and Acrogenous rank.—*Proc. Geol. Soc., Lond.*

At its last session, the American Congress made an appropriation of $18,000 for a Commission of three skilled Entomologists to investigate and report on the ravages of the Rocky Mountain locust, and to suggest means for their prevention; to be appointed by the Secretary of the Interior.—*Am. Nat.*

We have received a preliminary announcement of a Scientific Expedition around the World, organized on rather a unique plan, to be conducted by a faculty of ten. There will be accommodation for sixty to eighty students. For farther information we would refer our readers to James O. Woodruff, Indianapolis, Ind., or Prof. W. L. B. Jenney, Chicago, Ill., or Prof. J. B. Steere, Ann Arbor, Mich.—*Ibid.*

Published April 6th, 1877.]

THE DAWN OF LIFE,

Being the history of the oldest known Fossil Remains, and their relations to Geological time and to the development of the Animal Kingdom.

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"In a little volume entitled "The Dawn of Life" (Hodder and Stoughton), Dr. Dawson, the well-known Canadian geologist, has sketched in a style strictly popular, yet without the least sacrifice of scientific exactness, the curious discovery of the Eozoon, in the limestones of the ancient Laurentian series which attain such an amazing thickness in Canada. Although the existence of organic remains in those rocks was, as the author justly remarks, a fair inference from our knowledge of them, and we may add, of the kindred rocks in Scotland and Ireland, better known to us as the Lewisian, it is entirely to the Canadian geologists that this curious solution of a difficult problem is due. It was they who perceived that, the basis of these rocks being limestone, it was more than probable, in spite of the metamorphic character they had assumed, that they were originally sedimentary deposits like the basis of other limestone, and had the same origin in the corruption of the remains of the myriads of little creatures which, both on the surface and in the depths of the ocean are still, as the dredges of the Challenger teach us, forming beds of chalks and probably vast white cliffs to be revealed in future ages inconceivably remote. To the shrewdness of these American men of science we also owe the inference of vegetable life during the Laurentian period as evidenced by the existence of graphite or plumbago. Thus the final discovery of Eozoon, or the "Canadian dawn-animal," as it has been called from its presence in what we have ground to assume to be the very first of all aqueous deposits, was, as has been observed, somewhat like the discovery of the planet whose existence had been first determined *a priori* from planetary disturbances. How far back this discovery, at first received with scepticism, but now fairly established as a scientific fact, pushes the period of life on our globe beyond what was till lately known as the "primordial period," may be faintly conceived from the circumstance that the Laurentian was found on measurement by the officers of the Canadian Geological Survey to be 3,500 feet thick, in three beds, which have been computed to extend over an area of 200,000 square miles. Next to Sir William Logan, perhaps Dr. Dawson himself has had more to do with this discovery of the earliest known fossil than any one else. He speaks therefore with authority in his account of the nature and probable habits of the dawn-animal, and in tracing out the important relations which the discovery bears to facts and theories which extend far beyond the strict domain of the geologist. His monograph is written in a vein of quiet enthusiasm which is justifiable, and while it attracts the novice, will not be unpleasing to the scientific reader. Very little is really wanting to the full comprehension of his theme beyond the preliminary explanations, the condensed sketch of geological periods, and the wood-cut illustrations which accompany the book. We will undertake to say that even a reader who is entirely unacquainted with the science will, if he have only ordinary curiosity about natural phenomena, find this volume not only perfectly intelligible, but entertaining in a high degree."

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