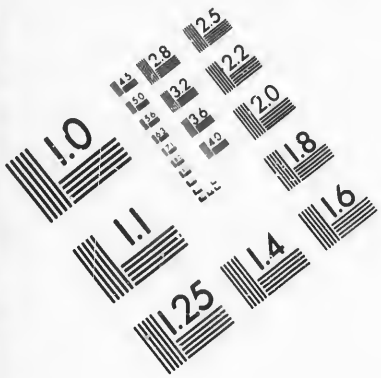

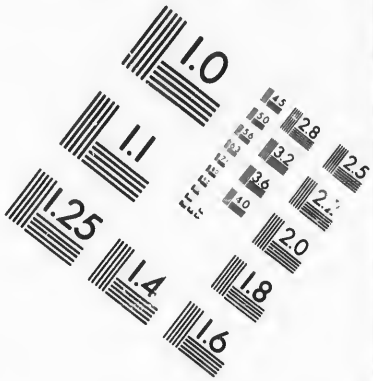

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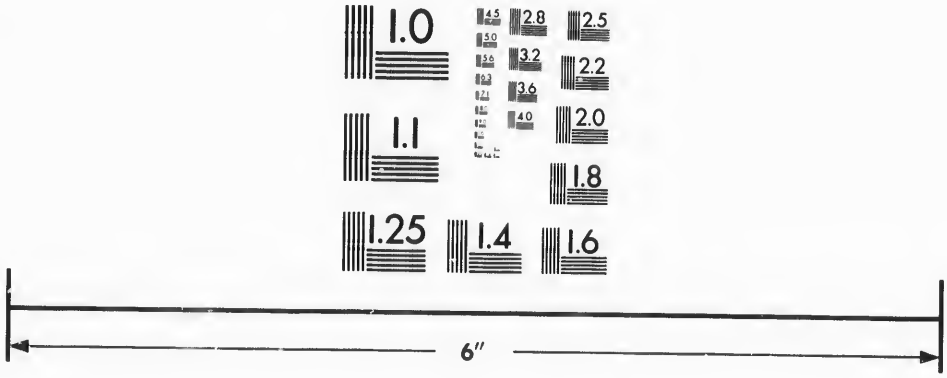

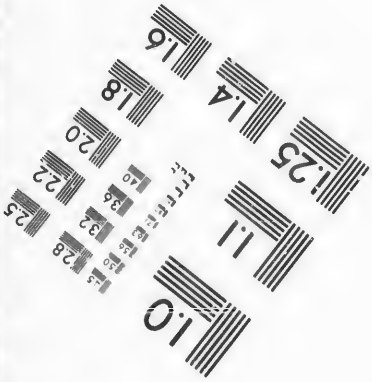

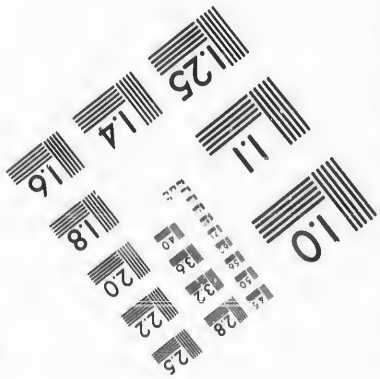

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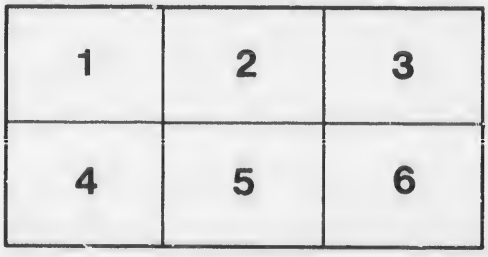

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PROVINCE HOUSE

by J. W. Dawson
(from Canadian Naturalist)

NOTICE OF TERTIARY FOSSILS

FROM LABRADOR, MAINE, &c.,

AND

REMARKS ON THE CLIMATE OF CANADA,

IN THE NEWER PLIOCENE OR PLEISTOCENE PERIOD.

I am indebted to Capt. Orlebar, R.N., for a small collection of fossils from the vicinity of Tertiary Bay on the coast of Labrador, a locality in which similar collections were made several years since by Adm^{l}. Bayfield. They occur in clay a little above high water mark; but the species present indicate a considerable depth at the time of the deposition of the bed in which they are contained, so that it cannot properly be regarded as merely a raised beach. The species contained in the collection are as follows; those found in the newer Pliocene of Canada being marked with asterisks.

*Balanus porcatus.**
Spirorbis vitrea, attached to shells.*
Sp. carinata.
*Buccinum undatum.**

Aporrhais occidentalis.
Natica, (fragment probably of *N. Clausa.*)*
Saxicava rugosa, var. *Arctica.**
Tellina proxima, (*calcarea*) *
Astarte elliptica.
*Rhynconella psittacea.**
Echinus granulatus.
Hippothoa catenularia, (attached to shells) *
*Lepralia pertusa.**
L. (not determined.)
Cythere.

The greater number of the above species have already been recognised in the tertiary clays of Canada; * but the following exceptions are deserving of notice.

Spirorbis vitrea, has not been named in my previous papers; but I now find, on comparison with the specimens from Labrador and recent examples from Gaspé, that it is this and not *Spirorbis sinistrorsa* as previously stated, that occurs in the tertiary beds at Montreal and Quebec. It is at present a deep water species in the Gulf of St. Lawrence and on the banks of Newfoundland. *Spirorbis carinata* has not previously been observed in the tertiary beds; but is common on the coast of Labrador and Gaspé.†

Aporrhais occidentalis, the American representative of the "Pelican's-foot Spout-shell" of Britain, and remarkable in the adult state for its singularly expanded outer lip, is a deep water shell somewhat widely though not very abundantly distributed on the American coast. I have specimens from Labrador, Sable Island, and Portland, where a very fine living specimen was dredged for me last summer by Mr. Ferrier.

Saxicava rugosa, occurs in the Labrador collection under the form described as *S. Arctica* by Forbes and Hanley. This form is not prevalent though sometimes seen among the *Saxicavæ* of the St. Lawrence valley deposits, and at present is I think found only in deep water. The intermediate specimens prove it to be merely a variety of the common species.

Astarte elliptica is the common *Astarte* of the Gulf of St.

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* See papers by the author in Canadian Naturalist, Vols. 2 and 4.

† See paper on *Spirorbes* of the Gulf of St. Lawrence in last number of this Journal.

Lawrence at present. Great numbers have been dredged by Mr Bell on the coast of Gaspé in about 60 fathoms. Along with them are found a few specimens having the characters of the typical *Astarte sulcata* of Great Britain, and others having the characters of *A. compressa*, a species much more nearly related than the others to the fossil *A. Laurentiana*, though quite distinct. I can recognise in the collections made by Mr. Bell and myself all the above species or varieties, and in addition the *A. Arctica*, which I have found only in the pleistocene beds near Portland. *A. Laurentiana* and *A. Arctica* are without doubt distinct species from *Sulcata*, but different views have been entertained as to the others. The distinction based by some authors on the crenulated or smooth margin, and on which the species *A. Scotica* and *A. Dannoniensis* have been founded, is evidently worthless, depending as it does on age; but the distinctions of external form and marking are apparently constant at all ages, and do not shade into each other. Although therefore Dr. Gould and Mr. Stimpson retain the name *sulcata* for all our American forms, I think it admits of a doubt whether the same distinctions made by Forbes and Hanley in Britain do not hold here. Mr. P. P. Carpenter when in Montreal very kindly went over my collections with me, and expressed himself satisfied that we have the forms recognised in Britain as *elliptica*, *sulcata*, and *compressa*, whatever their specific value. My impression at present is that *compressa* is a good species, but that *sulcata* and *elliptica* as we have them may be varieties of one. It is curious that while *A. Laurentiana* prevails exclusively in the St. Lawrence deposits, the modern species is found at Labrador; and very possibly, especially when we regard the more inland position and greater elevation o the former, this indicates a difference of age in the deposits.

The clay attached to and in the interior of Capt. Orlebar's specimens is very rich in the minute *Foraminifera*. It contains specimens of all the forms found in the clays of Montreal and described in my former papers, and in addition the following:

Rotalina oblonga, Fig. 1.
Bulimina pupoides, Fig. 2.
B. *auriculata?*
Orbulina universa,
Textularia variabilis, Fig. 3.
Nonionina Labradorica, N. sp. Fig. 4.
Truncatulina lobata Fig. 5.

All of these except one are well known living species, and all except *Textularia variabilis* have been found in the Gulf of St. Lawrence. This last statement however could not have been made but for specimens obtained from clay taken up by the sounding lead off the coast of Anticosti, from depths varying from 144 to 313 fathoms, and for which also I am indebted to Capt. Orlebar. In these soundings there also occur *Globigerina bulloides* a species world-wide in its distribution, and *Nodosaria pyrula*, neither of which have as yet been found in the tertiary beds of Canada. With these recent shells there is a *Cythere* like *C. angulata* of the British seas, and numerous spicules of sponges; there are also immense numbers of the round perforated silicious shields of *Coscinodisci* apparently the *C. lineatus* and *C. radiatus* of Ehrenberg. It is a remarkable and at present unaccountable fact that while in the pleistocene beds there is a great abundance of foraminifera, sponge spicules, and valves of cythere, imbedded in calcareous clays like those of the deep soundings of the Gulf, the *Coscinodisci* and other diatoms are absent or at least have not been recognised.

Fig. 1.

Fig. 2.

Fig. 3

Fig. 1.—*Rotalina oblonga.*
2.—*Bulimina pupoides.*
3.—*Textularia variabiltis.*

Truncatulina lobata. The last species in the list is a little parasitic foraminiferous shell adhering to shells, stones, and zoophytes. It abounds in Mr. Bell's and Mr. Richardson's recent collections from Gaspé, and since I observed it in Capt. Orlebar's collection, I have found it also at Montreal. It is the *Nautilus stellaris* of Fabricius.

The *Nonionina* which I name *N. Labradorica*, and which is found both recent and fossil, is a very beautiful species. It is perfectly equilateral, smooth and remarkably white and lustrous. It is most readily characterised by the great expansion of the last chamber, which spreads laterally and extends in two lobes on

either side of the earlier whorls. When seen from one side it resembles *Rotalina turgida*, for which indeed I mistook it at first; but when viewed in front it is seen to be equilateral and to have the characteristic septal aperture of Nonionina. It is about equal in size to *N. umbilicatula*, and has the last chamber inflated even in young shells.

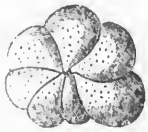

Fig. 4. Fig. 5.

Fig. 4.—*Nonionina Labradorica*, N. sp.
5. —*Truncatulina lobatula*.

The Foraminifera from the deeper parts of the Gulf are usually of small size, and this applies also to those from the pleistocene of Labrador.

In the past summer another deposit of pleistocene shells was discovered by Sir W. E. Logan at the Mingan Islands, Labrador. The specimens obtained from it consist of *Mya arenaria* and *Mollina proxima* in hard sand, and have the aspect of a littoral deposit corresponding to the "saxicava sand" of the vicinity of Montreal.

2. Portland, Maine.

In last August I enjoyed some opportunities of examining the tertiary deposits at and near Portland, and also at Pond Cove, Cape Elizabeth, where a small patch of this deposit occurs nearly at the level of the sea. At the south end of the city of Portland, in a deep railway cutting, the tertiary beds are well seen, and consist, in ascending order, of boulder clay, fossiliferous stratified clay and sand, and stratified sand and gravel. These beds appear to be very irregular, being entangled in ledges of metamorphic rock, which sometimes rise through them. The distinction between the deeper water and shallow water parts of the deposits is in

consequence less strongly marked than at Montreal, but is indicated by beds containing *Mytilus edulis* alone, overlying those which contain shells characteristic of the open sea. At Cape Elizabeth the pleistocene clays occupy depressions between ridges of slate. At the only place where I observed fossils, the deposit is a hard gray stony clay containing a mixture of deep sea and littoral shells. The bivalves are mostly in detached valves and often on edge, as if the bed had been subjected to the pressure of ice after its deposition.

The fossils observed in the above mentioned beds are as follows,—those common to Portland and the St. Lawrence valley being marked with asterisks :

*Balanus crenatus,**
Fusus decemcostatus, (var. *borealis,*)
*Buccinum undatum,**
Fusus scalariformis,
*Natica clausa,**
*Mytilus edulis,**
Mactra ovalis,
*Saxicava rugosa,**
Astarte elliptica,
A. compressa,
A. arctica,
*Tellina proxima,**
*Pecten Islandicus,**
*Mya truncata,**
Nucula Jacksoni,
Aphrodite Grœnlandica,
Lepralia variolosa,
*L. Bellii,**
Membranipora, (undetermined.)

The assemblage of shells in the above list cannot be said to indicate any very great change of climate, though more like that of the Gulf of St. Lawrence than of Portland at present. With the exception of *Astarte arctica* not now found on the American coast, and *Nucula Jacksoni* which is possibly extinct, they are

* A new species, now living in the Gulf of St. Lawrence, and described in the Report of the Geological Survey of Canada for 1858.

all common American species. It is curious that in the collections of the Canadian Geological Survey, the group of shells obtained by Mr. Bell and Mr. Richardson in dredging on the north coast of Gaspé in about 60 fathoms, is almost precisely that of these Portland beds.

On comparison with the St. Lawrence tertiaries, it will be seen that 8 out of 19 species are distinct. It is further to be observed that *Fusus decemcostatus* replaces the closely allied *F. tornatus*. that *Saxicava rugosa* is much less abundant, that modern Astartes appear instead of *A. Laurentiana*, and that *Mytilus edulis* is of large size and of the ordinary form. These differences are however probably nothing more than the effects of the more oceanic position of the Portland beds, as compared with the old inland sea of the St. Lawrence valley, and it will be observed that in respect to the Astartes the Portland beds correspond with those of Labrador. The less elevation of the Portland beds however renders it probable that they are somewhat newer than those of the St. Lawrence valley and of Lake Champlain.

In the cabinet of Dr. Jackson of Boston, I had an opportunity of examining a collection of about 14 species obtained by him from the beds on the Pressumpset River, described many years ago by Professor Hitchcock and Dr. Jackson. In this collection while several of the shells found at Portland are absent, I found *Leda Portlandica*,* *Nucula proxima*, *Terebratula septentrionalis*, *Mya arenaria*, and the carapace of a crab.

3. OCCURRENCE OF FRESH WATER SHELLS IN THE PLEISTOCENE BEDS.

I owe to the kindness of A. Dickson, Esq., additional collections of the fresh water shells and the sands containing them from Pakenham,† together with a communication from a gentlemen of that place giving a section of the deposits as seen in a deep road cutting. The arrangement is as follows in descending order:

Sand and surface soil, about,.....10 feet
Clay, ...10 "

* Dr. Gould informs me that he is now satisfied of the correctness of the identification of this shell by Mr. Wood with the species *L. truncata* of the British Pleistocene and of the artic seas, where it has been living.

† See my paper, Canadian Naturalist, Vol. IV.

Fine gray sand (shells of *Valvata*, &c.).....		2 inches
Clay, ...	1 foot	
Gray sand, laminated (*Tellina Grœnlandica*),..		3 "
Clay, ...		8 "
Light gray sand (*Valvata, Cyclas, Paludina, Planorbis* and *Tellina*),.....		10 "
Clay, ...	1 foot	2 "
Brown sand and layers of clay, (*Planorbis* and *Cyclas*), ...		4 "

The species were the same with those described in my previous papers, and the only marine shell is *Tellina Grœnlandica*, a species now found farther up in our estuaries than most others.

Mr. Dickson informs me that a similar case occurs near Clarenceville, about four miles from the United States frontier, and at an elevation of about ten feet above Lake Champlain. Specimens from this place contain large shells of *Unio rectus* and *U ventricosus*, the latter with the valves cohering, and a *Lymnea*. Intimately mixed with these in sandy clay are valves of *Tellina Grœnlandica* and *Mya arenaria*.

I record these facts, without pledging myself to the conclusion that these deposits really mark the margins or river estuaries of the old Pleistocene sea of Canada; though they will certainly bear that interpretation. In farther connection with these facts, and in relation also to the question why marine fossils have not been found west of Kingston, Mr. Dickson informs me that fossil capelin are found on the Chaudière Lake, 183 feet above Lake St. Peters, on the Madawaska 206 feet, and at Fort Colonge Lake 365 feet above the same level, a very interesting indication of the gradual recession of the capelin spawning grounds, from this last high elevation to the level of the more celebrated locality of these fossils at Green's Creek. Farther, throughout the Counties of Renfrew, Lanark, Carlton and Leeds, the marine deposits rise to an elevation of 425 feet, or nearly the same with that which they reach on Montreal Mountain; but while this elevation would with the present levels of the country carry a deep sea to the head of Lake Ontario, no marine fossils appear to have been found on the banks of that lake. Was the depression of the later pleistocene period limited to the country east of Lake Ontario, or have the marine deposits of the upper St. Lawrence hitherto escaped observation

or been removed by denuding agencies. The question awaits further explorations for a satisfactory answer.

In the mean time it is certain that the boulder clay and deposits corresponding in arrangement and mechanical character to the Leda clay and Saxicava sand of the Lower St. Lawrence, exist in these more western regions, though they have not been found to contain marine fossils.

4. CLIMATE OF CANADA IN THE PLEISTOCENE PERIOD.

The climate of this period and the causes of its difference from that which now obtains in the northern hemisphere, have been fertile subjects of discussions and controversies, which I have no wish here to re-open. I merely propose to state in a manner level to the comprehension of the ordinary reader the facts of the case in so far as relates to Canada, and an important inference to which they appear to me to lead, and which if sustained will very much simplify our views of this question.

Every one knows that the means and extremes of annual temperature differ much on the opposite sides of the Atlantic. The isothermal line of 49° for example passes from the south side of the gulf of St. Lawrence, skirts Iceland and reaches Europe near Drontheim in Norway. This fact, apparent as the result of observations on the temperature of the land, is equally evidenced by the inhabitants and physical phenomena of the sea. A large proportion of the shell fish inhabiting the gulf of St. Lawrence and the coast thence to Cape Cod, occur on both sides of the Atlantic, but not in the same latitudes. The marine fauna of Cape Cod is parallel in its prevalence of boreal forms with that of the south of Norway. In like manner the descent of icebergs from the north, the freezing of bays and estuaries, the drifting and pushing of stones and boulders by ice, are witnessed on the American coast in a manner not paralleled in corresponding latitudes in Europe. It follows from this that a collection of shells from any given latitude on the coasts of Europe or America, would bear testimony to the existing difference of climate. The geologist appeals to the same kind of evidence with reference to the climate of the later tertiary period, and let us enquire what is its testimony.

The first and most general answer usually given, is that the pleistocene climate was colder than the modern. The proof of this in Western Europe is very strong. The marine fossils of this

period in Britain are more like the existing fauna of Norway or of Labrador than the present fauna of Britain. Great evidences exist of driftage of boulders by ice, and traces of glaciers on the higher hills. In North America the proofs of a rigorous climate and especially of the transport of boulders and other materials by ice are equally good, and the marine fauna all over Canada and New England is of boreal type. In evidence of these facts I may appeal to the papers and other publications of Sir C. Lyell and Professor Ramsay on the formations of the so called glacial period in Europe and America,* and to my own previous papers on the tertiaries of Canada.

Admitting however that a rigorous climate prevailed in the pleistocene period, it by no means follows that the change has been equally great in different localities. On the contrary while a great and marked revolution has occurred in Europe, the evidences of such change are very much more slight in America. In short, the causes of the coldness of the pleistocene seas to some extent still remain in America, while they must have disappeared or been modified in Europe.

If we enquire as to these causes as at present existing, we find them in the distribution of ocean currents, and especially in the great warm current of the gulf stream, thrown across from America to Europe, and in the Arctic currents bathing the coasts of America. In connection with these we have the prevailing westerly winds of the temperate zone, and the great extent of land and shallow seas in Northern America. Some of these causes are absolutely constant. Of this kind is the distribution of the winds depending on the earth's temperature and rotation. The courses of the currents are also constant, except in so far as modified by coasts and banks; and the direction of the drift-scratches and transport of boulders in the pleistocene both of Europe and America, show that the arctic currents at least have remained unchanged. But the distribution of land and water is a variable element, since we know that in the period in question nearly all northern Europe, Asia and America were at one time or another under the waters of the sea, and it is consequently to this cause that we must mainly look for the changes which have occurred.

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* Lyell's travels in North America, Ramsay on the glaciers of Wales, and on the glacial phenomena of Canada. See also Forbes on the fauna and flora in the British Islands, in Memoirs of geological survey

Such changes of level must, as has been long since shown by Sir Charles Lyell, modify and change climate. Every diminution of the land in arctic America must tend to render its climate less severe. Every diminution of land in the temperate regions must tend to reduce the mean temperature. Every diminution of land any where must tend to diminish the extremes of annual temperature; and the condition of the southern hemisphere at present shows that the disappearance of the great continental masses under the water would lower the mean temperature but render the climate much less extreme. Glaciers might then exist in latitudes where now the summer heat would suffice to melt them, as Darwin has shown that in South America glaciers extend to the sea level in latitude 46° 50′; and at the same time the ice would melt more slowly and be drifted farther to the southward. Any change that tended to divert the arctic currents from our coasts would raise the temperature of their waters. Any change that would allow the equatorial current to pursue its course through to the Pacific or along the great inland valley of North America, would reduce the British seas to a boreal condition.

The boulder formation and its overlying fossiliferous beds prove, as I have in a previous paper endeavoured to explain with regard to Canada, and as has been shown by other geologists in the case of other regions, that the land of the northern hemisphere underwent in the later tertiary period a great and gradual depression and then an equally gradual elevation. Every step of this process would bring its modifications of climate, and when the depression had attained its maximum there probably was as little land in the temperate regions of the northern hemisphere as in the southern now. This would give a low mean temperature and an extension to the south of glaciers, more especially if at the same time a considerable arctic continent remained above the waters, as seems to be indicated by the effects of extreme marine glacial action on the rocks under the boulder clay. These conditions, actually indicated by the phenomena themselves, appear quite sufficient to account for the coldness of the seas of the period, and the wide diffusion of the gulf stream caused by the subsidence of American land, or its entire diversion into the Pacific basin*, would give that assimilation of the American

* This is often excluded from consideration, owing to the fact that the marine fauna of the gulf of Mexico differs almost entirely from that of the Pacific coast; but the question still remains whether this difference existed in the later tertiary period, or has been established in the modern epoch, as a consequence of changed physical conditions.

and European climates so characteristic of the time. The climate of western Europe in short, would under such a state of things be greatly reduced in mean temperature, the climate of America would suffer a less reduction of its mean temperature, but would be much less extreme than at present; the general effect being the establishment of a more equable but lower temperature throughout the northern hemisphere. It is perhaps necessary to add that the existence on the land, during this period of depression, of large elephantine mammals in northern latitudes, as for instance the Mammoth and Mastodon, does not contradict this conclusion. We know that these creatures were clothed in a manner to fit them for a cool climate, and an equable rather than a high temperature was probably most conducive to their welfare, while the more extreme climate consequent on the present elevation and distribution of the land may have led to their extinction.

The establishment of the present distribution of land and water, giving to America its extreme climate, leaving its seas cool and throwing on the coasts of Europe the heated water of the tropics, would thus affect but slightly the marine life of the American coast, but very materially that of Europe, producing the result so often referred to in these papers, that our Canadian Pleistocene fauna differs comparatively little from that now existing in the gulf of St. Lawrence, though in so far as any difference subsists it is in the direction of an arctic character. The changes that have occurred are perhaps all the less that so soon as the Laurentide hills to the north of the St. Lawrence valley emerged from the sea, the coasts to the south of these hills would be effectually protected from the heavy northern ice drifts and from the arctic currents, and would have the benefit of the full action of the summer heat, advantages which must have existed to a less extent in western Europe.

It is farther to be observed that such subsidence and elevation would necessarily afford great facilities for the migration of arctic marine animals, and that the difference between the modern and newer pliocene faunas must be greatest in those localities to which the animals of temperate regions could most readily migrate after the change of temperature had occurred.

It has been fully shown by many previous writers on this subject, that the causes above referred to are sufficient to account for all the local and minor phenomena of the stratified and unstra

tified drifts, and for the driftage of boulders and other materials, and the erosion that accompanied its deposition. Into these subjects I do not propose to enter; my object in these remarks being merely to give the reasons for my belief stated in previous papers on this subject, that the difference of climate between pleistocene and modern Canada, and the less amount of that difference relatively to that which has occurred in western Europe, may be explained by a consideration of the changes of level which the structure and distribution of the boulder clay and the overlying fossiliferous beds prove to have occurred.