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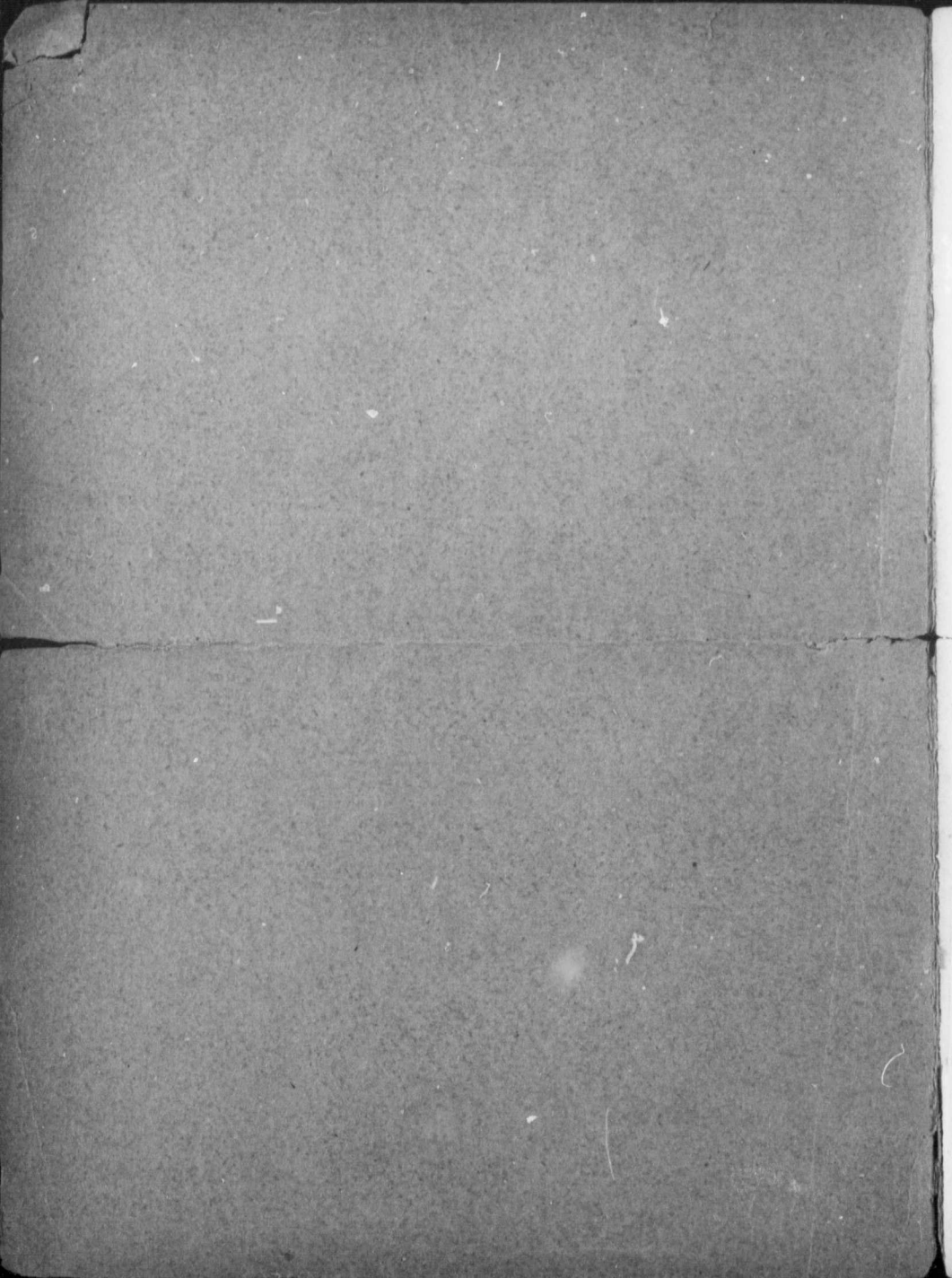


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V.

CHANGES OF CLIMATE IN NORTH-WESTERN CANADA SINCE THE GLACIAL PERIOD.

BY

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North Western Canada as here understood comprises the provinces of Manitoba, Saskatchewan, and Alberta, and the country to the north of them as far as the shores of the Arctic Ocean. It is bounded on the east to a large extent by the basin of Hudson's Bay and Lake Winnipeg, and on the west by the Rocky Mountains which extend almost continuously northward to the Arctic Ocean. Speaking broadly and generally it is a vast plain which has an elevation of more than 4000 feet above the sea at the base of the Rocky Mountains in the south-western portion of the region, and thence declines north-eastward, with a more or less regular slope, till it reaches sea level at Hudson's Bay.

From south to north it may be divided naturally into three divisions, viz. dry grassy steppes destitute of timber in the south; forests, chiefly coniferous, across the middle; and sedgy plains destitute of timber in the north.

During the Glacial period this whole country came within the influence of the Keewatin Glacier which had its centre on what are known as the Barren Lands, within the northern part of the Laurentian peneplain, somewhere between latitudes N. 60° and 64° .

From the centre it spread out in all directions, westward into the valley of the Mackenzie River, southward over what are now the fertile plains and prairies of Alberta, Saskatchewan and Manitoba, and eastward over the rocky surface of Keewatin and Ontario and down into the basin of Hudson's Bay. At its maximum extent it had an area of about 1 750 000 square miles, at which time, or times (as it possibly had about the same extreme regional extent more than once), it reached south of the southern boundary of Canada and into the United States, where its limit has been traced by several American Glaciologists.

On the west it approached some of the lobes of the Cordilleran glacier that descended down the valleys of the Rocky Mountains, while on the east it, at one time at all events, coalesced with the face of the Labradorian glacier.

Two sheets of till, one beneath the other, and in places separated by a boulder pavement, can be recognized in a number of places throughout the Canadian provinces which have been overridden by this glacier.

The epoch or time of the last ice invasion of this glacier has not been very exactly determined, and Mr. F. H. H. CALHOUN of the United States Geological Survey has stated his belief that it was not older than the Wisconsin period. However, if we assume that its whole southern face advanced southward and reached its southern extension at about the same time, and I know of no reason to lead one to suppose that it did not, then, as is clearly shown by the striae, grooves and all the other evidences so well known to geologists on the rocks which form the floor of the Winnipeg basin, the glacier had advanced into the United States and had retired at least as far as the region of the Saskatchewan River before the Wisconsin stage of the Labradorian Glacier reached and crossed the Winnipeg basin to the Manitoba escarpment. Therefore the last advance of the Keewatin glacier must have been of early Wisconsin or pre-Wisconsin age.

At this stage in the life of these two great glaciers, the one of which was retiring, and the other advancing, their fronts coalesced and together they formed the barrier which confined the waters of Lake Agassiz on the east and north.

The beaches formed around this lake and the stratified clays deposited in its waters show that, adding together its area at all times of its history, its waters covered more than 100 000 square miles, but it is reasonably certain that the lake did not cover this area at any one time. It was rather a long narrow body of water stretching between the front of the confluent glaciers and the rising land to the south and west of it. Finally it was drained by the drawing apart of the Keewatin and Labradorian glaciers shortly after the latter had retired as far as the present eastern shore of Lake Winnipeg, and the former to the vicinity of the Churchill River.

After they had separated, the Keewatin glacier continued to retire northward to the country west of Hudson Bay, while the Labradorian glacier retired eastward towards Labrador.

Of the character of the climate which prevailed while glaciers were retiring, very little evidence has yet been collected.

As the glacier retired northward across what are now the great plains between the southern boundary of Canada and the forest region which stretches north-westward through Manitoba and Saskatchewan and then westward across Alberta, the climate was probably at first much like that of the Barren Lands at the present time with a mean summer temperature below 10° C., permanently frozen sub-soil, and consequently a complete absence of trees. As the glacier retired farther northward and the climate of these southern plains became warmer, it also became drier, so that no forests were able to grow on them, neither were *Sphagnum* swamps ever formed on them. The whole known climatic history of these grassy plains is therefore included in the statement that a cold climate was succeeded by a dry continental climate, under neither of which conditions was a forest growth possible.

North and east of the dry grassy plains the country is now covered with a forest of poplar (*Populus tremuloides* and *balsamifera*), birch (*Betula alba*), spruce (*Picea alba* and

nigra), pine (*Pinus Banksiana*) and larch (*Larix Americana*); while beneath the coniferous forest are often extensive *Sphagnum* swamps.

The mean summer temperature of the forest region is 10°—15° C.

In the southern warmer parts the ground thaws out every summer, but in the more northern parts it is certainly permanently frozen, just as it is in the Klondike District in the Yukon Territory.

Poplar, birch and pine extend northward as far as the heavy forest extends, while larch and the two species of spruce extend northward to the northern limit of trees, becoming small and dwarfed before they finally disappear. Their northern limit extends north-westward from Fort Churchill on Hudson's Bay in a fairly regular line, but narrow tongues of forest extend northward of this line on the banks of the northward flowing streams which take their rise within the forested area. It is not an uncommon occurrence to find many of the trees in the most remote northern grooves dead, but again most of these are alive, and as far as I could determine they furnish no evidence of a change in climatic conditions in recent times.

As far as my observation goes, *Sphagnum* bogs are only found in the forest region, within the influence or shade of coniferous woods. They are very extensively developed in the wooded lowlands of northern Manitoba, overlying the lacustrine clays of Lake Agassiz, and they extend northward to the northern limits of the forest where they are often associated with *Chrystosphenes* or buried sheets of ice formed by springs.

Up to the present time the alluvial deposits and bogs have yielded little or no palaeobiological evidence of the spread of living animals through this region in past Glacial times, and the trees that are found in the swamps are of the same species as those that are growing on them at the present time.

All the evidence at hand therefore would seem to show that there had been a gradual change since the Glacial Period from a colder to a warmer climate, sufficiently moist to permit of forest growth.

The country known as the 'Barren Lands' or more properly the 'Treeless Lands' lies north and north-east of the forest, and is the coldest part of the North American continent, with a mean annual temperature below -8° C., and a mean summer temperature below 10° C. Its surface is rough and stoney, and is for the most part covered with sedges, grasses and lichens. Trees and *sphagnum* bogs are conspicuously absent.

Evidence of the former existence of trees on this country might have been largely destroyed, but if *sphagnum* bogs had ever been formed in it, they would be there at the present time. The absence of such bogs, and of any traces of the former existence of forest, would clearly indicate that the Barren Lands have not experienced any warmer climate since the end of the Glacial period than they are getting at the present time.

Thus the results of all the observations made up to the present time throughout north-western Canada point to the conclusion that there has been a fairly continuous amelioration of the climate since the retirement of the Keewatin and Labradorian glaciers.

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