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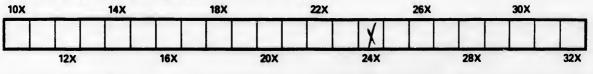
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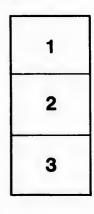
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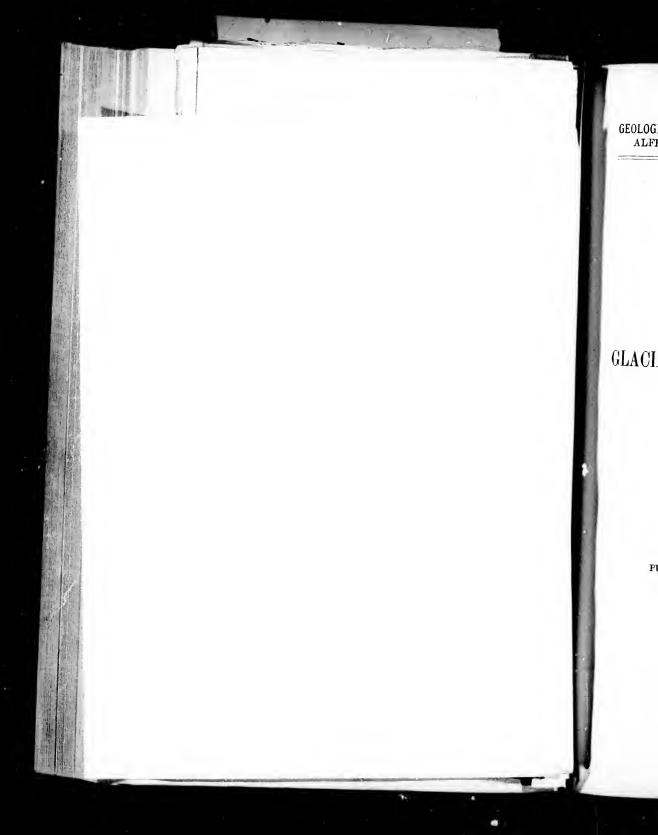
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GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA. ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

OF EXPLORATION OF THE

GLACIAL LAKE AGASSIZ IN MANITOBA.

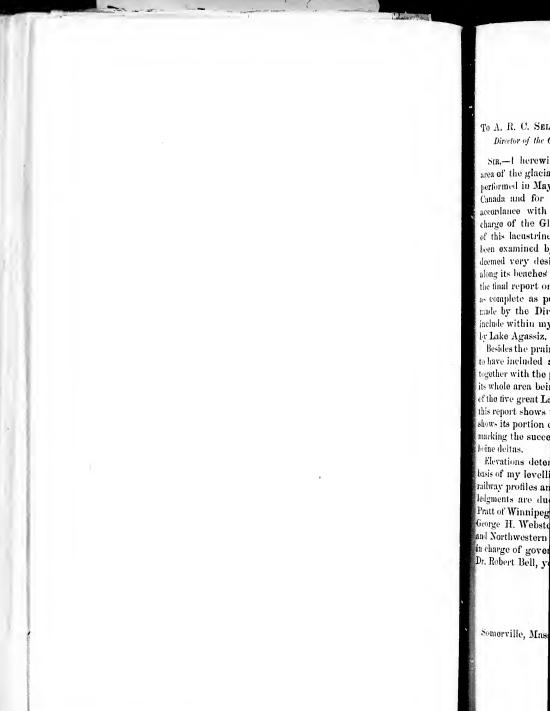
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WARREN UPHAM.



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MONTREAL: WILLIAM FOSTER BROWN & CO. 1890.



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TO A. R. C. SELWYN, C.M.G., LL.D., F.R.S.,

Director of the Geological and Natural History Survey of Canada.

Str.-1 herewith submit to you my report of observations on the area of the glacial Lake Agassiz in Manitoba. This exploration was performed in May, June and July, 1887, for the Geological Survey of Canada and for that of the United States, under which latter, in accordance with instructions from President T. C. Chamberlin in charge of the Glacial Division of that Survey, the southern portion of this lacustrine area, lying in Minnesota and North Dakota, had been examined by me during the two precoding summers. It was deemed very desirable to continue the exact mapping and leveling along its beaches northward into Manitoba for the purpose of making the final report on this subject for the United States Geological Survey as complete as possible; and arrangements providing' for this were made by the Director of that Survey and yourself, enabling me to include within my examination all the prairie region that was occupied by Lake Agassiz.

Besides the prairie district thus examined, this glacial lake is believed to have included a much larger wooded region on the north and east, together with the present lakes Winnipeg, Manitoba, and Winnipegosis, its whole area being probably somewhat more than the combined areas of the five great Laurentian lakes. One of the two maps accompanying this report shows this probable extent of Lake Agassiz; and the other shows its portion examined in Manitoba, with the course of its beaches, marking the successive stages of the lake, and the Pembina and Assiniloine deltas.

Elevations determined by railway surveys have been taken as the basis of my levelling along the beaches. For opportunity to examine railway profiles and for manuscript notes of them, my grateful acknowledgments are due to Mr. P. A. Peterson of Montreal and Mr. R. M. Pratt of Winnipeg, engineers of the Canadian Pacific Railway, to Mr. George II. Webster of Portage la Prairie, engineer of the Manitoba and Northwestern Railway, to Mr. Collingwood Schreiber of Ottawa, in charge of government railways, and to Dr. George M. Dawson and Dr. Rebert Bell, your associates in this survey.

I have the honor to be,

Sir,

Your obedient servant,

WARREN UPHAM.

Somerville, Mass., June, 1889.



Among the most in America are the extent, which are within the basin ancient area. Lal and Lake Lahonta Lake, Nevada, are lakes, formed by i the lakes to small across which they glaciated area of existence to the ch the glacial epochs basin of the Red I another class of th the ice-sheet when land surface. Such basins of Lake Wir of the ice-border, warmer climate; same kind then flo water-sheds. Exa Merjelen See, pen Great Aletsch glac Greenland.

On the western in the glacial drift one mile and a half

REPORT

OF EXPLORATION OF THE

GLACIAL LAKE AGASSIZ IN MANITOBA.

INTRODUCTION.

Among the most important geologic records of the Quaternary period in America are the sediments and shore lines of former lakes of great extent, which are now represented by lakes that occupy, excepting within the basin of the Saint Lawrence, only a small part of their ancient area. Lake Bonneville in the basin of Great Salt Lake, Utah, and Lake Lahontan in the basin of the Humboldt River and Pyramid Lake, Nevada, are conspicuous examples of one class of these Quaternary lakes, formed by increased rain-fall where now an arid climate limits Two classes of the lakes to small areas, with their surface far below the water-sheds lakes. across which they would outflow to the sea. These are south of the glaciated area of the continent, but they appear to have owed their existence to the changes of climate by which the supposed ice sheets of the glacial epochs were formed. Lake Agassiz, which occupied the lasin of the Red River of the North and Lake Winnipeg, belongs to another class of these lakes, caused directly by the supposed barrier of the ice-sheet where this was accumulated on a northwardly sloping land surface. Such glacial lakes were developed on a vast scale in the basins of Lake Winnipeg and the Laurentian lakes during the recession of the ice-border, when it was being gradually melted away by a warmer climate; and it is also evident that many small lakes of the same kind then flowed southward over the lowest points of the present water-sheds. Examples of this class now existing are the little Merjelen See, pent up in a tributary valley on the east side of the Great Aletsch glacier in the Alps, and similar ice-dammed lakelets in Greenland.

On the western boundary of Minnesota a remarkable valley is eroded in the glacial drift to the depth of 125 to 150 feet with a width of about one mile and a half, extending from north to south across the lowest

uaternary

GLACIAL LAKE AGASSIZ IN MANITORA.

Channel of outlet from Lake Agassiz. part of the water-shed that divides the basin of the Red River of the North from that of the Mississippi. This channel has been evidently the course of a great river since the drift was deposited. After the river ceased to flow here, portions of the bottom of the valley have become filled to the slight depths of ten or twenty feet by alluvial bels brought in by tributary streams, and the intervening portions of the old valley are occupied by the long, narrow and shallow Lakes Traverse and Big Stone, the former outflowing northward by the Bois des Sions to the Rod River, and the latter southward by the Minnesota River () the Mississippi. The general level of the land on each side of this water-course is about 1,100 feet above the sea; the heights of Lake, Traverse and Big Stone are respectively 971 and 963 feet above the sen; and the lowest point of the divide between them, in Brown's Valley, is only three feet above Lake Traverse. A valley of similar size extends all along the course of the Minnesota River; but toward the north the broad water-course, with the adjoining highland on each side, ends within a few miles.

The country north of Lake Traverse sinks gradually to a level n_d much above the small Bois des Sioux River, which flows north 35 mile, emptying into the Red River of the North at Breekenridge and Wahpeton. The Red River, here turning abruptly from its western course, flows thence north to Lake Winnipeg, 285 miles. These streams occupy the axial depression of a vast plain of glacial drift and lacustrine and fluvial deposits, forty to fifty miles wide and more than 300 milelong, stretching from Lake Traverse to Lake Winnipeg. This expanse widely famed for the large harvests and superior quality of its wheat is connaonly called the Red River Valley. It has a very uniform continuous descent northward, averaging a little less than one foot pemile. So slight an inclination is imperceptible to the eye, as is als the more considerable ascent, usually two or three feet per mile.

the first ten or fifteen miles to the east and west from the Red River

This river flows along the lowest portion of the plain, somewhat easy

of its central line, in a quite direct general course from south to north

but meanders almost everywhere with minor bends which carry

alternately a half mile or one mile to each side of its main course,

has cut a channel twenty to fifty feet deep and is bordered by only fer

and narrow areas of bottomland, instead of which its banks unal

rise steeply on one side and by moderate slopes on the other, to the

lacustrine plain which thence reaches nearly level ten to thirty mile

The Red River Valley.

> Where the surface rises on each side of this expanse, definite a continuous beach deposits are found marking the shore lines of a valake which formerly covered the Red River Valley and by its outfl

LEHAN. eroded the dec described. Thi ence to glacinl c of an ice-sheet v When this cont was yielding its drainage from it of the land is no beyond the wate Rivers, it is ovid foot of the ice tie the Red River Va of the lowest pai barrier was so fa Hudson Bay that its outlet was alo of its relation to 1 named in memor advocate of the th the past tifteen ye demonstrated by deposits that wer ce-sheet, extending nd Long Island, Ilinois, Wisconsin the characters of skers, also the gl fland ice as their he Red River Val be basins of the intemporaneous e River St. Law The evidences of iver Valley were st scientific expe lliser,¹ in 1858

Geological and Natura \$4, 85.

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INTRODUCTION.

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nse, definite an re lines of a varad by its outfor

eroded the deep channel extending thence sonthward as already described. This lake is believed by the writer to have owed its existence to glacial conditions during the final melting and gradual recession of an ice-sheet which overspread the northern half of North America. When this continental glacier, subdued by a more temperate climate, was vielding its ground between Lake Traverse and Hudson Bay, free drainage from its south side could not take place, because the descent Lake Amssiz of the land is northward. As soon as the border of the ice had recoded receding ico-sheet. beyond the water-shed dividing the basins of the Minnesota and Red Rivers, it is evident that a lake, fed by the glacial melting, stood at the foot of the ice fields and extended northward as they withdrew along the Red River Valley to Lake Winnipeg, filling this valley to the height of the lowest point over which an outlet could be found. Until the ice larrier was so far melted upon the area between Lake Winnipeg and Hudson Bay that this glucial lake began to be discharged northward, its outlet was along the present course of the Minnesota River. Because of its relation to the retreating continental ice-sheet, this lake has been named in memory of Professor Louis Agassiz, the first prominent advocate of the theory that the drift was produced by land ice.¹ Within the past fifteen years the truth of this explanation of the drift has been demonstrated by the recognition and detailed study of the morainic deposits that were accumulated along the southern boundary of the cesheet, extending from Nantucket, Martha's Vineyard, Cape Cod, ad Long Island, across New Jersey, Pennsylvania, Ohio, Indiana, Minois, Wisconsin, Minnesota, Iowa, and South and North Dakota. The characters of other drift deposits, as the till and the kames and skers, also the glacial strim, point with equal certainty to a vast sheet fland ice as their enuse; and the explanation accounts for this lake in e Red River Valley, for similar lakes that were tributary to it from he basins of the Souris and South Saskatchewan Rivers, and for the entemporaneous higher levels of the great lakes now discharged by e River St. Lawrence.

The evidences of the former existence of a great lake in the Red iver Valley were observed in 1823 by Kenting, the geologist of the _{Barlier} st scientific expedition to this district,² in 1848 by Owen,³ in 1857 by ^{observers}, alliser,¹ in 1858 by Hind,⁵ and in 1873 by Dr. G. M. Dawson.⁶ The

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Geological and Natural History Survey of Minnesota, Eighth annual report, for the year 1879, 31,85.

Narrative of an Expedition to the source of St. Peter's River, Lake Winnepeek, Lake of the $ede_i Ae_i$, performed in the year 1823, under the command of Stephen II, $b_i U.S.$ Topographical Engineer. London, 1825, Vol. ii, p. 3,

Report of a Geological Survey of Wisconsin, Iowa, and Minnesota. Philadelphia, 1852. p. 178. Journals, detailed reports, &c., presented to Parliament, 19th May, 1863, p. 41.

Report of the Assimboine and Saskatchewan Exploring Expedition. Toronto, 1859. pp. 39, 67, 148.

Report on the Geology and Resources of the Region in the Vicinity of the Forty-ninth lief, from the Lake of the Woods to the Rocky Mountains. Montreal, 1875, p. 248.

GLACIAL LAKE AGASSIZ IN MANITOBA,

excavation of the valley occupied by Lakes Traverse and Big Stohe and the Minnesota river was first explained in 1868 by Gen. G. K. Wurren, who attributed it to the outflow from this ancient lake. He nade a careful survey of this valley, and his maps and descriptions, with the accompanying discussion of geologic questions, are most valuable coltributions to science.¹ After his death, in commemoration of this work, the glacial river that was the outlet of Lake Agassiz was named River Warren.² That this lake existed because of the barrier of the receipting ice-sheet was first pointed out in 1872 by Prof. N. H. Winchell.

The part of the area of Lake Agassiz which lies in Minnesota, so far as it is prairie, was explored by the writer in 1879 and 1881, under the direction of Prof. N. H. Winchell, State Geologist, with the assistance in 1881 of Horace V. Winchell as rod-man in levelling.¹ Further

in 1881 of Horace V. Winchell as rod-man in levelling,¹ Further exploration of this lake was carried forward in 1885 and 1886 for the United States Geological Survey by the writer, under the direction of Pres. T. C. Chamberlin, with Robert H. Young as assistant, mapping the upper or Herman beaches in North Dakota from Lake Traverse to the international boundary, besides portions of the lower shore line both in North Dakota and Minnesota, with exact determinations of their elevation by levelling. A preliminary report of part of thes observations was published in 1887.⁵

By co-operation of the Geological Surveys of the United States at Canada, a portion of my field-work in 1887 was devoted to the exampation of the northward extension of the beaches of Lake Agassiza Manitoba. Travelling with horse and wagon, and assisted by M. Young as in the two preceding years, a somewhat detailed explorated of this lacustrine area was continued about a hundred miles north from

the international boundary, the most northern points reached being

Continuation in Manitoba.

¹⁴ On certain physical features of the Upper Mississippi River," American Naturalist, ed., pp. 497-592, November, 1868. Annual Report of the Chief of Engineers, United States Armyle 1868, pp. 307-314. "An essay concerning important physical features exhibited in the valge the Minnesota River, and upon their signification," with maps, Report of Chief of Engineer, 35, "Valley of the Minnesota River and of the Mississippi River to the junction of the the solution of the data and American Journal of Science, 111, vol. xvi, pp. 417-431, December, 1875. (General Warn Lied Angust 8, 1852.)

² Proceedings of the American Association for the Advancement of Science, vol. xxvb, 1883, pp. 213-231; also in American Journal of Science, 114, vol. xxvb, Jan, and Feb., 1844; a Geology of Minnesota, vol. i, p. 622.

* First Annual Report of the Geological and Natural History Survey of Minnesota, Jerb p. 63; and Sixth Annual Report, for 1877, p. 81. Professor Winchell also explained in manner the formerly higher levels of the Laurentian lakes, Popular Science Monthly, Ju 833; and the same view is stated by Prof. J. S. Newberry in the Report of the Geological Sur of Ohio, vol. ii, 1874, pp. 6, 8, and 51.

⁴ Geological and Natural History Survey of Minnesota, Eighth Annual Report, for 1872, pd 87; Eleventh Annual Report, for 1892, pp. 137-133, with map: and Final Report, vols, i and ⁶ United States Geological Survey, Bulletin No. 39. The Upper Boaches and Deltas de Glacial Lake Agassiz. pp. 34, with map.

UPHAN.

Shoal Lake, be Ridge post-office wooded characte ling and tracing condition limited ing the Red Rive is formed by th Hills, and Riding Brandon during observations wer include the vicin way to tiriswold, Lang's Valley, a Souris southeast course of that riv margin of Lake . ary. The breadt about a hundred a The upper or height determine Traverse east to] cast-southeast of C ing an extent of Dakota this shore of the Red River V Lake Traverse to thence in a nearly tional boundary. district supplied r and in many insta the beaches of thi reference points entire extent to b ment with the rai vals varying fron methods were em of the Canadian 1 Northwestern agineers of these of the elevations eport and in the ea level at mean urveys from the

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INTRODUCTION.

Shoul Lake, between Lakes Winnipeg and Manitoba, and Orange Ridge post-office, near the southeast end of Riding Mountain. The wooded character of the country further north makes continuous levelling and tracing the beaches of this lake impracticable; and the same condition limited my examination on the east to a narrow helt adjoining the Red River. The western border of this portion of Lake Agassiz is formed by the Pembina Mountain, the Tiger Hills, the Brandon Hills, and Riding Mountain; and the month of the Assiniboine was at Brandon during the highest stage of the lake. In this direction my observations were extended west of the shore line of Lake Agassiz to include the vicinity of the Assiniboine and the Canadian Pacific Railway to Griswold, the course of the Sonris River below Plum Creek, Lang's Valley, a glacial water-course extending from the Elbow of the Souris southeast to Pelican Lake and the Pembinn River, and the lower course of that river, by which a large delta was deposited in the west margin of Lake Agassiz a few miles south of the international boundary. The breadth of the country thus traversed from east to west is about a hundred and fifty miles.

The upper or Herman beach of Lake Agassiz was traced and its height determined in Minnesota by continuous levelling from Lake Traverse east to Herman and thence north to Maple Lake, twenty miles est-southeast of Crookston, a total distance of about 175 miles, including an extent of 140 miles from south to north. Through North Dakota this shore was thus followed continuously along the west side survey. of the Red River Valley about 250 miles, extending northwesterly from Lake Traverse to the vicinity of Wyndmere, Milnor, and Sheldon, and thence in a nearly direct course slightly west of north to the international boundary. Protiles of the numerous railway lines crossing this district supplied reliable elevations above the sea level at their stations; and in many instances they also show distinctly their intersections of the beaches of this lake. These elevations were taken as the data and reference points of my levelling, which was proved throughout its entire extent to be accurate within close approximation by its agreement with the railway surveys, the comparisons being made at interrals varying from twenty to forty or fifty miles apart. The same methods were employed in this survey in Manitoba, where the profiles of the Canadian Pacific Railway and its branches and of the Manitoba Northwestern Railway, kindly supplied for my examination by the ngineers of these roads, were similarly the basis of my determinations of the elevations of the beaches. All these heights, as stated in this eport and in the annexed notes of railway profiles, are referred to the en level at mean tide; and the close agreements of several independent elevations to urveys from the sea to this district and of the profiles of the many the sea level.

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GLACIAL LAKE AGASSIZ IN MANITOBA.

intersecting lines of railway in Minnesota, South and North Dakota and Manitoba, give complete assurance that these heights are not only consistent together but also absolutely true within limits of error prohably nowhere exceeding five feet. Such exact determinations of the elevations of the beaches of this lake seem very important because these deposits which were formed along the level shores of the lake in its successive stages are found at the present time to have a gradual ascent from south to north, amounting to about a foot per mile in the highest and oldest beach and gradually diminishing to a quarter or even an eighth part of this amount in the lowest and latest of the beaches. The general topographic features of the region traversed the character of the drift deposits, its underlying geologic formations, and numerous records of the sections passed through by well-, were also noted.

BA

UDSON

I

In this report are successively presented a brief description of the topography of the basin of Lake Agassiz, an account of the drift formations in Manitoba, and the history of this glacial lake in its relationship to the recession of the ice-sheet as shown by terminal moraines. The beaches and delta deposits of Lake Agassiz observel in Manitoba are described in detail, including their chauges of levels from the time of the highest and earliest to that of the lowest and latest beaches. Next follow notes of wells, and remarks on the soil, the agricultural capabilities of the district, and its economic geology, Finally, in Appendices I and II the courses of glacial stria in an about the area of Lake Agassiz, and tables of altitudes in Manitola, Assiniboia and Alberta, are given.

A map showing the whole extent of Lake Agassiz and for comparison with it the upper great lakes that outflow by the Saint Lawrence, and another map showing the beaches of this lake in Manitoba and isdeltas brought in by the Assiniboine and Pembina Rivers, accompany Accompanying this report. The courses of glacial striae and the terminal morning of the ice-sheet are noted on each. It should be remarked, however, respecting the first of these maps, that the northern and northeastern boundaries of this glacial lake probably can never be exactly determined, and must be laid down in any attempt of this kind, by estimation; for they were formed by the receding ice-sheet instead of a land surface on which beaches would be discoverable. During the formation of its highest continuous and well marked beach, this lake extended north in Minnesota at least to Maple Lake, and in Manitoba to Thornhill. The continued recession of the ice-sheet during the time of formation of the sixteen beaches made at lower levels while the lake outflowed southward probably caused it to attain nearly the area shown on this map before it began to be discharged into Hudson Bay, Afterward,

Plan of this report

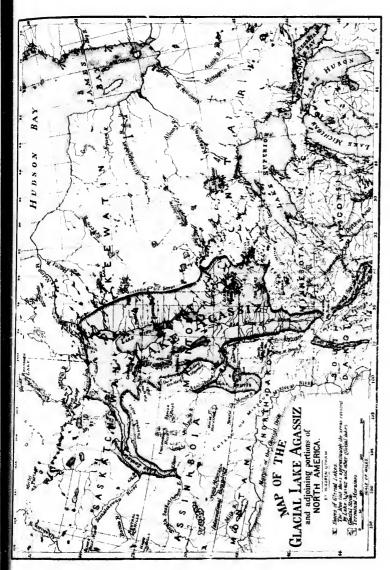
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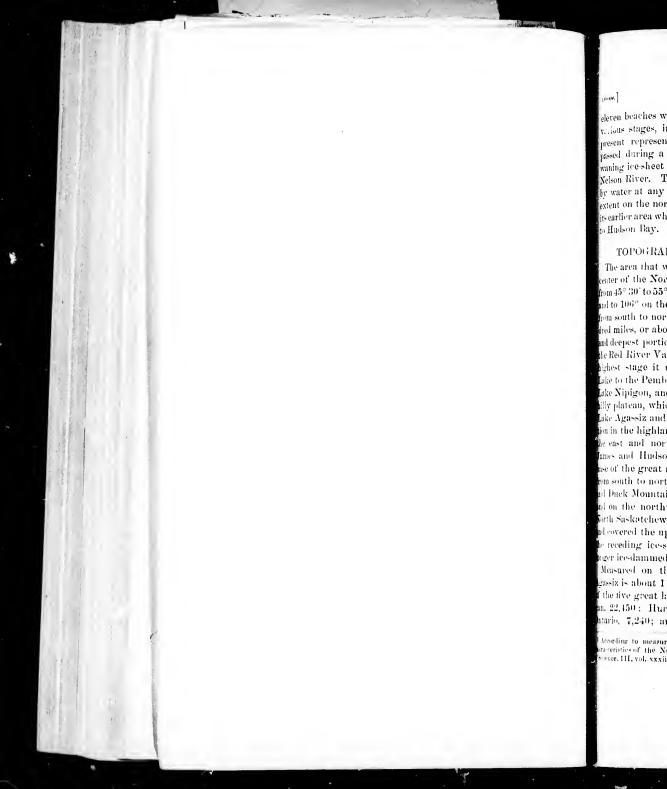
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INTRODUCTION.

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eleven beaches were formed while the lake stood near.y stationary at $\tau_{c,ious}$ stages, interrupting the further descent of its surface to its present representative, Lake Winnipeg, its northward ontflow having pased during a considerable time along the southern border of the waning ice-sheet before it was melted from the present course of the Xelson River. The lacustrine area therefore was not wholly covered by water at any one time; for when the lake reached its maximum extent on the north and northeast, it had receded below that portion of its earlier area which lies above the beaches marking its stages tributary to Hudson Bay.

TOPOGRAPHY OF THE BASEN OF LAKE AGASSIZ.

The area that was covered by Lake Agassiz occupies the geographic center of the North American continent. Its extent is approximately Area of Lake Agassiz. from 45° 30' to 55° of north latitude, and from 92° 30' to 100° at Brandon, and to 106° on the Saskatchewan, of west longitude. It thus measures from south to north, and likewise from east to west, nearly seven hunand miles, or about twice the length of Lake Superior. The central and deepest portion of Lake Agassiz covered the broad, flat expanse of he Red River Valley and of the lake region farther north; and in its lighest stage it reached on the international boundary from Rainy lake to the Pembina Mountain. It was separated from Lake Superior, take Nipigon, and James Bay by a moderately undulating or in part ally plateau, which rises 300 to 500 feet above the highest shore of take Agassiz and holds nearly this elevation southward to its terminaion in the highlands bordering Lake Superior, but from which toward he east and northeast a gradual slope descends to the sea level of lames and Hudson Bays. On the west this glacial lake washed the ase of the great range of highlands named in its successive portions on south to north the Coteau des Prairies, Pembina Mountain, Riding ad back Mountains, and the Porenpine Mountain, and Pasquia Hills; al on the northwest it extended beyond the fork of the South and with Saskatchewan. Northward it reached beyond Lake Winnipeg al covered the upper part of the course of the Nelson. When finally be receding ice-sheet gave place for this river, the glacial lake, no ager ice-dammed, was reduced to Lake Winnipeg.

Measured on the accompanying map, the probable area of Lake gassiz is about 110,000 square miles. It thus exceeded the total area with the areas f the tive great lakes, namely, Superior, 31,200 square miles; Michi-different an. 22,450; Huron, with Georgian Bay, 23,800; Erie, 9,960; and lake and the takes of tario, 7,240; amounting together to 94,650 square miles.¹ The Manitoba

According to measurements on the U. S. Lake Survey charts, as stated in "Physical interistics of the Northern and Northwestern Lakes," by L. Y. Schermerhorn, Am. Jour, Sence, HI, vol. xxxii, p. 279, April, 1857.

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GLACIAL LAKE AGASSIZ IN MANITOBA.

areas of the three great lakes of Manitoba, remaining where $hall_{0w}$ depressions prevented the complete drainage of Lake Agassiz, are approximately as follows: Lake Winnipeg, 8,500 square miles; and Lakes Manitoba and Winnipegosis, each 2,000 square miles.

Depth of Lake Agassiz.

Beach ridges.

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At the time of the formation of its highest beach the depth of lake Agassiz above Fargo and Moorhead was nearly 200 feet; above Grand Forks and Crookston, a little more than 300 feet; above Pembina, Saint Vincent, and Emerson, on the international boundary, about 450 feet; and above Lakes Manitoba and Winnipeg, respectively about 500 and 600 feet. The northward ascent of the beaches of this glacial lake a compared with the level of the present time, and its successive stage, during its fall to Lake Winnipeg, will be considered in a later part of this report.

Shore Lines, Deltas. and Dunes.

Viewed in their relation to the general topography, the shore lines of Lake Agassiz are inconspicuous, though they are very distinctly traceable. They are usually marked by a deposit of beach gravel and sund, forming a continuous, smoothly rounded ridge, such as is found along the shores of the ocean or of our great lakes wherever the land sinks in a gently descending slope beneath the water-level. The beaches of Lake Agassiz commonly rise three to ten feet above the adjoining land on the side that was away from the lake, and ten to twenty feet above the adjoining land on the side where the lake lay. In breach these beach ridges vary from ten to twenty-live or thirty rods. In some places they have been ent through and carried away by streams, and occasionally they are interrupted for a quarter or a half of a mile or even two or three miles, where the outline of the lake shore and the direction of the shore entremts prevented such accumulation.

Another type of shore lines is developed where the lake has forme a terrace in the till, with no definite beach deposit, the work of the waves having been to erode and earry away rather than to accumulate. The height of these steep, wave-cut slopes varies from ten to thiry feet, which is indeed a very slight elevation in comparison with the cliffs of till of similar origin on some parts of the shores of Lake Michigan and others of the Laurentain lakes. No portions of the beach ridges nor of these low eroded escarpments, marking the margin of Lake Agassiz, are noteworthy objects in the view from points softw

Eroded shores.

Lake Agassiz, are noteworthy objects in the view from points on a away as two or three miles; but nearer at hand they appear sufficently impressive, when the mind reverts to the receding ice-sheet and this great glacial lake by which they were made.

Delta deposits of sand and gravel, so extensive as to be important features in the topography, were formed in the edge of Lake Agasii by several of its th east side of the lal west side by the Pembina formed : and has a maximu tain," which rises iew mile- south escarpment about Valley at its base the eroded front brought into Lake from northwest to miles. But the la Manitoba, which Portage la Prairi miles north to Gla miles, and its dep about 200 feet.

Extensive tracts and Assiniboine I drifting sand hill hundred feet. T a-pect, being part place- wholly dest drifted by the wir graphy of the Re agriculture is also ing prairie, but th the intervening probably soon after had -pread over t than now, and he size and height; stantly undergoin

East from the f and in part rollin eastern Manitoba is mapped approx boundary, where the country adjoint

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The beaches the adjoining to twenty feet . In breadd irty rods. In y by streams, half of a mile shore and the jon.

ke has forme e work of the to accumulate, ten to thirty ison with the ores of Lake hs of the beach he margin of points so far uppear sufflecice-sheet and

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BASIN OF LAKE AGASSIZ.

by several of its tributary streams. Such deltas were brought into the east side of the lake by the Buffalo and Sand Hill Rivers; and into the set side by the Sheyenne, Pembina, and Assiniboine Rivers. The Deltas. pembina formed a delta that reaches twelve miles from north to south and has a maximum width of seven miles. The "First Pembina Mountain," which rises very conspicuously near Walhalla, North Dakota, a few miles south of the international boundary, as a steep wooded ecarpment about 175 feet above the flat prairie of the Red River Valley at its base, with its crest 1,150 to 1,200 feet above the sea, is the eroded front of this Pembina delta. The sand and gravel beds brought into Lake Agassiz by the Sheyenne River reach fifty miles from northwest to southeast, and their maximum width is nearly thirty miles. But the largest of all these deltas is that of the Assiniboine in ganitoba, which extends from Brandon seventy-five miles east to Portage la Prairie, and from Treherne, Glenboro and Milford forty miles north to Gladstone and Neepawa. Its area is fully 2,000 square miles, and its depth probably averages 50 feet, with a maximum of about 200 feet.

Extensive tracts of the deltas formed by the Sand Hill, Shevenne, and Assiniboine Rivers have been heaped up by the wind in dunes, or drifting sand hills, which vary in height from twenty-five to one hundred feet. Their extremely uneven contour, and their singular spect, being partly covered by small trees and bushes but in many places wholly destitute of vegetation where they are now gullied and drifted by the wind, make these hills a unique element in the topography of the Red River basin. The worthlessness of the dunes for Dunes, agriculture is also in marked contrast with the fertility of the surrounding prairie, but they frequently include patches of good pasturage in the intervening hollows. The time of formation of these dunes was probably soon after the withdrawal of Lake Agassiz, before vegetation had spread over the surface. The winds could then erode more rapidly than now, and heaped up these hills of sand in nearly their present size and height; but it is evident also that their forms have been constantly undergoing slight changes since that time.

Country adjoining Lake Agassiz.

East from the flat prairie of the Red River Valley is the undulating and in part rolling and hilly wooded region of northern Minnesota and castern Manifoba. Through this district the outline of Lake Agassiz is mapped approximately. It extends farthest east on the international boundary, where it reaches beyond Rainy Lake. The general level of Wooded region the country adjoining Rainy Lake and the Lake of the Woods is 50 to Manifoba.

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GLACIAL LAKE AGASSIZ IN MANITONA.

150 feet below the highest stage of Lake Agassiz; but the northern and eastern part of this district may have been still covered by the waning ice-sheet when the lake stood at that height. On account of the impracticability of tracing the shores of Lake Agassiz through this wooded and uninhabited region, the northeastern limits of this glatial lake, where the shore in its successive stages passed from the land surface to the barrier of the receding ice-sheet, remain undetermined.

The country north and northeast of Lake Winnipeg presents no considerable elevations, but is mainly a broad, nearly flat expanse, similar to the Red River Valley and the lake district of Manitoba, slowly declining to the sea level. Dr. Robert Bell writes of it as follows:-"The region through which the upper two thirds of the Nelson River flows may be described as a tolerably even Laurentian plain, sloping towards the sea at the rate of about two feet in the mile. The river, for the first hundred miles from Great Playgreen Lake, does not flow in a valley, but spreads itself by many channels over a considerable breadth of country. This tendency to give off 'stray' channels is characteristic of numerous rivers throughout the northern and comparatively level Laurentian regions, but it is perhaps more strongly marked in the Nelson than in any other. In the above section of this stream the straggling channels are of all sizes, from mere brooks up to large rivers. . . . The general aspect of the country is even, or slightly undulating, the highest points seldom rising more than thirty or form feet above the general level." The country adjoining the lower par of this river, according to the same explorer, has a similar contour, only moderately uneven; but the channel of the river, excepting it the ten miles next to its mouth, is deeply eroded. Its enclosing bluff vary in height from one hundred to two hundred feet between Broad Rapid, where the river is approximately 125 feet above the sea, and Gillam's or Lower Seal Island, which is at the head of the tide, about twenty miles from Hudson Bay.¹

Along the west side of the basin of the Minnesota River, of the Red River Valley, and of Lakes Manitoba and Winnipegosis, the surface rises from two or three hundred to one thousand feet above the slightly multilating or quite flat belt of lowland. No other feature in the contour of the Northwestern States and adjoining British territery is more noteworthy, extended and prominent, than this, excepting perhaps the ascent along the similar and parallel Coteau du Missouri. The latter, however, lacks the accompaniment of such a continuous broad depression beside it. This wide valley, occupied by Lake Winnipeg, Manitoba and others, and by the Red and Minnesota Rivers

¹ Geological Survey, Reports of Progress for 1877 to 1879,

Ascent westward from Lake Agassiz.

Plain stoping from Lake Winnipeg to Hudson Bay, described by Dr. Bott. 14 E

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varying in eleva of the slowly aswestward to a 1 at the foot of Most of this elev firefect per mil River to the Romately from son again in the Ce surface rises mon a terrace-like asc and continuing s glacial lake while Rivers.

The southern high Coteau des , of South Dakota, des Prairies, wes seventy-tive miles spicuous, or in so ferils the oppos Farther north thi Pembina Mounta Mountains and t accessive parts o ing from North 11 pegosis to the S aned are divide treams.

Pembina Mount or a distance of a f the internation art of T. 158, R. Jouth and Middle bout six miles eas ighland turns to ame Tiger Hills. 1400 feet high, ext a few degrees uies from a half plateau, having t with slow ascep undary averages

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BASIN OF LAKE AGASSIZ.

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varying in elevation from 710 to 1,100 feet above the sea, is the base of the slowly ascending expanse of the great plains which rise thence westward to a height somewhat exceeding 4,000 feet above sea level at the foot of the Rocky Mountains on the international boundary. Most of this elevation is attained by a gradual slope, averaging four or fire feet per mile throughout the distance of 730 miles from the Red River to the Rocky Mountains ; but at two lines, extending approximately from south to north, first on the west side of this valley, and again in the Coteau du Missouri, 100 to 200 miles farther west, the surface rises more rapidly several hundred feet within a few miles by a terrace-like ascent. The first was the western shore of Lake Agassiz, and continuing south and southeast held the same relation to an earlier glacial lake which occupied the basin of the Minnesota and Blue Earth Rivers.

The southern portion of this line of elevation is the massive and high Coteau des Prairies of southwestern Minnesota and the east part of South Dakota. Its lower continuation from the Head of the Coteau des Prairies, west of Lake Traverse, for the next one hundred and coteau des erenty-live miles northward, bears no name, and is scarcely more contraining spicons, or in some parts even less so, than the moderate ascent that continuing the opposite border of the Red River Valley in Minnesota. Farther north this line of higher land rises abruptly 300 to 500 feet in Penbina Mountain, and from 500 \pm 0.000 feet in Riding and Duck Montains and the Porcupine and Pasquia Hills. All of these are necessive parts of a very remarkable terrace-like escarpment, stretchng from North Palaci, by the west side of Lakes Ma itoba and Winniegois to the Saskatchewan River. Its portions thus differently amed are divided by deep and broad valleys eroded by intersecting treams.

Pembina Mountain is a distinct and conspicuous topographic feature is a distance of about seventy-five miles, of which two thirds lie north if the international boundary. Its southern end is in the southwest art of T. 158, R. 56, in Walsh county, North Dakota, between the bound and Middle branches of Park River; and its northern end is pembina out six miles east-southoast from Treherne, where the course of this Mountain, ighland turns to the west and its more uneven continuation takes the me Tiger Hills. It is a prominent, wooded escarpment, mostly 300 400 feet high, extending in a very direct course from south to north is a few degrees west of north. The width occupied by its slope ries from a half of a mile to two or three miles, and from its crest plateau, having a moderately rolling surface, stretches nearly level with slow ascent westward. Its crest north of the international undary averages about 400 feet above its base, or 1,400 feet above

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the northern overed by the On account of z through this of this glacial from the land undetermined, resents no conspanse, similar nitoba, slowly t as follows:-e Nelson River, plain, sloping The river, for

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iver, of the Rei osis, the surface eet above their other feature in Beitish territory this, escepting eau du Missouri h a continuoupied by Lake innesota Rivers

GLACIAL LAKE AGASSIZ IN MANITOBA.

the sea; but within a few miles farther west the rolling surface of the highland rises 100 to 200 feet higher.

Northwestward from Treherne the plateau of which Pembina M_{Out} tain forms the eastern edge, is interrupted across a distance of six_{t} , tive miles, to Riding Mountain. This broad depression is occupied by the Assiniboine and its tributaries, and by small streams on the northeast which send their waters to Lake Manitoba. The plateau, indeed, loses its regularity of surface upon all the country further north and west, because it has been eroded to the depth of several hundred feet on the greater part of the basin of the Assiniboine.

The border of the plateau south of this river, reaching from close south of Treherne westerly fifty miles to the Elbow of the Souris River. is called the Tiger Hills.1 It is irregularly sculptured in steep rounded, massive hills, and is overspread by drift deposits consisting partly of morainie accumulations. For a distance of forty miles wes from the Pembina Mountain this belt occupies a width of five to eight miles, upon which the surface falls from south to north 300 to 400 feet. The country on the south has an average elevation nearly de same as the summits of the hills, which yet rise very prominently a seen from the lower region on the north. The western part of the Tiger Hills, extending ten or twelve miles east and an equal distance west from the gorge that is cut through the range by the Souris, rise considerably above the adjoining nearly flat surface on each side. The foot of the belt of hills there is 100 to 150 feet lower on the north that on the south; and the Souris flows through it in a gorge 350 feet deep From this vicinity Hind applied the name Blue Hills of the Sourist this belt, but that name is not used by the people of the district.

North of the Assiniboine the eastern outline of the continuational this plateau is preserved in the prominent elevations of Riding and Duck Mountains, two remarkable wooded highlands, much alike is their general features and extent. The steep eastern escarpment each is about fifty miles long, that of Riding Mountain trending free southeast to northwest, and that of Duck Mountain having a course few degrees west of north. These elevations rise above the county adjoining the Assiniboine by a somewhat gradual slope, but they as abruptly cut off on their northeast side by a precipitous descent. The takes place on a line approximately parallel with Lakes Manitola an Winnipegosis, the former of these lakes being about forty miles east Riding Mountain, while the south end of the latter is twenty-tive mile east of Duck Mountain. The crests of these highlands, according: Mr. J. B. Tyrrell's measurements, are respectively about 2,000 at

¹ From the aboriginal name, which doubtless refers to the eougar or American Pauther M concolor, L.). 2.300 to 2,700 Manitoba; and feet above the lakes on the ea

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Beyond Duck across the basir continued in the twenty-five mild plateau, similar activity on the side another gap and Overflowing Next are the

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Riding and Duck Mountains.

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BASIN OF LAKE AGASSIZ.

2300 to 2,700 feet above the sea, the latter being the highest land in Manitoba; and the bases of their escarpments are about 1,200 to 1,500 feet above the sea, being four hundred to seven hundred feet above the Jakes on the east, whose height slightly exceeds 800 feet.

The reader is referred to Mr. Tyrrell's maps and descriptions of the district of Riding and Duck Monntains, to be published in the annual Maps and reports of this Survey, for details of its topography and geology and reports of Mr. of the shore lines of Lake Agassiz north of the limit of my exploration. Beyond Duck Mountain, after an interruption of about thirty miles across the basins of Swan and Woodv Rivers, this line of highlands is continued in the Porcupine Mountain or Hills, which reach about Preparine time, twenty-live miles from south to north. These form a somewhat broken plateau, similar with the preceding in its general features of steep acclivity on the east and gentle descent westward. On their north side another gap about twenty miles wide is occupied by the Red Deer and Overflowing Rivers.

Next are the Pasquia Ilills, whose eastern end is in line with Pemlina, Riding and Duck Mountains, and the Porcapine Hills, being about a hundred miles west from the mouth of the Saskatchewan. The Pasquia Ilills extend thence a hundred and fifty miles westward, where they formed the southern shore of the northwestern arm of Lake Pasquin Illils. Agassiz, lying about twenty-five miles south of the Saskatchewan River and parallel with it, to the Birch Hills and the South Saskatchewan Eiver. They are the northern escarpment limiting the irregularly erskel country which is here considered as an extension of the great plateau of North Dakota and southern Manitoba and Assiniboia, thus biding the same relation to the valley of the Saskatchewan that the T.er Hills sustain to the Assiniboine Valley.

Existing Lakes within the area of Lake Agassiz.

The glacial Lake Agassiz was gradually reduced in size, first by the ension and lowering of its southward outlet, and afterward by finding spressively lower outlets to the northeast, until with the complete departure of the ice-sheet it sunk to its present representatives, the grat lakes of Manitoba. These are three in number, Lakes Winnipeg. The great lakes Manitoba, and Winnipegosis. With them are associated several others, ^{eff} Manitoba, comparatively small, as Cedar Lake, through which the Saskatehewan flows near its mouth, Lake Dauphin, south of Lake Winnipegosis and clientary to it, and Lake Saint Martin on the Fairford or Little Saskachewan River, the outlet of Lakes Manitoba and Winnipegosis. Lake Winnipeg is two hundred and fifty miles long, trending from

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GLACIAL LAKE AGASSIZ IN MANITOBA,

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part is about twenty-five miles, and of its northern part sixty miles Its area is approximately \$,500 square miles, being intermediate in extent between Lakes Ontario and ' ... Eighty-five miles fromity LakeWinnipeg, south end, Lake Winnipeg is reduce . strait two to four miles wide. which extends northwesterly two miles, terminating at the cape called Dog's Head. The narrowest part of the streit, scarcely exceed ing a mile in width, is at this cape. Here the strait opens into the northern and main portion of the lake, which includes five sixths of its area. The elevation of Lake Winnipeg, determined by the surveys for the Canadian Pacific Railway, is 710 feet above the sea. Its depth according to Mr. J. Hoyes Panton, nowhere exceeds sixty-live feet "The shallowness of this comparatively large body of water," as Mr. Panton writes, " accounts for its treacherous nature and explains how on many occasions it has proved a disastrons water-way to the freight ing boats of by-gone days. As you sit upon the deck of the steamer threading its way among the islands, you are surprised at the tortuon course made, when water seems on every side and no shore near, a shallow is the lake that many places miles from land are not covered with more than six or seven feet of water. It is only safe to experienced captains, thoroughly acquainted with the concealed channel that afford a safe course at a distance from the shore." 1 On account @ this slight depth, the mud brought in by the Red River is held in six pension, being almost constantly stirred up from the bottom by the waves of the lake, throughout its southern half; but in the break northern half of its length, beyond Beren's River and Island, the water is comparatively clear.² Low land borders this lake along nearly a whole extent, and the highest points on the shore or visible from rarely attain an elevation of fifty feet.

> Lake Manitoba,3 from which comes the name of the province of Manitoba, lies about forty miles west of the south half of Lake Windpeg; and Lake Winnipegosis,' separated only about two miles from the north end of Lake Manitoba, lies mostly forty to fifty miles west of th north half of Lake Winnipeg, but its most northeast part is only tweet miles southwest from that lake. The length of each of these lake

1 " Notes on the Geology of some islands in Lake Winnipeg," Transactions of the Ilistatical Scientific Society of Manitoba, Jan. 28, 1886.

³ Meaning the "Narrows or Strait of the Manitou or Great Spirit," as I am informed by k from Prof. George Bryco and Mr. J. B. Tyrrell. This name was originally pronounced by a inhabitants, nearly as by the Indians, with accents on the initial and final syllables ; but im the past ten years or more its almost universal pronunciation in English has been with only accent, which is laid on the next to the last syllable.

"Meaning "Little Winnipeg."-Hind's Narative of the Canadian Exploring Expeli vol. ii, p. 42.

measured in trending in p an area of net to their size, r of Lake Mani it- middle, it two miles long nearly interse according to le being thus alm The country 1 Lake Dauphin mately level, b per mile. The miles. Its nor following this e moreover, are y son of bays, caj Lake and River teet above the la Railway, or 828

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ary, are bodies o part of the area fifty miles, tren average width is approximately. bays and narrow is about 1,117 fee by Dr. A. C. Law The Lake of the isga large penin on the north and y narrow channe

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² " Lake Winnipeg receives its name from the muddy or sallow appearance of its water." signifies muddy, and Nope water, in Chippewa,"-Keating's Narrative of Long's Expedit vol. ii. p. 77.

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measured in a straight line, is about a hundred and twenty miles, trending in parallelism with Lake Winnipeg; and each of them covers an area of nearly 2,000 square miles. Both are shallow in proportion to their size, and are surrounded by low shores. The maximum width of Lake Manitoba, about twenty-eight miles, is at its south end. Near its middle, it is narrowed to a strait about half a mile wide and two miles long. Its northern part is of quite irregular form, and is nearly intersected from the north by a long peninsula. This lake, according to levelling by Mr. II. S. Treherne, is 809 feet above the sen, being thus almost exactly a hundred feet higher than Lake Winnipeg. The country between these lakes and from Lake Manitoba west to Lake Dauphin and to Riding and Duck Mountains is low and approximately level, but has a general westward ascent, averaging a few feet per mile. The width of Lake Winnipegosis varies from five to fifteen miles. Its northern portion is bent to the west, so that its length, following this curve, is nearly a hundred and fifty miles. Its outlines, moreover, are very irregular, presenting a constantly varying successon of bays, capes, and islands. This lake outflows by the Water Hen Lake and River to Lake Manitoba, and has a elevation of nineteen teet above the latter, as determined by surveys for the Canadian Pacific Railway, or 828 feet above the sea.

Rainy Lake and the Lake of the Woods, on the international boundary, are bodies of water of considerable size, lying within the eastern part of the area of Lake Agassiz. The length of Rainy Lake is nearly Rainy Lake, fity miles, trending from east-southeast to west-northwest, and its average width is about five miles, giving it an area of 250 square miles, approximately. It is much diversified by projecting points, numerous lays and narrow arms, and plentiful islands. Its height above the sea is about 1,117 feet; and its maximum depth, according to soundings by Dr. A. C. Lawson, is a hundred and ten feet.

The Lake of the Woods has a very irregular form, nearly surrounding a large peninsula in its northern part, and including many bays on the north and east, some of them connected with the main lake only by narrow channels. A multitude of islands, large and small, dot its surface, excepting in its southwest part, called Sand Hill Lake, where is adjoins Minnesota. Measured from north to south or from east to Lake of the west, its maximum extent in either direction is sixty miles, approxiwoods, mately; and its area is about 1,500 square miles. Its elevation, deternined by the Canadian Pacific Railway survey, is 1,060 feet above the ear and the maximum depth of its northern part, called Clear Water take, is stated by Dr. Dawson to be eighty-four feet.

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GLACIAL LAKE AGASSIZ IN MANITOBA.

Rivers tributary to Lake Agassiz and draining its area.

The area of Lake Agassiz is drained to Lake Winnipeg, chiefly by the Winnipeg, Red, and Little Saskatchewan or Fairford Rivers. On the northwest this glacial lake also included the region crossed by the lower part of the Saskatchewan. Flowing out from Lake Winnipeg, the united waters of all these river systems are carried by the Nelson to Hudson Bay.

> It seems probable that the recession of the ice-sheet uncovered the entire course of the Rainy and Winnipeg Rivers before Lake Agassiz had fallen below the level of Rainy Lake. These are upper and lower portions of the main trunk of the same river system. East of Rainy Lake a large tract tributary to it reaches nearly a hundred miles on the international boundary, including almost countless lakes and small streams. The Rainy River, about eighty miles long, connecting Raine Lake and the Lake of the Woods, is a broad and majestic, deep stream, with an average width of a sixth of a mile, flowing in generaling somewhat direct west-northwest course. At the month of Rainy Lake it has rapids that fall about three feet. Its principal falls are at Fort Francis, a little more than two miles from Rainy Lake, where it descends twenty-three feet in about a tenth of a mile. Maniton Rapids, about thirty-five miles from Rainy Lake, are a short descent of about two feet, with outeropping rock in the channel and banks. Six miles below these is the Long Sault, a mile in length, estimated by Major Long to have "an aggregate descent of about ten feet," Excepting these rapids, Rainy River has an average descent of only about three inches per mile, giving to the ordinary low stage of water a very gentle current. It is navigable for large steamboats from the Lake of the Woods to the foot of the Long Sault; and chence to Rainy Lake it is navigated by a tug or propeller, towing Mackinan boats. The banks of the river are only ten to twenty feet high, and are fertile and heavily wooded, having commonly a clayey soil.

Winnipeg River, the outlet of the Lake of the Woods, has a length of about a hundred and sixty miles, flowing in a winding course to the northwest. Its total descent is 350 feet, four-fifths of this being in the many talls and rapids which occur along nearly its entire exter. These falls are divided by portions with only a strong or gentle current, or by lake-like expansions of the river where no current is peceptible. On each side the country rises to a moderate elevationi low hills and ridges, with trequent outcrops of the bed-rocks. The highest land crossed by the Canadian Pacific Railway south of the Winnipeg River, from eighteen to twenty-eight miles west of R Portage, is about 200 feet above the Lake of the Woods and about 50 feet above La Lake Agassiz, Lake, is a larg important utflu siderable area River is very e of Lake Winnly

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The Red Riv Red River of L above the sen, t about sixty mile Many Point, R Lakes, to Otter Tail River. In The contour of t andulating or fl called the Red 1 and the prevailin as Otter Tail Riv miles west of O feet, or about five Because of the n its volume along by either heavy r at Breckenridge measured in a di the Red River, n south, west, and nowhere diverging miles. Its descer its source to its McCauleyville and ridge, it is navigat the Goose Rapids, of Goose River as the channel is obs low stages of wate varies from six to length of the steam eommonly twent lighest stages inc hirty-two feet at M ity feet at Belmon

Rainy River.

Winnipeg River. 20 E

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acovered the ake Agassiz er and lower ust of Rainy red miles on ces and small ecting Rainy deep stream, general in a f Ruiny Lake Is are at Fort ke, where it ile. Manitou ort descent of d banks. Six gth, estimatel omt ten feet." escent of only low stage of enmboats from and chence to ing Mackinaw feet high, and ey soil. s, has a length g course to the is being in the entire extent or gentle cur current is per te elevation is

BASIN OF LAKE AGASSIZ,

feet above Lake Winnipeg, rising thus nearly to the highest level of Lake Agassiz. English River, which flows through Lac Seul or Lonely Lake, is a large tributary of the Winnipeg from the east. The only important affluent from the south is the Whitemouth, draining a considerable aren west of the Lake of the Woods. The water of Winnipeg River is very clear, and is strongly contrasted with the muddy water of Lake Winnipeg with which it mingles at its mouth,

The Red River of the North, so named to distinguish it from the Red River of Louisiana, has its source in a small lake about 1,600 feet above the sea, thirteen miles west of Lake Itasca. It first flows south about sixty miles, mensured in a direct line, passing through Elbow, Many Point, Round, Height of Land, Little Pine, Pine, and Rush Lakes, to Otter Tail Lake, this portion being commonly called Otter Tail River. In this distance it descends to 1,315 feet above the sea. Rod Biver of The contour of the adjoining country is rolling or hilly northward and indulating or flat southward. Below Otter Tail Lake this stream is called the Red River by this report, following the example of Owen and the prevailing popular usage; but it is still occasionally spoken of as Otter Tail River to its junction with the Bois des Sioux, forty-two miles west of Otter Tail Lake. The descent in this distance is 372 feet, or about five feet per mile, following the course of the stream. Because of the numerous large lakes on the upper part of its course, its volume along this descent to Breckenridge is not greatly affected by either heavy rains and snow-melting or dry seasons. From its bend at Breekenridge and Wahpeton the Red River flows north 285 miles. measured in a direct line, to Lake Winnipeg. The entire length of the Red River, measured thus in straight lines successively to the tough, and south, west, and north, is about 390 miles; but in its meanderings, descent, nowhere diverging far from these lines, it flows nearly seven handred miles. Its descent below Breckenridge is 233 feet, and in total from its source to its mouth approximately 900 feet. All the way below Mclauleyville and Fort Abererombie, titteen miles north of Breckenridge, it is unvigated by steamboats, barges, and flat-boats; but along Navigation, the Goose Rapids, extending about twelve miles next below the month of Goose River as measured in the meandering course of the stream, the channel is obstructed by boulders which forbid navigation during low stages of water. The width of this river in the United States varies from six to twenty rods, being in some places less than the te clevation a length of the steamboats; but north of the international boundary it al-rocks. The semmonly twenty rods wide. The range between its lowest and y south of the bighest stages increases rapidly north of Breckenridge, becoming s west of R shirty-two feet at Moorhead and Fargo, and attaining its maximum of and about 50 mity feet at Belmont. It continues nearly at forty feet from Grand

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GLACIAL LAKE AGASSIZ IN MANITOBA.

Forks to the international boundary and to Winnipeg, At Lower Fort Garry, sixteen miles north of Winnipeg and about twenty miles Highes, floods. from the mouth of the river, it is thirty-five feet; but beyond that point it rapidly diminishes in approaching Lake Winnipeg. Floods rising nearly or quite to the high water line thus noted have been rare, occurring in 1826, 1852, 1860, 1861, and 1882. They are caused in the spring by the melting of unusual supplies of snow and by accompanying heavy rains, and often are increased by gorges of ice. These floods attain a height only a few feet below the level of the adjoining prairie where that is highest, and along the greater part of the distance between Grand Forks and Lower Fort Garry the banks are overflowed and the flat land on each side of the river to a distance of two to four or five miles from it is covered with water one to five feet or more in depth.

> Excepting the Red Lake River and the Sheyenne, Pembina, and As-iniboine, all the tributaries of the Red River are small, the length of their areas of drainage varying from forty to seventy-five miles. In summer droughts several of them, including the Bois des Sioux, are dried up along the greater part of their course, containing only here and there pools in the deeper hollows of their channels.

> Sheyenne River, having its sources near the great southeastern bend of the Seuris River in North Dakota, first flows to the east nearly a hundred miles, passing ten miles south of Devil's Lake; next it flows south about a hundred miles, to where it enters the area of Lake Agassiz; and thence its course is eastward and northward, miting with the Red River ten miles north of Fargo and Moorhead. The large valley of the upper part of this river, and its extensive dela deposited in Lake Agassiz, are probably attributable to a stream much larger than the present Sheyenne, formed by drainage from the iesheet when it terminated near Devil's Lake. At that time, also, a glacial lake in the basin of the Souris outflowed southeastward to the Sheyenne and James Rivers.

> During a later stage in the recession of the ice-sheet, this glacial lake in the Souris basin was extended west and north of 'Tartle Mountain and finally found a lower outlet in southern Manitoba. Its out-

> flowing river ran southeasterly from the Elbow of the Souris, eighteen miles southwest of its month, to the Pombina River. Pelican Lake, eleven miles long from northwest to southeast and about a mile wide occupies a part of the channel of this stream; and a distinct watercourse of similar width, called Lang's Valley,' eroded 110 to 150 fee below the general level, extends eleven miles between this lake and

¹ Named for James Lang, who was the first inamigrant here, coming in 1880.

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the Souris. The the sea and alcaclosed by blu Lakes Travers River Warren of Pembina Riv.

a rather crooke edge of North 1 in a direct line, junction with the First Pembina M Rock Lake and long and from a into this valley drainage from the Pembina runs in from the northe feet, and thence being 748 feet al or Cypress River the south side.

The Assiniboi lasin three hund miles long from : of the Porenpine hundred miles, t Qo'Appelle and t about a hundred level at the mout Canadian Pacific Souris, about 1,1 junction with the stages of water, Fort Ellice at th varies from ten te The highest flo a considerable dis it-lowest stage, the highest portion merged. At this

This name is stated i beashortened and corr opalas, L.).-Narrative

Tributaries of Red River.

Sheyenne River.

Lang's Valley.

BASIN OF LAKE AGASSIZ.

the Souris. The highest portion of Lang's Valley is 1,364 feet above the sea and about 100 feet above the Souris at its Elbow, and it is enclosed by blutis 110 feet high. It is a chaunel similar to that of Lakes Traverse and Big Stone and Brown's Valley, eroded by the River Warren outflowing from Lake Agassiz.

Pembina River 1 flows from the northern part of Turtle Mountain in a rather crooked easterly course through southern Manitoba and the edge of North Dakota about one hundred and thirty miles, measured in a direct line, to its mouth at Pembina and Saint Vincent. From its junction with the outlet of Pelican Lake to Walhalla at the base of the First Pembina Mountain, its valley varies from 175 to 450 feet in depth. Pembina River. Rock Lake and Swan Lake on this part of the river, each several miles long and from a half mile to one mile wide, are due to deposits brought into this valley by tributaries after it ceased to be the avenue of drainage from the Sonris basin. In crossing the Red River Valley the Pembina runs in a channel only twenty to forty feet deep. Its descent from the northern base of Turtle Mountain to Walhalla is about 790 feet, and thence to its mouth 186 feet, its junction with the Red River being 748 feet above the sea. Long or White Mud River, Clearwater or Cypress River, and Tongue River, are its chief tributaries, all from the south side.

The Assiniboine, the largest tributary of the Red River, drains a lasin three hundred miles wide from south to north and four hundred miles long from west to east. From its sources, fifty miles southwest of the Porcupine Hills, the Assiniboine flows south-southensterly two handred miles, to a point about fifty miles below the mouth of the Assiniboine qu'Appelle and forty miles west of Brandon; thence it flows easterly fliver, about a 'hundred and fifty miles to its mouth. Its height above sea level at the mouth of the Qu'Appelle is 1,264 feet; at the bridge of the Canadian Pacific Railway near Brandon, 1,161 feet; at the mouth of the Souris, about 1,100 feet; at Portage la Prairie, 842 feet; and at its pinetion with the Red River in Winnipeg, 724 feet. During its high stages of water, the Assiniboine has been mavigated by steamboats to Fet Ellice at the mouth of the Qu'Appelle. Along this portion it varies from ten to twenty-five rods in width.

The highest floods of the Assiniboine at Portage la Prairie and along a considerable distance eastward rise only twelve to fifteen feet above its lowest stage, but they then attain a height only a few feet below Overflow from the highest portions of the adjoining country, much of which is sub the Assiniboine merged. At this extreme height, which the river reached and main-Manitoba.

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At Lower twenty miles beyond that peg. Floods d have been now and by gorges of ice, level of the reater part of cry the banks to a distance er one to five

Pembina, and all, the length five miles. In les Sioux, are ing only here

theastern bend e east hearly a ; next it flows area of Lake hward, uniting oorhead. The extensive delta a stream much from the icet time, also, a astward to the

et, this glacial t'Turtle Mounitoba. Its outouris, eighteen Pelican Lake. ut a mile wide. distinct water 110 to 150 fee this lake and $23~{\rm e}$

This name is stated by Kenting to be from the Ojibway word "*aneponinon*, which name has ben-shortened and corrupted into Penbina," meaning the fruit of the bush eranberry (Viburnum "gdus, L.).-Marative of Long's Expedition, vol. in, p. 38.

QLACIAL LAKE AGASSIZ IN MANITOBA.

tained from the 3rd to the 15th of May, 1882, the only time of such high water since 1860 or 1861, it overflowed near the former site of the fort of the Hudson's Bay Company two miles southwest of Portage la Prairie, and a portion of its flood passed north in shallow, winding water-courses to Lake Manitoba, making a descent of about forty feet in the distance of fifteen miles between the river and the lake. Near the same time Lake Manitoba also reached its highest stage, about $\frac{1}{1000}$ overdow from the same time Lake Manitoba also reached its highest stage, about Lake Manitoba eight feet above its lowest level, rising until it overflowed southward and the across the east part of T. 13, R. 6, and thence eastward through the southern row of sections in T. 13, R. 5, falling ten feet in tiltera tilles to Long Lake, through which old channel of the Assiniboine its waters were discharged into this river twenty miles east of Portage la Prairie,1

> Qu'Appelle or Calling River and the Souris or Mouse River ave the largest tributaries of the Assiniboine. Each of these streams has an interesting glacial history, which is recorded in the topographic features of their valleys and areas of drainage. The Qu'Appelle valley was the outlet of a glacial lake in the basin of the South Saskatchewas, The description, map and sections given by Hind.² show that till, valley is quite uniformly about one mile wide, and is from 110 to 550 feet below the general level of the region through which it lies this height being reached by steep bluffs on each side. Its length, from the Elbow of the South Saskatchewan to its junction with the Assic boine is about two hundred and seventy miles, the general course being a little to the south of east. Of this extent the west end of the valley for about twelve miles is occupied by the River that Turns, and the remainder by the Qu'Appelle, the summit or height of land in this channel at the divide between these rivers being approximately 55 feet above the South Sa-katchewan, 440 feet above the mouth of the Qu'Appelle, and 1.700 feet above the sea. The enclosing bluit- are composed mainly of glacial drift, with only a few exposures of the underlying Cretaceous rocks. The alluvial bottomland of the Qa'Appelle is generally from a half mile to one mile wide, and through it the river flows in a winding course, here and there passing through lag lakes. Like the similar lakes of the Pembina and Minnesota Rivers these owe their existence to the recent deposits of tributaries and show that the bed of the glacial river was considerably lower than that of the present stream. The outflow of the Saskatchewan gladal lake, fed by the melting ice-fields of an immense area reaching west to

the Rocky Moun er valley, enterin border of Lake A Long or Last north and one or On'Appelle and ta The elevation of lower than the di Sekatchewan to icesheet had recea extend to the diobtained some low of this lake, fors relati elevation Agassiz since that one of several su S-skatchewan basi even a hundred fe ("Appelle, that i difference being pro between the old an Souris River, fle ato North Dakota ributary to the As wn basin, at firs wholly drained av Pembina River. miles, but it is only North Dakota its hove the sea, and

Little Saskatchev nore than two hund n equal distance Winnipegosis to th eccives several sm River, the outlet of ensiderable stream losy River, the o ed the Swan, Rec ad, Riding and D

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Report of the Assiniboi

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Qu'Appelle Valley, the outlet of the Saskatchewan glacial lake,

¹ Compare H. S. Treherne's description of this vicinity, "An ancient outlet of Lake Manitolo," Ninth Annual Report of the Geological and Natural History Survey of Minnesota (for the year 1890), pp. 388-392.

² Report of the Assiniboine and Saskatchewan Exploring Expedition, Toronto, 1859, by Heigh Youle Hind.

BASIN OF LAKE AGASSIZ.

the Rocky Mountains, took its course east by this trough-like channel er valley, entering the Assiniboine at Fort Ellice and reaching the boder of Lake Agassiz at Brandon.

Long or Last Mountain Lake, about fifty miles long from south to north and one or two miles wide, lying north of the upper part of the or Appelle and tributary to it, occupies a similar glacial water-eourse. Long Lake The elevation of Long Lake is 1,598 feet, being about a hundred feet probably the lower than the divide in the channel from the Elbow of the South outlet from the Sskatchewan to the Qu'Appelle. It seems probable that when the basin. ie-sheet had receded so far north as to allow the Saskatchewan lake to extend to the district northwest and north of Long Lake, it there obtained some lower point of discharge and outflowed along the course at this lake, forsaking its former outlet.1 Owing to the changes in reati elevation which have taken place in the region of Lake agasiz since that time, this new outlet, or the earliest and highest the of several successive outlets, across the water shed between the sekatchewan basin and Long Lake may now be found tifty or perhaps even a hundred feet higher than the old channel to the head of the mAppelle, that is, 1,750 or 1,800 feet above the sea, the possible difference being probably as much as a foot to each mile of the distance between the old and new outlets.

Suris River, flowing circuitously southwestward from Assiniboia in North Dakota and thence northeastward into Manitoba, became gibtary to the Assiniboine after the waters of the glacial lake in its evaluation in the flowing to the James and Sheyenne, had been Souris River whelly drained away by its outlet through Lang's Valley and the Pendina River. The length of the Souris is nearly four hundred niles but it is only five to ten rods wide along its lower portion. In Yorth Dakota its descent is approximately from 1,650 to 1,400 feet lare the sea, and thence to its mouth it falls about three hundred far

Little Saskatchewan or Fairford River drains an area that extends nere than two hundred miles west from Lake Winnipeg and includes a equal distance in latitude, from the most northern part of Lake Winnipegosis to the south end of Lake Maniteba. The latter lake weives several small streams at its sonth end; and the Water Hen Little Statathewan Ever, the outlet of Lake Winnipegosis, flows into its north end. Four River, ansiderable streams are tributary to Lake Winnipegosis, namely, the fissy River, the outlet of Lake Dauphin, flowing into its south end, nel the Swan, Red Deer, and Overflowing Rivers at its northwest well, Riding and Duck Mountains form the southwestern boundary of

Report of the Assiniboine and Saskatchewan Exploring Expedition, 1859, pp. 28 and 35.

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me (f such or site of the 'Portage la ow, wholing at forty feet lake. Near stage, about 1 southward 1 southward through the fifteen nales ne its waters 'Portage la

River are the eams has an topographie ppelle valler askatchewat. ow that this em 110 to 350 sh it lies tui length, from th the Assile eneral colles. est end of the at Turns, and of land in this nately 55 feet nouth of the ng blutt- are osures of the f the Qa'Aphrough it the through log nesota Rivers, ibutaries, and **iv** lower than hewan gladal ching west to

t Lake Manitola," resota (for the year ato, 1859, by lleny 25 е

GLACIAL LAKE AGASSIZ IN MANITOBA.

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this basin; but the Porcupine Hills are entirely enclosed between the Swan and Red Deer Rivers, and the latter drains much of the plateau

The lower part of the basin of the Saskatchewan, next to its mouth was latest occupied by the ice-sheet; but that area was relinquished br it, allowing this great river to take its present course, long before Lake Agassiz began to be drained northward. From the most western sources of the Saskatchewan in the Rocky Mountains to its mouth isa distance of more than seven hundred miles; and the maximum width of its basin is about three hundred and fifty miles. Its two branches of nearly equal size, the North and South Saskatchewan Rivers, unite two hundred and thirty miles west of Lake Winnipeg. The elevation of the South Saskatchewan at Medicine Hat, where it is crossed by the Canadian Pacific Railway, is 2,137 feet; at its Elbow, 1,619 feet approximately; and at its junction with the North Saskatchewan above 1.200 feet. Cedar and Cross Lakes, through which the Saskatchewan flows near its mouth, are approximately 114 and 108 feet above Lake Winnipeg, or 824 and 818 feet above the sea. Hind informs us that the name Saskatchewan means "the river that runs swiftly;" and he states that in the Grand Rapids, between Cross Lake and its mouth it falls forty-three feet in two and a half miles.1 Its average descent per mile from Medicine Hat eastward is about two feet. The Saskatchewan and both its North and South branches for several hundred miles above their junction vary commonly from a sixth to a third of a mile m width, and during favorable stages of water are navigable by steamboats from Cedar Lake to the Rocky Mountain House on the North Saskatchewan, about 3,000 feet above the sea, and beyond the confluence of the Bow and Belly Rivers, which form the South Saskatche wan, fifty miles west of Medicine Hat, at an elevation exceeding 2.20 feet. The chief hindrances to their navigation in low stages and shifting sand-bars, over which they expand in some places to widtle of a half mile to one mile, being very shallow and divided by low sandy islands. The adjoining country rises within a few miles from these rivers, or at the furthest ten or twenty miles, to an elevation three hundred to six hundred feet or more above them, excepting along the last hundred miles of the Saskatchewan, where it flows through a broad lowland region. There the highest parts of the country are only fity to a hundred feet above the river, and its shores are generally low ad in many portions swampy.

Besides the great tributaries of Lake Winnipeg, namely, the Wind peg. Red, Little Saskatchewan and Saskatchewan Rivers, about a doze

¹ Report of the Assiniboine and Saskatchewan Exploring Expedition, 1859.

streams varying and twenty or me side. Of the latte ahundred miles l portheast incove probably the who east, before its m Agassiz to be dra The Nelson, as along its course o Hudson Bay. Th only a few degree Playgreen. Pipest it turns to the ea Lake; and tinall handred miles. is approximately below Lake Winn 40 and 120 feet : miles, to the foot Nelson is naviga Limestone Rapid. the sea level.

About four fifth basins of the Rec the Sa-katchewan the Rainy and W: sheet and were tr ward outlet. The carried along the Gulf of Mexico. mately 350,000 sq the lake itself. 1 northeastward by extended north be the Nelson to incl and the Mackenzi ly the waning ice the area of the g

Saskatchewan River. 26 E

bordered by the Pasquia Hills.

Grand Rapids.

Navigation.

Adjoining country.

BASIN OF LAKE AGASSIZ

ed between the of the plateau CHAN.

xt to its mouth relinquished by se, long before e most western) its mouth is a naximum width ts two branches a Rivers, unite

The elevation s crossed by the ow. 1.619 feet, atchewan, about Saskatchewan feet above Lake informs us that viftly ; " and he nd its mouth, it age descent per e Saskatchewan Ired miles above rd of a mile m gable by steam-

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streams varying in length from ten to forty miles enter its west side, smaller and twenty or more of similar or somewhat greater length enter its east LakeWinniper. side. Of the latter the largest are Beren's and Poplar Rivers, each about ahundred miles long. The recession of the ice-sheet from southwest to northeast uncovered the entire region west of Lake Winnipeg, and probably the whole of the country traversed by these streams on the ast, before its molting finally pormitted the waters of the glacial Lake

Agassiz to be drained to the level of this lake. The Nelson, as before noted, is bordered by no areas of highland along its course of about four hundred miles from Lake Winnipeg to Indson Bay. The upper half of this river flows in a general direction only a few degrees east of north, passing through Great and Little Netson River. Playgreen. Pipestone, Cross and Sipi-wesk Lakes, to Split Lake; thence it turns to the east for about a hundred miles, passing through Gull lake; and finally takes a northeastward course along its lower one hundred miles. According to Dr. Bell's observations, Sipi-wesk Lake sapproximately 570 feet above the sea, or a hundred and forty feet below Lake Winnipeg; Split and Gull Lakes are respectively about 440 and 420 feet above the sea; and the descent in the next forty-eight Nelson is navigable from the sea about ninety miles to the First Limestone Rapid, where the elevation is probably denoted by Limestone Rapid, where the elevation is probably about tifty feet above the sea level.

About four tifths of the area drained by the Nelson, including the basins of the Red River of the North, the Little Saskatchewan and e on the North the Saskatchewan, and the greater part or possibly all of the basin of e on the North the Saskatchewan, and the greater part or possibly all of the basin of soyond the contribution the Rainy and Winnipeg river system, were uncovered from the ice-outh Saskatche thet and were tributary to Lake Agassiz while it still had its south-exceeding 2.200 ward outlet. The waters of a large part of British America were thus low stages are terrifed along the course of the Minnesota and the Mississippi to the places to widths failed Mexico. The basin of Lake Agassiz then included approxi-terrifed along the course of which nearly a third was covered by Azasiz. ites from these the lake itself. In the later stages of this glacial lake, when it flowed elevation three northeastward by omlets higher than the Nelson, its basin probably pting along the extended north beyond the present water-shed of Lake Winnipeg and through a break the Nelsen to include the upper portion of the basins of the thurchill ry are only fifty and the Mackenzie, the lower course of these rivers being obstructed nearly low and the water brief the water is the seems probable that with this addition nerally low and by the waning ice-sheet. It seems probable that with this addition the area of the glacial lake basin was not less than 500,000 square mile-.

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QLACIAL LAKE AGASSIZ IN MANITOBA,

DRIFT FORMATIONS IN MANITOBA.

Thickness of the drift in Manitoba.

The thickness of the sheet of superficial deposits overlying the bed. rock in West Selkirk is 65 feet; in Winnipeg and Saint Boniface it varies from 30 to 80 feet; near Niverville it is from 65 to 100 feet; in Dominion City, near Letellier, and on the Low farm west of Morris, it is at least 170 to 250 feet, and in West Lynne at least 108 feet; at Rosenfeld it is 143 feet; near Carman it is about 100 feet; and seven miles west of Portage la Prairie, 158 feet. From these records it seems probable that the thickness of these deposits upon the flat plain of the Red River Valley in Manitoba averages abont a hundred feet, considerably exceeding this, to a maximum of 150 to 250 feet, along the central part of this area south of the Assiniboine, but not probably averaging more than 50 feet in the lower part of the valley between Winniper and Lake Winnipeg, where the higher portions of the bed-rock rise to the surface. On the Archaean area of the east part of Lake Agasiz plentiful rock-outcrops occur about Rainy Lake and the Lake of the Woods, westward along the Canadian Pacific Railway nearly to the Whitemouth River, and in the country cast of Lake Winnipeg; and it is probable that the average thickness of the superficial deposits in that extensive district is not more than 30 to 50 feet. West of Lake Agassiz, many portions of the plateau bordered by the Pembina Monntain and the Tiger Hills have only a small depth of drift, ranging from a few feet to 20 or 30 feet, but in some places the drift appears t extend deeper, as shown by stream valleys, and its average thickness may be 40 feet or more. Till, also called boulder-clay, constitutes the greater part of the entire

Distribution of the till.

sheet of superficial deposits, both within the area of Lake Agassiz and upon the adjoining country. It usually lies on the striated bed-rock and upon large areas it reaches thence upward to the surface; but else where this unmodified glacial drift is covered by modified drift, the stratified gravel, sand and clay deposited by streams which flowed down from the ice-sheet during its melting, or by lacustrine and durid sediments. Fully half of the area of Lake Agassiz in Minnesota and North Dakota has a surface of till; but in the part of this lake area examined in Manitoba its proportion is less, because much of the district is covered by the Assiniboine delta and its associated lacustrine beds. Extensive tracts of till, however, occupy the surface on the

Tracts of till

forming the north and east portions of this area, as north of Lake Manitola surface within the area of Lake side of the Big Grass Marsh, from the south end of Lake Manitola the area of Lake side of the Big Grass Marsh, from the Pod River and Winnipeg and eastward by Shoal Lake nearly to the Red River and Winnipeg and south to the Canadian Pacific Railway, from East Selkirk castward along this railway, and ten miles east of Emerson, where the flat plan

5484 of the Red River forms the surface tain escarpment Beneath the delt tion of the flat commonly tine s and the bed-rock The till is the sisting of elay, s an unstratified a Very tinely puly its principal ing It has a dark b rellowish to a d commonly betwe due to the influe deposit, changing binations to hydr till is that its up below there is a must be picked a canse of this diffe of the ice-sheet u contained in the side of Lake Age surface. Within smoother and m manner of deposi feet stratification Yet even where than like ordina through its entir Boulders are f their abundance and in the least size extends up t epecially in the sizes up to ten or ninety-nine per consists of Archa the Archavan ar occasional limes stones, constituti

28 E

DRIFT FORMATIONS IN MANITOBA,

of the Red River Valley is bordered by slightly higher land. Till also forms the surface of the terrace along the foot of the Pembina Mounmin escarpanent between the international boundary and Thornhill. Beneath the delta deposits of gravel and sand, and on the central portion of the flat plain of the Red River Valley, where the surface is commonly time silt or clay, a sheet of till lies between these sediments and the bed-rock.

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The till is the direct deposit of the ice-sheet, as is shown by its con- Characters of sting of clay, sand, gravel, and boulders, mingled indiscriminately in the till. an unstratified mass, without assortment or transportation by water. Very finely pulverized rock, forming a stiff, compact, unctuous elay, is its principal ingredient, whether at great depths or near the surface. t has a dark bluish gray color, except in its upper portion, which is rellowish to a depth that varies from five to fifty feet, but is most commonly between tifteen and thirty feet. This difference in color is due to the influence of air and water upon the iron contained in this deposit, changing it in the upper part of the till from protoxide combinations to hydrous sesquioxide. Another important difference in the fills that its upper portion is commonly softer and easily dug, while below there is a sudden change to a hard and compact deposit, which must be picked and is far more expensive in excavating. The probable cause of this difference in hardness was the pressure of the vast weight of the ice-sheet upon the lower and older till, while the upper till was contained in the ice and dropped loosely at its melting. Upon each sile of Lake Agassiz the till has a moderately undulating and rolling surface. Within the area that was covered by this lake it has a much

smoother and more even contour, and its upper portion, owing to its manner of deposition in this body of water, sometimes shows an imperfect stratification, with a scantier intermixture of boulders and gravel. Yet even where it has distinct lamination, it usually is more like till than like ordinary modified drift, and contains stones and gravel through its entire mass.

Bonders are frequent or plentiful in the till throughout Manitobatheir abundance being nearly the same as in northeastern Minnesota and in the least rocky parts of New England. Their usual range in size extends up to a diameter of four or five feet; but in a few localities, especially in the course of morainic belts, they were observed of all sizes up to ten or twelve feet enbes. Generally as large a proportion as Bonders and interprint per cent. of the boulders exceeding one foot in diameter Archaen are consists of Archaean granite, gneiss and schists, being derived from Pitheored the Archaean area on the northeast and north. With these are accessional limestone blocks, derived from the belt of Paheozoic limesones, constituting on the average perhaps nearly one per cent. of the

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erlying the bed. int Bonitace it to 100 feet; in est of Morris, it ist 10% feet; at feet ; and seven records it seem. flat plain of the d feet, consider long the central bably averaging tween Winnipe; bed-rock rise to f Lake Agassiz the Lake of the y nearly to the innipeg; andit icial deposits in West of Lake Pembina Mounft, ranging from

art of the entire ake Agassiz and triated bed-rock urface; but else dified drift, the s which flowel trine and fluvial Minnesota and f this lake area e much of this siated lacustrine surface on the iwa, on the east Lake Manitoba 1 Winnipeg and dkirk eastward

re the flat plain

drift appears to

orage thickness

GLACIAL LAKE AGASSIZ IN MANITOBA. large rock fragments of the drift. The bedded and jointed characteral

the limestones has prevented their supplying many large boulders in

comparison with the more massive crystalline Archiean rocks, while

yet usually about half of the smaller cobbles and pebbles in the till and

in gravel and sand deposits are from these Paleozoic limestones. But

east of Lake Winnipeg and northeast of a line drawn from this lake

southeastward across the Lake of the Woods to the west end of Raine

Lake, both boulders and gravel of limestone are absent or exceedingly

rare. This line probably marks the eastern limit of the glacial currents

that moved south-southeast in the vicinity of Winnipeg and a Black

flat area at its top. Pilot Mound, an equally prominent hill seen from

this looking toward the northwest, is like Star Mound a knob of Create

ceous shale with thin covering of drift, but it has no such unusua

profusion of boulders on its slopes. Rock Lake, through which the

Pembina flows, derives its name from the remarkable abundance of

boulders, mostly granitic, up to six feet or more in diameter, bordering

its shores; and along a distance of one or two miles west from this lake

the Pembina Valley is much encumbered with boulders, which in some

places are accumulated upon small morainic ridges and knolls. The

largest boulder noted in this exploration, having nearly twice the size

of any other observed, is a block of dark gray granitoid gneiss, 22 fee

long, 8 to 14 feet wide, and projecting 2 to 5 feet above the surface,

the N. W. 4 of sec. 9, T. 1, R. 4 E., on the low ridge ten miles east

Emerson. Among the other plentiful boulders of that vicinity, none

were seen exceeding seven or eight feet in dimension. Like many

the smaller boulders throughout this prairie region, this block is su

rounded by a slight depression, one to three feet below the adjoining ground; and a careful examination shows that some of its projecting corners and edges are smoothly polished. These depressions we

formed by the trampling and pawing of buffaloes in rubbing upon the

LEMAV. boulders, which

A belt of mor the ice-sheet dur rupting its retre Agassiz on the Pembina Rivers exploration for t have attempted : Dakota and of M boundary of the or Herman bench

Evidence which report, in treatin lake, leads me to the recession of porth as the latit peg and Manitob of this valley t abundant boulder between Morden on the east marg and remarkable shore of Lake A Dakota, seem ref

The west side (two or three earl of which Dr. G. region, with an a gradually upwnre atits highest poin slopes and ridges ance, and these a western is more prominent ridges with the intervo Large areas of co are however, four appears to be tha modified by subse

Bulletin No. 39, U. S

Northeastern Ilmit of limestone drift.

30 E

Star Mound.

Localities of

abundant and large boulders.

Pilot Mound.

Rock Lake.

East of Emerson.

Bear Island near the Narrows of Lake Winnipeg, carrying débris from the limestone region of the Manitoba lakes. Upon the Cretaceous and a considerable proportion of the gravel and cobbles is derived from the Fort Pierre shale, but this formation supplies no large boulders. The following localities may be mentioned as having especially abundant boulders. On the slope of the Pembina Mountain. in T.3. R. 6, between Morden and Thornhill, very plentiful and large bouldes are spread upon an area of several square miles, as noted in the description of the Tintah beaches. The sides of Star Mound, especially those facing the north and northeast, are strewn with a multituded boulders, nearly all granitie, of all sizes up to five feet in diameter rarely larger. These were probably combed out of the ice-sheet in is passage over this hill. Comparatively few boulders occur on the small

as could be done

DRIFT FORMATIONS IN MANITOBA.

boulders, which were thereby sometimes worn and polished as perfectly nonders pullipled by as could be done by art. buffaloes

A belt of morainic drift deposits, accumulated along the border of the ice-sheet during one or more pauses or times of re-advance inter- necessional morphic in moting its retreat, was observed upon the country that adjoins Lake Manitoba, Agassiz on the west and is crossed by the Assiniboine, Souris and Pembina Rivers. Though sufficient time was not available in this exploration for tracing the entire course of this recessional moraine, I have attempted to correlate it provisionally with the moraines of North Inkota and of Minnesota, thus indicating the probable course of the hundary of the ice-sheet at the time of the formation of the highest or Herman beach of Lake Agassiz,

Evidence which is more fully detailed in the ensuing parts of this report, in treating of the modified drift and the history of this glacial lake, leads me to believe that the Red River Valley was uncovered by the recession of the ice-sheet and was occupied by this lake as far with as the latitude of Winnipeg and the south end of Lakes Winnipeg and Manitoba, while the ice still extended south on the west side of this valley to Devil's Lake and Turtle Mountain. The very On the east abandant boulders noted on the east slope of the Pembina Mountain Pembina between Morden and Thornhill were probably deposited at this time southward. on the east margin of this ice-lobe that reached south to Devil's Lake; and remarkable crescent-shaped moraines observed on the highest slore of Lake Agassiz in the southwest part of Walsh County, North bakota, seem referable to the same time and manner of deposition."

The west side of this Dakota lobe of the ice-sheet during this and two or three earlier stages of its recession rested on Turtle Mountain, of which Dr. G. M. Dawson writes :- "It is a broken, hilly, wooded Morainie drift region, with an area of perhaps about twenty miles square, and slopes on Turtle gradually upward from the plain around it, above which it is elevated, described by atits highest points, about 500 feet. . . . Nearly all the abrupt slopes and ridges--of which there are many-show boulders in abundance, and these appear to be chiefly of Laurentian rocks. . . . The western is more abruptly hilly than the eastern side, and the more prominent ridges have a general northerly and southerly direction, with the intervening valleys characterized by swamps and lakes. Large areas of comparatively level or only gently undulated ground are however, found in some places. The surface of the 'mountain' appears to be that of the drift, as deposited, and has been but little modified by subsequent sub-norial action. The lakes lie in basin-like

Bulletin No. 39, U. S. Geological Survey, p. 61.

21 E

outhwestern

ited character of argo boulders in an rocks, while es in the till and mestones. But n from this lake est end of Rain t or exceedingly glacial currents eg and at Black ying débris from Cretaceous area terived from the

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boulders. aving especially onntain, in T.3. ad large bouldes is noted in the lound, e-pecially h a multitude of et in diameter of e ice-sheet in its eur on the small nt hill seen from a knob of Creta no such unusua ough which the le abundance « moter, bordering st from this lake s, which in somand knolls. The ly twice the size id gneiss, 22 fee e the surface, it on miles east o at vicinity, none

Like many d his block is surow the adjoining of its projecting epressions we ubbing upon the

GLACIAL LAKE AGASSIZ IN MANITORA,

hollows, and notwithstanding their great number, drainage valleys and stream courses are few and unimportant." $^{\prime\prime}$

The outermost moraine marking the farthest advance of the ite sheet in the last glacial epoch passes along the Coteau du Missoni, crossing the international boundary in its northwestward course about a hundred and fifty miles west of Turtle Mountain. Between this Altamont moraine and the Fergus Falls and Leaf Hills moraines, which are probably contemporaneous with the great moraines close south of Devil's Lake and on Turtle Mountain, several distinct stages in the recession of the ice-sheet are recognizable by morainic deposits in lowa, Minnesota, and South and North Dakota. The morainie drift, of Turtle Mountain apparently represents two or three stages in the glacial recession, and in the country lying on the west and northwest numerous morainic belts will doubtless be found beyond the limits of my exploration.

The moral, e observed by me in southwestern Manitoba belongs is a time somewhat later than the great moraines of the Leaf Hills, the south side of Devil's Lake and Turtle Mountain; but it is believed is by contemporaneous with the accumulation of the boulders east thornhill and the moraines of southwestern Walsh County below mentioned, and with morainic hills on the north side of Devil's Lake. The most southern part of its observed course extends northerly true the east end of Turtle Mountain by Killarney to the northern part of Pelican Lake, a distance of about twenty-five miles. Thence it extends west-northwest twenty miles, forming the west part of the Tiger Hills in their extent along the north side of Lang's Valley and the Souris 5 T. 7, R. 19, where it again bends to the north and holds that consten or twelve miles to the prominent Brandon Hills. Here again is

Moraine of the Tiger, Brandon and Arrow Hills.

32 E

Stages in the

and north of Tartle Mountain,

recession of the

turns to the west, making a sharp angle, but within a few milest sinks to the general level of the adjoining country and loses its distative character. Proceeding onward to the west about twenty mile, this moraine is next found on the north side of the Assimiboine a fer miles northwest of Griswold, and thence it takes a northwest connelying mostly from five to eight or ten miles northeast of the Assimboine and approximately parallel with it to the Arrow River and Ba Tail Creek, beyond which I have no definite information of its farther course. On both sides of the Arrow River it rises in prominent eletions, with characteristically rough contour and plentiful boulders, at this portion is called the Arrow Hills. The ascertained extent of the moraine, known in successive parts as the Tiger, Brandon and Arro-Hills, is about a hundred and twenty-five miles. Its general courses

¹ Report on the Geology and Resources of the region in the vicinity of the Forty-ninth Park, pp. 223, 224. northwest, but w the Pembina, o about twenty-fiv dented by two re the Tiger Hills 1 of Pelican Lake, danmed by the i the course of thi around the sout tributary to Lak A conspicuous

R. 16, two to thr morainic hills ris being 1,550 to 1,3 marter of a mile enclosed by these s very gravelly fragments being g lat nowhere aba diameter. This t to Lang's Valley, small proportion of irregular hills and west in sec. 19, an b the south-south east, beyond an in consisting of a slig h hillocks and ; prominent in sec. western bluff of Pa Within tive mild his moraine is typ regularly groups eet above the inte ea, Notman's Hi the north. On Hill in sec. 2, **T**. 6, akes, Lang's Val oward the Turtle restern part of the roken outlines th ounded massive hi that smooth sheet з

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DRIFT FORMATIONS IN MANITOBA.

- 33 E

northwest, but within the Souris basin and that of the head streams of the Pembina, on the north side of Turtle Mountain, it is deflected about twenty-tive miles to the northeast. The ice-sheet was there indented by two re-entrant angles, one having its apex in the range of the Tiger Hills near Poor's Lake, a few miles north of the north end of Pelican Lake, and the other in the Brandon Hills. A glacial lake, dammed by the ice-sheet and probably causing its indentations along the course of this moraine, then filled the Souris basin and outflowed around the south side of Turtle Mountain and Devil's Lake, being mibitary to Lake Agassiz by the Sheyenne.

A conspicuous portion of this moraine was examined in sec. 19, T. 4, R 16, two to three miles west of the middle of Pelican Lake. Here see, 19, T. 4, norainic hills rise 40 to 60 feet above the general level, their tops Petican Lake. being 1,550 to 1,575 feet above the sea. A beautiful lakelet, about a marter of a mile long and said to have a depth of fourteen feet, is enclosed by these hills near the center of the section. Their material is very gravelly till, not water worn, about half of the small rock fragments being granite and half limestone. It also contains frequent, hat nowhere abundant, granitic boulders up to two or three feet in dameter. This till, like that of the flat country north and northwest to Lang's Valley, and of the Tigor Hills beyond, includes only a very small proportion of gravel from the Fort Pierre shale. These roughly irregular hills and hillocks occupy a width of a half mile from east to west in sec. 19, and extend more or less noticeable in a narrower belt to the south-southwest at least five miles. Toward the north-northast, beyond an interval of one mile of the plain like that on each side, unsisting of a slightly undulating sheet of till, the moraine re-appears n hillocks and short ridges 20 to 40 feet high, becoming most mominent in sec. 32 of this township, near the verge of the southrestern bluff of Pelican Lake.

Within tive miles northward from the north end of Pelican Lake, his moraine is typically developed around Poor's Lake, consisting of regularly grouped hills, knolls and ridges of till, rising 50 to 100 ket above the intervaning hollows, to 1,550 and 1,600 feet above the en. Notman's Hill in sec. 15, T. 6, R. 16, is one of its outlying knobs athe north. On the southwest side of this morainic belt, Lookont Hill in sec. 2, T. 6, R. 17, affords a fine prospect of Pelican and other kee, Lang's Valley, and the flat plain that rises thence slowly oward the Turtle Mountain. The morainic drift here spread over the restern part of the Tiger Hills gives to this range more knolly and the Turer Hills, roken outlines than along most of its extent farther east, where its made massive hills of Cretaceous shale are only covered by a sometiat smooth sheet of till that commonly varies from a few feet to 3

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ninnge valleys are of the its a du Missouri, ad course above PHAN.

Between this toraines, which a close south of t stages in the die deposits in morainie drift to stages in the and northwes; in the limits of

oba belongs to Leaf' Hills, the t is believed to boulders east of County before of Devil's Lake, northerly from orthern part of

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the Tiger Hils

nd the Sourish olds that course Here againh i a few milesh loses its distint twenty miles ssiniboine a fer orthouse a fer of the Assis River and Bri on of its farther oroninent elevan al boulders, and l extent of this

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being T 4 twenty feet in thickness. In contrast with this, along the western morainic portion of the range, extending from Notman's Hill and Poor's Lake west-northwest across the Souris, the thickness of the drift probably averages 100 to 150 feet.

tetween Lang's The road from Langvale post office, in Lang's Valley, to Gregory, Valley and mill on the Souris, five miles to the north, crosses this morainic helt

of the Tiger Hills, which there is three to four miles wide and lasa surface of many hills and short ridges, with typical morninic contour, rising in elevat. as mostly 20 to 50 feet above the intervening depre-

Big Tiger Witt sions. It is a half mile cast from this road to the top of the Big Tiger

Hill, which is the highest point of the entire range, about 1,640 feet above the sea, being nearly 300 feet above Lang's Valley. The elevation of the road on the west is about 1,525 feet, and of its highest place one and a half miles north-northwest of this hill, about 1.570 feet. All this portion of the range is till, but it has fewer boulders than are usually found on morainic areas, though they are probably twenty time as abundant as on the plain southward. Small rock fragments, rater water-worn, are very abundant, nearly all Archnean granitoid gneis and Paleozoic limestone in about equal proportions, with little or p shale. Looking west-northwest from the Big Tiger Hill, this below rolling morainic hills is seen extending ten miles along the northear side of the Souris at an elevation of about 1,575 feet. South of the Souris and thence southeast to the moraine west of Pelican Lake,a vast flat expanse is seen rising slowly from an elevation of abor-1,475 feet at its verge bordering the Souris and Lang's Valley to alor 1,700 feet at the northern base of Turtle Mountain, which rises

Gorge cut by the Souris through the Tiger Hills. 34 E

2,000 feet or more in the blue distance thirty miles south-southwest, In the central part of T. 6, R. 18, two miles west of the Big Tige Hill, the Souris cuts through this moraine by a very picturesque gen that extends four macs north from its Elbow. The stream in the distance descends approximately from 1,265 to 1,210 feet above is sea, its channel being in many places obstructed by boulders but having no considerable abrupt fall. The width of the gorge is a half miles one mile between the tops of its steep sides, which rise in their highs portion 350 feet from the river to the crest of the morainic belt. some places along the southern part of the gorge the Fort Pierreshi is exposed by recent crosion to a height of 100 feet or more above river; but it has only low outcrops near Gregory's mill at the norther boundary of the moraine. The Souris there and through its next in or six miles northeast to Souris City has eroded its channel to a dep of about 140 feet in a smooth sheet of till, only reaching the under lying shale in a few places, without cutting deeply into it. This expansion of till has a descent of several feet to the mile, nearly the same as the

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of the Souris its margin adjoins the elevation of 1,350 souris, it is strewn ten feet in diamete From the west e 19, this morainic b Hills, having throu coon a width of fo teet above the sea. rises to 1,550 and 1 most prominent clu farther north and 83, T. S. R. IS. VI and from Brandon e conspicuously, havi cest, which is 1,57 most eastern ridge. makes here from a r wverv steep slopes - 30 feet along its c haslightly crooke opproximately 1,55t of gravelly drift, pri erv plentiful boulde nall rock fragment he large boulders be ill cluster lies one t t this ridge, and so at with trend from idges the prospect to porainic knolls and s ien of 1,450 to 1,550 e cast to west mora doining country of est, from Plum Cree encath delta deposita On the north side ominently in the w Griswold. The cha ep, mainly or wholl egeneral surface or efirst six miles nor

DRIFT FORMATIONS IN MANITORA,

35 E

et the Souris itself, toward the Assiniboine. Where its southern vientized margin adjoins the moraine, in the vicinity of Gregory's mill, at an Gregory's Mill, devation of 1,350 to 1,360 feet above the sen, or 150 feet above the souris, it is strewn with multitudes of granitle boulders up to eight or ten feet in diameter.

From the west end of the Tiger Hills in the south part of T. 7, R. Brandon Hills. 12 this morainic belt curves to the north and is called the Brandon Hills, having through this township a characteristically knotly contour upon a width of four or five miles, with an elevation 1,450 to 1,500 teet above the sea. In the southeast part of T. S, R. 19, the moraine rises to 1,550 and 1,600 feet, attaining about the same height as the most prominent cluster of these Brandon Hills, which lies a few miles farther north and northeast, in the northern part of sees. 31, 32, and S.T. S. R. IS. Viewed from the Souris and Assiniboine on the east and from Brandon on the north, this cluster of hills stands forth very conspicuously, having a steep ascent of about 250 feet from base to rest, which is 1,575 to 1,610 feet, approximately, above the sea. The most custern ridge, running to the apex of the angle which the moraine takes here from a northern to a western course, is narrow and bounded greev steep slopes, having an osar-like form, with undulations of 20 age feet along its crest, which extends about three fourths of a mile haslightly crooked course to the N. or N. 10° E., having a height approximately 1,550 to 1,575 feet. The surface of this ridge consists gravelly drift, principally not water-worn, with frequent but not erv plentiful boulders up to five feet in diameter. About half of the nall rock fragments are Archaean and half limestone, but nearly all le large boulders belong to the former. The highest portion of this ill cluster lies one to two miles west-northwest from the highest point this ridge, and seen at that distance it appears as a similar ridge at with trend from east to west. Within the angle between these dges the prospect to the southwest overlooks a very uneven tract of prainic knolls and small ridges irregularly grouped, having an elevam of 1.450 to 1.550 feet. In the northern part of T. S. R. 19 and 20, reast to west morainic belt sinks and becomes indistinct from the joining country of undulating till which rises westward; and farther est from Plum Creek to Griswold and the Assiniboine, it is concealed meath dolta deposits of sand.

On the north side of the Assiniboine this moraine again rises North of the minently in the west half of T. 10, R. 23, three to six miles west Assiniboine. Griswold. The channel eroded by the river here is about 200 feet ep. mainly or wholly in drift, the river being about 1,200 feet and egeneral surface on each side about 1,400 feet above the sea. In effect six miles north from the Assiniboine the moraine attains a

the western n's Hill and

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o Gregory's iorainie helt de and has a inic contour. ming depres. he Big Tiger put 1,640 feet fulley. The of its highest mit 1.570 feet. ders than are twenty time ments, rately anitoid guess th little or ne II, this belt !! the northead

South of the elican Lakes tion of abor alley to about which rises h-southwest, the Big Tige turesque gets stream in the feet above the lers but havin a half miles n their highs minic belt. ort Pierre sha nore above the at the northe gh its next b nnel to a det ing the unit . This expan he same as the

GLACIAL LAKE AGASSIZ IN MANITOBA.

height 50 to 100 feet or more above the adjoining country, the tops of its irregular hills and ridges being 1,450 to 1,550 feet above the set Thence this belt of drift hills, having an average width of three 6 four miles, continues northwest diagonally across T. 11, R. 24, th west half of T. 12, R. 24, and the northeast part of T. 12, R. 25, the south and west parts of T. 13, R. 25, and the east half of T. 13, R. 2. In the two townships last named its hills rise 100 to 150 feet above the country on the east and west; and from the name of the river which intersects it in the north edge of T. 13, this part of the moraine's known as the Arrow Hills. Farther northwest, where its continuation erosses Bird Tail and Snake Creeks, the surface, though not prominently hilly, is rough and unusually strewn with boulders,

Enough of this moraine is thus known to show that at the time a

the Qu'Appelle and the Assiniboine for nearly sixty miles below the

mouth of that river, to Oak Lake. The significance of this will appear

more fully on subsequent pages relating to the Saskatchewan and San

glacial lakes, the latter of which extended at this time from the

southern bend of the Souris in North Dakota to the Assiniboine and

Arrow Hills.

36 e

Extent of the glacial recession to this its formation the ice-sheet had so tar retreated from its former western moraine. boundary on the Missouri Coteau as to uncover the entire length

Modified drift Modified drift bordering Rainy River and the southwest part of the Lake of the Woods.

the lower Qu'Appelle. Modified drift, consisting of stratified gravel and sand, overlies the bed rocks and the till, and generally forms the surface on an extension area about the southwest part of the Lake of the Woods and along the Rainy River. Southward similar deposits cover large tracts in Mina sota, reaching to the lakes at the sources of the Mississippi and to d Leaf Hills, and thence southeastward to Minneapolis and Saint Par The contour of the greater part of these deposits is flat or moderated undulating, and their surface varies in height from a few feet to fit feet or rarely more above the adjoining lakes and streams. In cents Minnesota these tracts of gravel and sand have an elevation that creases from south to north, being 825 to 950 feet in the vicinity Minneapolis and Saint Paul, rising gradually to 1,200 feet in the tance of about a hundred miles northwest to Brainerd, and range from 1,350 to 1,500 feet between the Leaf Hills and Itasca La Thence their surface sinks to 1,150 and 1,075 feet in the vicinity Rainy River and the Lake of the Woods. West of this lake grav and sand cover most of the country for nearly seventy-five miles the upper part of the Roseau, Rat, and Seine Rivers, declining in a direction to about 900 feet above the sea. Northwestward the deposits continue to a remarkable group of osars and small plateau

continuation south into Minnesota, and northwest to Bird's Hill,

gravel and sand, between 750 and 875 feet above the sea, sevel near Winnipeg, fifteen miles east-northeast of Winnipeg, of which Bird's Hill, be

1 may.]

the Canadian most con-pieuo

This broad 1 and deposits o porthwest abou north to the R Winnipeg, it li this belt is bor which have moheight of the ti that of the und spread as a shee in their elevation sand and gravel average thickne 400 to 600 feet : part of both the the former bein other portions a knolly and hilly 100 to 200 feet, : ing country. In chiefly of till w tracts of stratifie them and are me areas of this mod was brought by a ime of accumula of modifie 1 drift. bort ridges of been heaped up w were spread out 1 ag power, upon he lower part of ated by Chamb rathered clay, sau f the ice,

During the rap pressive morain al volume, and 1 rift, spreading it beyond the ice-ma ravel and sand,

DRIFT FORMATIONS IN MANITORA.

the Canadian Pacific Railway, is the most western and one of the gost conspicuous.

37 е

This broad belt of country, characterized by extensive gravel and and deposits overlying the till, reaches from south-southeast to northnorthwest about four hundred miles. From Red Lake in Minnesota worth to the Rainy River, the Lake of the Woods, and the vicinity of Winnipeg, it fies within the area of Lake Agassiz. On each side Adjoiningareas this belt is bordored by areas of nearly the same general elevation associated which have mostly a surface of till; and it is to be remarked that the moraines. height of the tracts of modified drift and till are alike detormined by that of the underlying rocks on which these superficial deposits are aread as a sheet of slight depth in comparison with the gradual change in their elevation. The drift sheet on this belt, including both the sand and gravel and underlying deposits of till, probably varies in its average thickness from 50 to 150 feet, while its central portion rises 400 to 600 feet above its south and north ends. Though the greater part of both the modified drift and till have only slight undulations, beformer being often nearly flat and the latter moderately uneven, ther portions are crossed by moraines which have a prominently moly and hilly contour, rising usually 25 to 75 feet, or occasionally pooto 200 feet, and in the Leaf Hills 100 to 350 feet, above the adjoining country. In some places the belts of morainic hills, consisting diefly of till with abundant boulders, are bordered on one side by tracts of stratified gravel and sand which slope slowly downward from them and are merged in the extensive plains or moderately undulating areas of this modified drift, showing that a part of the gravel and sand was brought by streams that descended from the ice-sheet during the time of accumulation of its moraines. Besides these overwash slopes _{Kames}. gmolifiel drift, the morainic belts often include knolls, hillocks, and short ridges of sand and gravel, called kames, which seem to have been heaped up where such streams left their ice-walled channels and were spread out more widely, thereby losing their velocity and carrying power, upon the adjoining land surface. These deposits show that he lower part of the ice-sheet enclosed much drift material, denomiated by Chamberlin englacial drift, from which the glacial streams athered elay, sand, and gravel, and spread them beyond the border of the ice.

During the rapid melting of the ice in its times of retreat between _{Osars}, arressive moraines, the glacial streams attained their greatest extent galvolume, and brought proportionately extensive deposits of modified fill, spreading it mainly in plains or moderately undulating tracts beyond the ice-margin, but here and there leaving prolonged ridges of gavel and, called *osars*, which were formed in their chaunels

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(try, the tops of t above the set, idth of three of t, 11, R. 24, the T, 12, R. 25, the of T, 13, R. 25, 50 feet above the the river which f the moraine is softs continuation agh not promin.

at at the time g s former westen entire length f y miles below the t' this will appear hewari and Sons s time from the Assinibolne an

sand, overlies the e on an extensio ods and along the o tracts in Mina sissippi and to de is and Saint Pai flat or moderates a few feet to the eams. In cents elevation that a in the vicinity 200 feet in the da nerd, and ranging and Itasea Lak in the vicinity f this lake grave enty-five miles declining in a thwestward tid d small plateaus the sea, seven Bird's Hill, bet

38 E

GLACIAL LAKE AGASSIZ IN MANITOBA, between walls of ice.* The distribution of the modified drift, thus tound

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Fig.3. Secti

F O R.

bet dete the set

Fig. 4. Sect Intern

Fig.5. Sect

Fig. 6. Sec

LACUSTAINEE CLAY

V.W. TILL

TILL

Arden

Deposition of the modified to rivers flowing vergingly to this belt from the melting ice-sheet.

the medified drift attributed upon large tracts along a broad belt from Saint Paul to Winning while it is very scantily developed on a still wider region of Minnesota North Dakota, and Manitoba southwest of this belt, and likewise seanty or wanting on its northeast side in northern Minnesota and about the northeast and north portions of the Lake of the Woods, seems to be attributable to converging slopes of the surface of the ice-sheet and the consequent convergence of its currents, which brought an unusual amount of englacial drift into the ice along this belt, and by which also the streams produced in its melting were caused to flow thither from extensive areas of the ice on the east and west. The glacial striæ of these adjoining areas show that on the least the course of the motion, and the descent of the surface, of the ice-sheet were from northeast to southwest, but that on the west the glacial current moved, and the ice surface sloped, toward the southeast. On the east drift limestone is absent or very rare, because no limestone formations were crossed within several hundred miles by that part of the jessheet; but on the west the drift contains much fine limestone detritue sand and gravel, and frequent boulders of limestone, borne southeast ward from Manitoba over the Arehean area of the southwest part of the Lake of the Woods, of Rainy River, and of northern and central Minnesota. In the same directions with the slopes of the ice surface. which are known from the coarses of the glacial striae and the transportation of the drift, the streams of the glacial melting flowed convergently from the east and west, from the ice over northern Minneses and eastern Manitoba on one side, and from that over the Red Birer Valley and western Manitoba on the other, toward this belt of plentific superficial deposits of gravel and sand.

Group of osars northeast of Winnipeg.

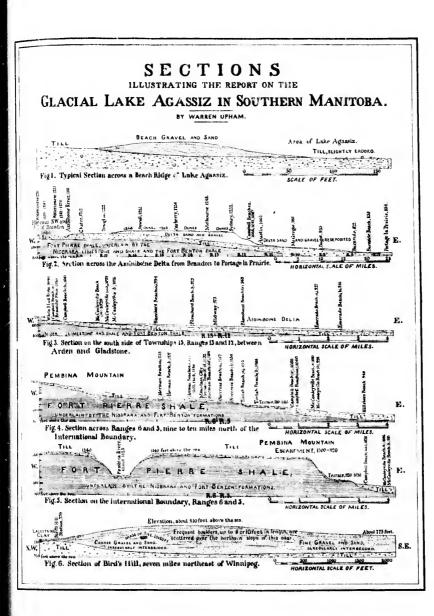
Prominent osars begin at Bird's Hill, the first station of the Canadian Pacific Railway northeast of Winnipeg, from which it is seven miles distant, and extend thence seven or eight miles east-northeast and a equal distance southeast. The southern and southeastern portion i this group comprises many low ridges of gravel and sand five to fifteen feet high, trending from northwest to southeast; also somewhat rounded mounds, as Oak Hummoek in the S. E. 1 of sec. 12, T. H. R. 4 E., which rises about thirty feet above the adjoining country, with its top approximately 810 feet above the sea; and occasionally: massive and conspicuous hill, as Moose Nose in secs, 29 and 30, T. Il

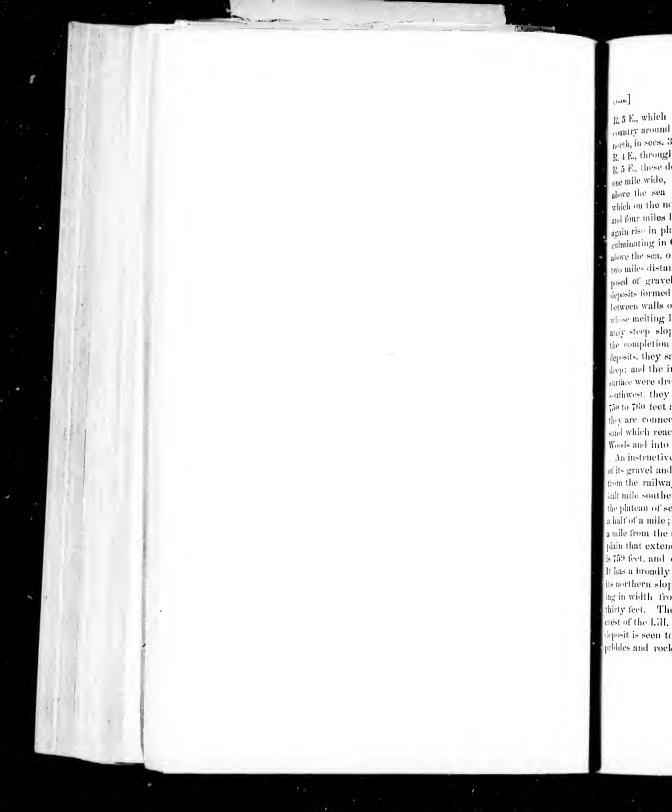
[•] The discrimination of the two classes of gravel and sand deposits named thus know owars was advocated by W. J. McGee in the Report of the International Geological Congresecond session, Boulogne, 1881, p. 621; and by T. C. Chamberlin, in the Third Annual Report the U.S. Geological Survey, for 1881-82, p. 299, and Am. Jour. of Science, Itl. vol. un May, 1884, p. 3-9. President Chamberlin shows that the latter term, in this Anglicized for has long been in common use by Jackson, Hitchcock, Desor, Murchison, and other writers.

hift, thus found il to Winnipeg, n of Minnesota. and likewise is Minnesota and of the Wood. surface of the , which brought g this belt, and eaused to flow and west. The east the course ice-sheet were glacial current st. On the east tone formations ourt of the ice. estone detritus, orne southeas. thwest part of ern and central the ice surface. and the transing flowed conthern Minnesota • the Red River belt of plentifa

of the Canadian t is seven miles ortheast and as tern portion i nd five to filteen nlso somewhat t see, 12, T. II, ig conntry, with occasionally a 9 and 30, T. II.

amed thus *ka* ac at Geological Corres ind Annual Report ience, 111, vol. w., this Anglicized form d other writers.





LEHAV.

DRIFT FORMATIONS IN MANITOBA.

g. 5 E., which projects sixty feet above the average of the nearly flat country around it, rising to about 840 feet above the sea. Toward the worth, in sees. 35 and 36, T. 11, R. 4 E., and again from sec. 2, T. 12, R. J.E., through a distance of four miles east-northeast to see. 9, T. 12, $_{R,5}E_{s}$ these deposits of gravel and sand form plateaus a half mile to one mile wide, trending from west to east, elevated 820 to 850 feet above the sea and 40 to 60 or 75 feet above the adjoining low land, which on the north is a spruce and tamarack swamp about a mile wide and four miles long from east to west. Next to the north, these osars again rise in plateaus, ridges, and hills in sees. 19 to 22, T. 12, R. 5 E., edminating in Griffith's Hill 'n the N. E. 4 of sec. 19, about 875 feet above the sea, or a little more wan a hundred feet above the railway two miles distant on the west. This whole group of elevations is comnosed of gravel and sand, irregularly bedded, which appear to be deposits formed near the mouths of glacial rivers where they flowed between walls of ice and were here and there divided by ice islands. whose melting left these hills, ridges and plateaus bounded by moderately steep slopes and separated by intervening depressions. With Submergence the completion of the melting of the ice about and beneath these in lake Agassiz, deposits, they sank to the bottom of Lake Agassiz, here about 500 feet deep; and the infrequent boulders that are found scattered upon their artice were dropped from floating ice. Toward the north, west, and outhwest, they are bounded by the flat plain of the Red River Valley, 750 to 760 feet above the sea; while toward the east and southeast they are connected with plains and undulating tracts of gravel and said which reach with slow and gradual ascent to the Lake of the Woods and into Minnesota,

An instructive section of Bird's Hill has been made in the excavation Bird's Hill. of its gravel and sand for railway ballast. This massive osar extends from the railway station about one mile east-southeast and thence a half mile southeast, beyond which it is connected by a low ridge with the plateau of secs. 35 and 36, T. 11, R. 4 E. Its width is a quarter to a half of a mile; and its maximum height, one third to two thirds of a mile from the station, is 45 to 50 feet above the railway and the flat plain that extends thence west. The elevation of Bird's Hill station is 759 feet, and of the crest of this hill 805 to 810 feet above the sea. It has a broadly rounded top, with gentle slopes on all sides. Along its northern slope an excavation reaches three fourths of a mile, varying in width from ten to twenty-five rods and in depth from ten to thirty feet. The top of the excavation is about twenty feet below the crest of the kill. As thus exposed to view, the greater part of this deposit is seen to be gravel, much of which is very coarse, containing pebbles and rock fragments of all sizes up to one and a half feet in

GLACIAL LAKE AGASSIZ IN MANITORA,

diameter, many of the smaller being well rounded, but the larger mostly angular with only slight marks of water-wearing. In some portions near the west end of this section no interbedding of coarser and finer layers of the torrential osar gravel is noticeable for ten feet or more vertically, the spaces between the large stones and cobbles Imhedded in this coarse being tilled with finer gravel and sand. gravel on the south side of the excavation 1 noted a mass of ordinary till, unstratified boulder-clay enclosing gravel and boulders in a solid matrix of somewhat sandy clay, wholly bounded by definite but irregular outlines, its dimension vertically being about ten feet and its length twenty feet. No other mass of till, either of small or large size, was observed in this entire section. It probably was derived from the drift that was contained within the ice-sheet and finally overspread its surface when the greater part of the thickness of the ice was melted, From a sheet of drift thus deposited on the ice that formed the bank of the glacial river, this mass may have fallen into its channel. The eastern half of the section includes much fine gravel and sand irregularly interbedded, and along a considerable extent there the south side of the excavation from ten to twenty feet below its top is clear said. Palaozoic limestones make up about three quarters of the gravel, the remainder being Archaean granites, gneiss and schists. Some two hundred boulders were found scattered upon the area of the excavation ; and they occur with nearly the same frequency on other portions of this northern slope of the hill, but are rarely found on its top and southern slope. They vary in size from two to eight or ten teet in length; nearly all are Archæan, but a few of Palaeozoie limestone, un to five feet in length, were observed. None were seen enclosed within the gravel and sand of the osar; and the workmen informed me that they occur only on or near the surface. This hill was covered by Lake Agassiz, and its boulders were doubtless dropped or stranded from bergs and floes on this lake, before the border of the ice-sheet hal retreated from the vicinity. Indeed, the occurrence of the boulders chiefly on the northern slope seems to indicate that they were mostly stranded there while ice yet remnined beneath this deposit and prevented its entire submergence in the lake. The thickness of this osar is at least nearly 100 feet; for a well 45 feet deep, dug at the bottom of the excavation was wholly in the same formation of gravel and sand. It is thus known to extend considerably below the level of the Red River Valley plain, which consists of fluvial and lacustrine clay underlain at a slight depth by till. A section across the osar and plain would show till abutting upon the edge of the gravel and sand, indicating that both the stratified osar and the upper part of the till were formed from englacial drift.

Mass of till imbedded in torrential gravel. 40 e

Boulders dropped or stranded[from floating icc.

Thickness of this osar and its relation n the upper part of the till.

Smaller osar to twenty miles cast of Rosser gravel and sai estend- northw corner of sec. 1 westward throu rise ten to twe milulating surf the sea. Along the form and ch boulders. A si irom southeast Grosse Isle, a na township and in From the cas Barns's Ridge, r R.I.E. Five m idge was made Railway, which Winnipeg. The totwelve feet in A well in the le that is, sixteen f consists of strati at least as tar be visible width of itmay extend, p gravel, which is : ia diameter. No upon the surface portions of this everal rods; but hits somewhat a half miles, it o p to three or for løhave been stra aclosing the osa he melting of the Lake Aga-siz to July a small dep lect at the most, s the underlying

DRIFT FORMATIONS IN MANITOBA.

but the larger ring. In some ling of coarser ble for ten feet ies and cobble. in this coarse ass of ordinary lders in a solid y definite but ut ten fectand ' small or large as derived from ally overspread ice was melted. ormed the bank channel. The nd sand irregue the south side p is clear said. the gravel, the sts. Some two of the excavan other portion. on its top and t or ten teet in e limestone, up enclosed within formed me that was covered by ed or stranded ie ice-sheet had of the boulders cy were mostly leposit and preess of this osar g at the bottom of gravel and he level of the lacustrine clay e osnr and plain d sand, indicatf the till were PHAN.

Smaller osar deposits were observed in Ts. 12 and 13, R. 1 E., ten osars of twenty miles northwest of Winnipeg. Beginning about three miles Winnipeg. east of Rosser, a narrow and occasionally interrupted belt of osar gravel and sand, with frequent boulders scattered on the surface, estends northwest diagonally across sees. 10, 16, and 20, the northeast corner of sec. 19, and the southwest part of sec. 30, T. 12, and thence wetward through see, 25 of the next township. Its highest portions rise ten to twenty-five feet above the depressions of the moderately multating surface of till on each side, and are 800 to 810 feet above the sea. Along a distance of about a third of a mile in sec. 30 it has the form and character of an ordinary beach ridge and is destitute of louders. A similar low osar crosses sees. 12 and 14, T. 13, trending non southeast to northwest; and others occur in the vicinity of the forese lsle, a name applied to poplar groves in secs. 17 and 18 of this bayaship and in secs. 12 and 13 of the next west.

From the east part of the Grosse Isle a notable osar, known as Burns's Ridge, Burns's Ridge, runs north-northwestward across sees, 30 and 31, T. 13. R.1 E. Five miles west of Stonewall a section of this little beach-like sige was made in see, 30 by the original line of the Canadian Pacific Railway, which was abandoned for the more southern route by way of Winnipeg. The osar is cut to a depth of eight feet by the railway and tetwelve feet in an excavation on the south side of the railway grade, A well in the lowest part of this excavation goes four feet deeper, that is, sixteen feet below the crest of the ridge. The entire section onsists of stratified gravel and sand, extending eight feet above and at least as far below the general level of the adjoining surface, and the risible width of the deposit is about thirty rods. How much deeper itmay extend, perhaps with increasing width, is undetermined. Its gravel, which is nearly all limestone, contains pebbles up to six inches indiameter. No boulders occur in this excavation, and they are rare non the surface of this and other such comparatively broad and high portions of this osar, none being sometimes seen along a distance of everal rods; but in its narrower and slightly lower portions, as traced hits somewhat erooked course northward through the next one and half miles, it often is found to be sprinkled with frequent boulders pto three or four feet in diameter, mostly Archaean. They appear stranded whave been stranded as at Bⁱ Ps Hill, immediately after the ice-walls ^{boulders.} alosing the osar were melted or even during that process, and before he melting of the ice under this gravel and sand allowed the water of ake Agassiz to submerge the more massive portions of the ridge. by a small depth of water, probably not more than thirty or fifty et at the most, would be required for this; and afterward the melting the underlying ice gave to the lake here a depth of fully 500 feet.

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Farther to the north the osar sinks or is merged in the moderately undulating till which there forms the surface. The crest of this peculiar ridge, approximately \$00 to \$05 feet above the sea, undulates three to five feet within short distances, not showing so much uniformity in elevation and directness in its course as are characteristic of beach ridges; and it is the only instance observed in all my exploration of Lake Agassiz where a gravel formation nearly resembling a beach bears boulders on its surface. Not a single boulder has been anywhere found on or within the beaches of this lake ; nor have osars like the Bird's Hill group or like these of smaller size and more stream. like courses been observed by me in any other part of this lacustrine area, excepting the vicinity of Red Lake in Minnesota. But osars doubtless exist here and there throughout the belt of modified drift that extends upon this area from Red Lake by the Lake of the Woods to Bird's Hill and Burns's Ridge; and probably they continue northnorthwesterly upon the country between Lake Winnipeg and shoal Lake.

INSTORY OF LAKE AGASSIZ.

Drainage from the receding ice-sheet.

Deserted river-courses.

During the recession of the ice-sheets of both the earlier and later epochs of glaciation, drainage from the ice-border in many places flowed in channels from which the streams became turned by the slopes of the land into more northern courses when this was permitted by the farther retreat of the ice. Where the slope is southward free drainage from the melting ice took place along the present valleys. and these were partially filled with modified drift, remnants of which form terraces and plains on each side of the present streams. But on areas that sloped more or less directly toward the receding ice-border. the streams of that time eroded channels which were abandoned when lower outlets were uncovered. Because of the large supply of water from the glacial melting, some of these river-courses became conspicuous topographic features, as noted by Dawson,* McConnell,? and Tyrrell‡ in various parts of the region between Lake Agassiz and the Rocky Mountains. On a slope nearly parallel with the retiring ice border, the deserted river-courses were seldom the outlets of lakes of considerable size; but where a large area was inclined toward the ice-sheet, it was covered by an expanse of fresh water, formed by the streams that flowed down from the melting ice surface and overflowing across what is now a line of water-shell between great drainage basin,

James, Souris, outflowed east Laurentian lak United States levels than no which they the ward to the Me In tracing th the recession of sages of that r of lowa, Minnes the stages of the and to note the wert, whose o brought large d deposits of tine . When the late its outlies a por

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lobes, one of wh to central lowa. near Des Moines the first and c moraines of this the second or Ga Mineral Ridge i Antelope morair Mound in Hanec tormed when th across the south Freeborn and Fa ing southern Le place of the ice. south end of the miles from its fat rested on the cre

¹¹ Changes of Leve Jac. 1888. Geol. Surthe Fresh-water Gluein inhumous, vol. xv. J ep. 50.65, with three m maps, Trans. of the Ge

Report on the Geology and Resources of the region in the vicinity of the Forty-and Parallel, pp. 263-265; Geological Survey of Canada, Report of Progress for 1882-85-84; p.100,
 Geological Survey of Canada, Annual Report, vol. i, for 1885, pp. 21 and 74 C.
 Loo, Annual Report, vol. ii, for 1886, pp. 43, 45 E, and 145, 116 E.

LAKE AGASSIZ.

until the continued recession of the ice allowed the lake to be discharged by the natural slope of the land. Lake Agassiz was the largest of these glacial lakes. Others existed in the basins of the Glacial lakes James, Souris, and Saskatchewan Rivers, of which the two last named outemporaneauthowed eastward into Lake Agassiz. The basins of the great Agassiz. Laurentian lakes, which are being studied by Mr. G. K. Gilbert of the United States Geological Survey, were also filled at this time to higher levels than now, determined by the elevations of the outlets through which they then flowed southward to the Mississippi and finally eastward to the Mohawk and Hudson.*

In tracing the history of Lake Agassiz it will be needful to review submary of the the recession of the ice-sheet which was its northern barrier, as the Agassiz. sages of that recession are shown by the successive terminal moraines dlowa, Minnesota, South and North Dakota, and Manitoba; to observe the stages of the lake itself which are recorded in its successive beaches; and to note the contemporaneous history of the glacial lakes on the met, whose outflow by the Sheyenne, Pembina, and Assiniboine brought large deltas into the western edge of Lake Agassiz and spread deposits of fine silt over extensive areas of its bottom.

When the latest North American ice-sheet attained its greatest area, Recession of the is southern portion from Lake Erie to North Dakota consisted of vast of the ice-sheet jes one of which reached from contral and western Minnesota south from bes Money to the ice sheet from the interview of the ice sheet is the providence of th to central lowa. This Minnesota lobe in its maximum extent ended Leaf Hills. near Des Moines, and its margin was marked by the Altamont moraine, the first and outermost in the series of eleven distinct marginal metaines of this epoch which are recognizable in Minnesota. When the second or Gary moraine was formed, it terminated on the south at Mineral Ridge in Boone County, Iowa. At the time of the third or Antelope moraine, it had farther retreated to Forest City and Pilot Mound in Hancock County, Iowa. The fourth or Kiester moraine was braned when the southern extremity of the ice-lobe had retreated gross the south line of Minnesota and halted a few miles from it in Freeborn and Faribault Counties. The fifth or Elysian moraine, crossing southern Le Sueur County, Minnesota, marks the next haltingpace of the ice. At the time of formation of the fifth moraine, the with end of the ice-lobe had been melted back a hundred and eighty miles from its farthest extent, and its southwest side, which at first restel on the crest of the Coteau des Prairies, had retired thirty to

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sea, undulates so much unie characteristic all my exploray resembling a ulder has been nor have osars d more stream. this lacustrine ota. But osars ' modified drift e of the Wassis continue northipeg and Shoal

arlier and later in many places turned by the s was permitted southward, free present valleys, anants of which reams. But on ding ice-border. bandoned when supply of water es became con-McConnell,† and Agassiz and the he retiring icetlets of lakes of ned toward the r, for med by the and overflowing drainage basins

y of the Forty-nat for 1882-83-84, p. 150 of 74 C.

^{*} Changes of Level of the Great Lakes," by G. K. Gilbert, in The Forum, vol. v, pp. 417-425, Ime. 1888. Geol. Sur. of Canada, Report of Progress to 1863, pp. 910-915. C. Whittlesey, " On the Fresh-water Glacial Drift of the Northwestern States," 1864, pp. 17-22, in Smithsonian Conminitions, vol. xv. J. S. Newberry, in Report of the Geological Survey of Ohio, vol. ii, 1874. $p_1^{-50,c5}$, with three maps — "The Lake Age in Ohio," by E. W. Clayrole, pp. 42, with four maps, Trans. of the Geol, Soc. of Edinburgh, 1887.

GLACIAL LAKE AGASSIZ IN MANITOHA,

tity miles to the east side of Big Stone Lake and the east part of Yellow Medicine County, Minu. During its next stage of retreat this ice-lobe was melted away from the whole of 'Le Sneur County, and its southeast extremity was withdrawn to Waeonia in Carver Country where it again halted, forming its sixth or Waconia morine. The seventh or Dovre moraine marks a pause in its recession when its southeast end rested on Kandiyohi County. Probably nearly all of the southern half of Minnesota was at this time divested of its lee. mantle, while nearly all of the northern half was still ice-covered. By its next recessions the glacial border was withdrawn to the eighthor Forgus Falls moraine, and the ninth or Leaf Hills moraine. These are merged together in the prominent accumulations of the Leaf Hills which lie in southern Otter Tail County, Minnesota, reaching in a semicircle from Fergus Falls to the southeast, east, and northeast, a distance of about tifty miles, and marking the southern limits of this ice-lobe when it terminated half-way between the south and north borders of Minnesota.* The south part of Lake Agassiz probably began to be nneovered by the retreating ice-sheet between its stages marked by the Waconia and Dovre moraines; and this lake reached northward from Lake Traverse 100 to 125 miles along the Red läver Valley when the Fergus Falls and Leaf Hills moraines were accumulated.

On the west side of Lake Agassiz the Dakota lobe of the ice sheet, from its junction with the Minnesota lobe near the head of the the Coteau des Prairies, twenty-five miles west of Lake Traverse and Brown's Valley, at first reached about 200 miles south along the valley of the James or Dakota River to Yankton and the Missouri; but it was gradually diminished in its extent until, at the times of formational the Kiester, Elysian, Waconia, and Dovre moraines, it no longer retained its lobate ontline. While these moraines were being formed in Minne-ota, the southwestern boundary of the ice-sheet in South and North Dakota passed from the vicinity of Big Stone Lake and Lake Traverse northwesterly along moraine belts that have been traced through Sargent, Ransom, Barnes, and Griggs Counties, North Dakota and by the sources of the James and Shevenne Rivers. During the later stages represented by the Fergus Falls and Leaf Hills moraine, the Dakota ice-front appears to have become again lobate, extending from the west shore of Lake Agassiz southward and then westward and northward, between the lake area and the Shevenne River, to de prominent and typical moraines that are found south of Stump and Devil's Lakes, on the Big Butte, about Broken Bone Lake and north-

 For detailed descriptions of these moraines, and of the recession of the ice-sheet in this state see Geology of Minnesota, vols, i and ii. ward, and on these moraines seem to have b

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The course d Lake Agassiz, of the Leaf I morainie depo: 17º 10', which abundance of 1 of the till form till which stret tating the bed lake this mora but it has man five feet or ri gravel are plen the lacustrine occupies the ce to Winnipeg.

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Recession of the ice-sheet in

South and North Dakota

from Yankton

to the south side of Devil's Lake.

LAKE AGASSIZ.

ward, and on Turtle Mountain. In their remarkable development these moraines are similar to the massive Leaf IIIIIs, with which they seem to have been contemporaneous.

The course of the ice front where it formed the northern barrier of Lake Agassiz, at the time of its accumulation of these great moraines of the Leaf Hills and the south side of Devil's Lake, is marked by morainic deposits both east and west of the lake near the latitude of f² 10', which passes twenty miles north of Fargo; by an unusual Tract of till abundance of boulders near this intitude and farther north on portions group al River of the till forming each side of the lacustrine area; and by a tract of Valley. till which stretches across the Red River Valley at Caledonia, constinting the bed and banks of the river along the Goose Rapids. In the lake this morainic till was spread with a generally even surface, but it has many small inequalities, the higher portions being three to five feet or rarely ten feet above adjoining hollows. Boulders and gravel are plentiful on its surface, this being the only interruption of the lacustrine and alluvial clayey silt which elsewhere continuously occupies the central part of this valley plain from near Breckenridge to Winnipeg.

Toward the east the ice-sheet at this time had receded from the Eastward southwest part of Lake Superior, which was held about 500 feet higher corrections than now and overflowed to the Saint Croix and Mississippi Rivers by the time of the the way of the Bois Brulé River and Upper Saint Croix Lake. It moraine, seems nearly certain also that the ice-border continued across Green Bay and the north part of Lake Michigan; and further east, I think that it probably crossed southwestern Ontario and the central or porthern portions of New York, Vermont, New Hampshire, and Maine. The Laurentian lakes were dammed by the retreating glacial barrier and overflowed at the lowest points on their southern water-shed.

During the formation of the tenth or Itasea moraine, crossing the The Itasea lake region at the head of the Mississippi, the ice-sheet bounding Lake or the moraine Agassiz probably extended thence northward, passing not far west of That of the Agassiz probably extended thence northward, passing not far west of The of the Agassiz probably extended thence northward, passing not far west of The Agassiz probably extended thence northward, passing not far west of The Agassiz probably extended thence northward, passing not far west of The Agassiz probably extended thence northward, passing not far west of History and Arrow History of the ice-sheet turned back southwestward. In that course it seems to have reached across the lake area to the boulderstrewn escarpment of the Pembina Mountain east of Thornhill, and leyond to have passed south along the west shore of Lake Agassiz into North Dakota, to Pilot Knob in see, 5, T. 154, R. 56, thence westward to the north side of Devil's Lake, and thence north northwestward by the east part of Turtle Mountain and along the moraine of the west part of the Tiger Hills and of the Brandon and Arrow Hills.

The eleventh or Mesabi moraine, well developed in northeastern

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he east part of of retreat this County, and its Carver County. morine. The ession when its y nearly all of sted of its ice. e-covered. By > the eighth or ine. These are the Leat Hills, reaching in a nd northeast, a n limits of this with and north gassiz probably ween its stages is lake reached the Red River s were accumi.

of the ice sheet, to head of the e Traverse and dong the valley mri; but it was of formation of s, it no longer re being formed set in South and Lake and Lake ve been tracel , North Dakota rs. During the Hills moraine, obate, extending then westward ne River, to the of Stump and Lake and north-

ce-sheet in this State

GLACIAL LAKE AGASSIZ IN MANITOBA.

Minnesota, is probably represented by morainic accumulations borth of Pokegama Falls of the Mississippi, about Bowstring Lake, the head of the Big Fork of Rainy River, east of the Narrows between the south and north parts of Red Lake, and on the east part of the Tiger Hills Lake Agassiz had contemporaneously a length of more than 300 miles from Lake Traverse to near the south end of Lake Winnipeg. Later moraines, formed at times of halt or re-advance, interrupting there. cession of the ice-sheet between northern Minnesota and Hudson Bay have not been determined; but I believe that they exist and await discovery when the glacial drift of that wooded and very scantily in. habited region shall be fully explored.

on the area of Lake Agassiz during the formation of the highest Herman beach.

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The highest of the Herman beaches of Lake Agassiz extends in Mis-Glacial melting nesota, as traced in this survey, to the north side of Maple Lake, twenty miles east-southeast of Crookston, and probably it continues thence into the forest region on the east, where it is impracticable to follow its course, to the vicinity of Red Lake ; and on the west side of Lake Agassiz it reaches through North Dakota and at least fourteen miles into Manitoba, terminating on the northern part of the Pembina escarpment somewhere between Thornhill and its northern end, that is, between fourteen and forty miles north of the international boundary. Before the formation of this beach was completed, the ice-sheet had retired from the lake area as far north as the beach extends. Due ing panses of this glacial recession the Dovre, Fergus Falls, Leat Hills, and Itasca moraines were formed, showing a northward retreat of the ice border across a distance of about 150 miles in central Minnesota and 150 to 200 miles in North Dakota and southern Manitoba, with a maximum of probably not less than 300 miles in the Red River Valley. where Lake Agassiz would doubtless cause a more rapid melting of the ice-margin. Through this time the River Warren eroded a channel about fifty feet deep, approximately from 1,100 to 1,050 feet above the sea, or perhaps it eroded only the lower half of that depth, in the mod erately undulating sheet of till which reached across the present valley of Lakes Traverse and Big Stone. The shortness of the time probably occupied in the formation of the beaches of Lake Agassiz may well astonish us in what it implies concerning the rapidity of the recession of the ice-sheet, and the brevity, geologically speaking, of the stage of pause or re-advance when its moraines were accumulated,

Southwestern shore near Milnor first uncovered from the ice.

The retreat of the ice seems to have uncovered the southwest horder of Lake Agassiz earlier than its shores further north and on its east side, as is shown by the Milnor beach, a less distinct shore deposit that the Herman beach and 20 to 25 feet above it, which was observed near Milnor, North Dakota, and along a distance of about ton miles thence north-west to the Sheyenne, but was not recognized farther north nor

in Minnesotu. time of the Mi man beach, w Assiniboine de ice from the R the accumulat Agassiz, excep delta, until its which probabl due to diminisl stream.

Compared w beach has a gri a fort per mile. month of the la The mouth of t international be It is further fo Lake Agassiz t southern part o beaches that we tion of that are ever, was due to account of the ice-sheet, propo ing. As many recognizable by bined with a si ×. 10, 7, 15, 10, a Dakota and Mar the adjoining la porthward from not sufficient for

la a later par changes in the l table of the pres lake on its west the levels of Lal-(a and ad) in th the Pembina Me well developed northern limit of During the int

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LAKE AGASSIZ.

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extends in Minof Maple Lake ly it continues npracticable to the west side of least fourteea of the Pembina thern end, that national bounds d, the ice-sheet extends. Duralls, Leat Hills, I retreat of the ntral Minnesota anitoba, with a ed River Valley d melting of the ided a channel 0 feet above the pth, in the mol e present valles · time probably cassiz may well of the recession , of the stagelated.

onthwest border and on its east ore deposit that is observed near on miles thence rther north nor in Minnesota. The formation of the Sheyenne delta had began at this time of the Milnor beach, and continued through the time of the Herman beach, with which latter the Buffalo, Sand Hill, Pembina, and Assinibilitie deltas were also contemporaneous. The departure of the ice from the Red River Valley seems to have been too rapid to permit the accumulation of definite shore deposits on the borders of Lake Agassiz, excepting the senity Milnor beach derived from the Sheyenne delta, until its outlet was cut down to the level of the Herman beach, which probably represents a time of much slower erosion of the outlet, due to diminished glacial melting and smaller volume of the outflowing stream.

Compared with the level of the present time, the highest Herman leach has a gradual ascent from south to north which averages nearly a fort per mile, amounting to about 175 feet in the 224 miles from the mouth of the lake at its southern end to the international boundary. The mouth of the lake was then about 1,055 feet, and its surface on the international boundary about 1,230 feet, above the present sea level. Northward cent of the It is further found that in the northern part of the explored area of flerman Lake Agassiz this upper or Herman beach, which is single along the beaches. southern part of the lake, becomes divided into numerous parallel teaches that were formed at intervals of pause in a progressing elevation of that area. A portion of these relative changes of level, however, was due to a subsidence of the lake itself toward the north, on account of the diminution of its attraction by gravitation toward the ice-sheet, proportionate with the decrease of the ice in its final melting. As many as six other Herman stages below the highest are recognizable by beach deposits, which indicate a rise of the land combined with a sinking of the lake to the amount successively of about 10, 7, 15, 10, and 5 feet, or in total 55 feet, on the line between North bakota and Manitoba, while yet the relative elevations of the lake and the adjoining land along its southern part for some seventy-five miles northward from Lake Traverse remained with only slight changes, not sufficient for the formation of any secondary beach ridge.

In a later part of this report the discussion of the causes of these changes in the height of the land and of the lake is accompanied by a table of the present elevations of the successive beaches formed by the lake on its west side through its entire existence, until it was drained to the levels of Lakes Manitoba and Winnipeg. The two highest beaches (a and aa) in the Herman series of this table were not found north of the Pembina Mountain escarpment; but the next two (b and bb) are well developed at Brandon and near Neepawa, reaching thus to the porthern limit of my exploration at the south end of Riding Mountain. During the interval between these Herman beaches a and b, the

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combined rise of the land and fall of the lake were only eighteen or twenty feet on the international boundary; but in this time the somhern end of the ice-lobe west of the lake had been withdrawn from the east part of the Tiger Hills to Riding Mountain, and the Assiniboine delta was being rapidly deposited. The northward extent of Lake Extent or Lake Agassiz in its Herman stages Agassiz in its subsequent Herman stages is not definitely determined. north to Riding but evidently some of the upper beaches observed by Mr. Tyrrell $_{0\mathrm{h}}$ and Duck the foot slopes east of the escarpments of Riding and Duck Mountains belong to this series, the highest, according to information supplied by him, being in lat, 51°52' or two hundred miles north of the international boundary, at an elevation of about 1,460 feet above the sea,

Later stages of the lake while it outdowed southward.

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Mountains,

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The foregoing observations show that the ice-sheet was melted awar from at least half of the area of Lake Agassiz during its Herman stages, In the ensuing Norcross, Tintah, Campbell and McCauleyville stages through which the lake continued to outflow southward by the River Warren, the recession of the ice doubtless permitted it to extend north and east beyond Lake Winnipeg and along the ower valley of the Saskatchewan. Each of these stages is represented by two or three beaches in northern Minnesota and North Dakota and in southern Manitoba, which, with the seven beaches of the Herman series, make -eventeen shore lines recognizable in that part of the lacustrine area belonging to the time of its southern outlet. Between the Herman and Norcross beaches the channel of the River Warren was eroded about 25 feet; it was deepened 15 to 30 feet more at the time of the Tintah beaches; 10 to 20 feet farther down to the Campbell beaches; and again 10 to 20 feet to the McCauleyville beaches. In all, the month and southern end of the lake were lowered about 100 feet between the highest Herman beach and the lowest McCaulevrille beach. Proceeding northward, the vertical distance between these beaches gradually increases to 240 feet on the international boundary, the difference of 140 feet more than the depression caused by erosion of the outlet being a"ributable to the northward rise of the land and subsidence of the water-level.

Before Lake Agassiz could obtain an outlet to the northeast, the thick ice-sheet that had filled the basin of Hudson Bay was so far melted as to admit the sea, which at first covered the land west of Jame-Bay 350 to 500 feet above the present sea level. Eleven stages of Lake Agassiz are marked by beaches that lie below the beds of Lakes Traverse and Big Stone, which were the channel of the River Warren

Stages of northeastern outflow.

when the lake ceased to outflow to the south. These beaches and separated by vertical intervals that vary from 10 to 45 feet through the range of elevation between the lowest McCauleyville beach and Lake Winnipeg, which was originally twenty feet higher than now.

Assoon as the country had so than the Rive perhaps flowing Severn, and late the Hill and Ha eraded to a conduring the time of the southeast west of Hudson the Nelson, the Winnipeg. The latitude of the se the present sea the Nelson betw channel of the n Fossils have I localities. They district, occurrin to obtain sand fo southwest of Ca feet above the common species beach, a half mi above the sea and con-iderable abm I'no lutcolus, Lau lam, and Gyrau were kindly deto Unio luteolus is o the genus, its rang York, and west to Both these species lake of the Woo ommon species o stends at least to as been collected he later part of ladstone beach be eward the northe he international 1 Evidences of ma he ice-sheet have

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northeast, the Bay was so far d west of James i stages of Lake beds of Lakes B River Warren eso beaches are 15 feet through ville beach and oher than now. A soon as the ice upon Hudson and James Bays and the adjoining country had so receded as to give to Lake Agassiz an outlet lower than the River Warren, it began to be drained in that direction, perhaps flowing at first across the water-shed between the Poplar and severn, and later along lower courses, including the canoe route by the Hill and Hayes Rivers. Each of its successive outlets was probably ended to a considerable depth, being occupied by the outflowing river during the time of formation of two or more beaches, until the retreat of the southeastern border of the portion of the ice-sheet remaining mest of Hudson Bay finally permitted drainage to take the course of the Nelson, the ice-dammed Lake Agassiz being thus changed to Lake Winnipeg. The northeastern outflow commenced when the lake at the latitude of the south end of Lake Winnipeg stood about 1,000 feet above the present sea level, and it was gradually lowered to 730 feet when the Nelson between its successive lakes began to erode the shallow channel of the upper part of its course.

Fossils have been found in the deposits of Lake Agassiz at two healities. They are all fresh-water shells of species now living in this strict, occurring in beach ridges where excavations have been made to obtain sand for masons' use. The Campbell beach, about six miles outhwest of Campbell, Minnesota, at an elevation approximately 985 Mottusean ket above the sea, has thus yielded shells of Unio ellipsis, Lea, a fauna of Lake common species of the upper Mississippi region. In the Gladstone leach, a half mile northeast of Gladstone, Manitoba, about 875 feet above the sea and 165 feet above Lake Winnipeg, four species occur in ensiderable abundance from two to four feet below the surface, namely, The luteolus, Lamavek, Spharium striatinum, Lam., Spharium suicatum, lam, and Gyraulus parcus, Say. These species from both localities vere kindly determined by Prof. R. Ellsworth Call, who states that this lateolus is one of the most widely distributed representatives of he genus, its range being from Lake Winnipeg to Texas, east to New Tork, and west to Montana. It is generally abundant in Minnesotabili these species of Sphærium are reported by Dr. Dawson from the ake of the Woods and Pembina River; and the first is the most ommon species of its genus in Minnesota, while its range northward stends at least to Great Playgreen Lake and York Factory, where it as been collected by Dr. Bell. The Campbell beach was formed in helater part of the time of the lake's southward outflow; and the hidstone beach belongs to the middle portion of the time of its outflow ward the northeast, its south end being then about 85 miles south of leinternational boundary.

Evidences of man's presence in this region during the departure of leice-sheet have been discovered by Miss Franc E. Babbitt at Little

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Traces of men contemporancons with the glacial recession and Lake Agassiz.

Measurements

of time since the last glacial

epoch.

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Falls in central Minnesota. A stratum containing many artificially chipped fragments of quartz is enclosed there in the modified drift of the upper Mississippi Valley, which was deposited by the foods supplied from the melting ice-sheet in its retreat while it was being withdrawn from northern Minnesota and the Red River Valley.³⁶ It seems probable therefore that men lived on the shores of Lake Agassiz and witnessed the erosion of the channel of the River Warren, the gradual lowering of the lake level and reduction of its area, and its later northcastward entflow to Hudson Bay. But this is not left wholly to conjectur. The Tyrrell informs me that in northwestern Manit-Ja, at an elevation of 1,135 feet above the sea, he has found sharp-edgel fragments of quartzite, chipped by human workmanship, interheddel with the rounded gravel of one of the Campbell beaches.⁴

If the question be asked how many thousand years ago did the recession of the ice-sheet take place, causing Lake Agassiz to fill the Red River Valley and the basin of Lake Winnipeg, a reply is furnished by the computations of Prof. N. II. Winchell,⁴ that approximately 8,000 years have elapsed during the crosion of the postglacial gargent the Mississippi from Fort Snelling to the Fails of Saint Anthony: et Dr. Andrews, || that the erosion of the shores of Lake Michigan, and the resulting accumulation of dune sand drifted to the southern end of that lake, cannot have occupied more than 7,500 years; of Professor Wrights that streams tributary to Lake Eric have taken a similar length of time to cut their valleys and the gorges below their water-falls; of M Gilbert,*** that the gorge below Niagara Falls has required only 7,000 years or less; and of Prof. B. K. Emerson, "t on the rate of deposition of modified drift in the Connecticut Valley at Northampton, Massa chusetts, from which he believes that not more than 10,000 years have clapsed since the glacial period. An equally small estimate is as

11 Am. Jour. Sci., III., vol. xxxiv, pp. 404-5, Nov., 1887.

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indicated by the last great of time, surpr with the perilong record of the last glacia Mississippi, of

The entire at the most in this time may of its beaches concurrent su amounted toge Mountain and estimates may with those of their north an have sufferred a time which ver the shores of L them being sm similarly great about its south contrast indeed recession of the Nelson River, 1 vents.

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Proceedings of Am. Assoc. for Adv. of Science, vol. xxxii, 1883, pp. 385-3801; Amerey Naturalist, vol. xviii, pp. 594-605, and 697-708, June and July, 1881; and Proc., Boston Sci., Natural History, vol. xxiii, 1888, pp. 421-419.

[†] Preliminary notes of this discovery, and of the northwestward continuation of the beacles-Lake Agassiz in the district of Riding and Duck Mountains, are included by Mr. Tyrrell gapaper, "On the Superficial Geology of the Central Platean of Northwestern Canada," real being the Geological Society of London, Nov. 7, 1888, of which an abstract is given in the Geolog Marazine, 111, vol. vi, pp. 37-38, Jan., 1889.

[‡] Geology of Minnesota, Fifth annual report, for 1876; and Final report, vol. ii, pp. 5084. Quart. Jour. Geol. Soc., vol. xxxiv, 1878, pp. 886-901.

f Transactions of the Chicago Academy of Sciences, vol. ii. James C. Southall's Epoch 449 Mammoth and the Apparition of Man upon the Earth, 1878, chapters xxii and xxiii.

^{\$} Am. Jour. Sci., H1., vol. xxi, pp. 120-123, Feb., 1881; The Ice Age in North America, 'se chapte: xx.

[•] Proceedings, Am. Assoc. for Adv. of Science, vol. xxvv. for 1886, p. 222. "The History," the Niagara River," Sixth An. Rep. of Commissioners of the State Reservation at Niagara for 1889, pp. 61-81.

ny artificially odified drift of flood- supplie! ng withdrawn .* It seems e Agassiz and en, the gradual its later northleft wholly to tern Manitoba, nd sharp-edget ip, interboldel 5.4

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tion of the beaches (1 by Mr. Tyrrell us Canada," read bette ven in the Geole

rt, vol. ii, 14, 313-4

uthall's Epoch : and xxiii North America, 1st

22. " The History ervation at Niagan LAKE AGASSIZ.

indicated by the studies of Gilbert * and Russell † for the time since the last great rise of Lakes Bonneville and Lahontan. These measures of time, surprisingly short whether we compare them on the one hand with the period of authentic human history or on the other with the long record of geology, carry us back to the date when the ice-sheet of the last glacial epoch was melting away from the basins of the upper Mississippi, of the Red River of the North, and of the Laurentian lakes.

The entire departure of this ice-sheet therefore probably occupied Duration of at the most not more than two or three thousand years; and half of Lake Acassis commard at this time may measure the duration of Lake Agassiz, with the formation that of lake of its beaches marking more than twenty-tive successive stages in the indicated by concurrent subsidence of its surface and rise of the earth's crust, which and beach amounted together to 700 feet on the latitude of the north part of Duck Mountain and the middle of Lake Vinnipeg. But even these short estimates may be too long. The shores of Lake Michigan, similar with those of Lake Agassiz in the drift of which they are formed, in their north and south trends, and in the adjoining depths of water, have suffered an amount of erosion by the lake waves during postglacial time which very far exceeds the total erosion that was effected upon the shores of Lake Agassiz during all its stages, the proportion between them being surely not less than ten to one; and Lake Michigan has a imilarly greater amount of beach deposits, which upon a large area about its south end are raised by the wind in conspicuous duncs. This contrast indeed suggests that the duration of Lake Agassiz, and the recession of the ice-sheet from Lake Traverse to the lower part of the Yelson River, may have been included within less than one thousand vents.

Before Lake Agassiz began to exist, the receding Minnesota and bakota ice-lobes had each given place to a large lake on the central part of the area from which they withdrew. By the barrier of the Minnesota ice-lobe a lake having an elevation of about 1,150 feet above (lagial lake in the sea was formed in southern Minnesota in the basin of the Blue the basin of the Earth and Minnesota rivers, outflowing southward by way of Union Minnesota Sough to the East Fork of the Des Moines. In its maximum extent his lake probably had a length of 160 miles, from Waseca to Big Sone Lake, with a width of forty miles in Blue Earth and Faribault Counties, attaining an area of more than 3,000 square miles. The continued glacial recession afterward opened lower outlets eastward to the Cannon River, and at the time of the Waconia moraine had uncovered the lower part of the Minnesota Valley, permitting the lake to

"U.S. Geological Survey, Second annual report, p. 188.

U.S. Geological Survey, Monograph XI, Geological History of Lake Laboutan, p. 273.

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be wholly drained northeastward to the Miss'ssippi.* The modified drift from the retreating ice on the upper anesota basin was deposited along the lower half of this valley, filling it with stratified gravel, sand and clay, to a depth 75 to 150 feet above the present river from New Ulm to its mouth, which shows that at least this portion of the valley was excavated in the sheet of till during the interglacial epoch, and remained with nearly its present form through the later glaciation. It seems also probable that the upper part of the channel above New Ulm, occupied by the River Warren at the time of the Herman beaches, remained from such interglacial erosion, so that the first outflow from Lake Agassiz was at a level some twenty-five feet below the general surface adjoining Lakes Traverse and Big Stone and Brown's Valley, being thus approximately marked by the Milnor beach.† As long as streams poured into this valley directly from the melting ice-sheet, its modified drift, gathered from the ice in which it had been held, continued to increase in depth; but when the ice had retreated beyond the limits of the Minnesota basin, the water discharged here from Lake Agassiz brought no modified drift, and was

Erosion by the River Warren.

Modified drift of the Minnesota

Valley.

Lake Dakota, outflowing southward to the Missouri River. consequently a most powerful eroding agent. By this River Warren the valley drift, so recently deposited, was mostly swept away, and the channel was excavated to a depth lower than the present river. But since Lake Agassiz began to outflow northeastward, the Minnesota Valley and that of the Mississippi below, earrying only a small fraction of their former volume of water, have become considerably filled by the alluvial gravel, sand, clay and silt, which have been bronght in by tribataries, being spread for the most part somewhat evenly along these valleys by their floods, ‡

Prof. J. E. Todd supplies me the approximate outline of a lake namel by him Lake Dakota, which occapied the valley of the James or Dakota River contemporaneously with the foregoing, reaching from Mitchell 170 miles north to Oakes and varying from 10 to 30 miles in width. [] It outflowed southward by the present course of the James to the Missouri. The Dakota ice-lobe, which had filled this valley and in its recession formed the northern shore of Lake Dakota, was not therefore the cause of this lake in the same way that the lake in the Blue Earth and Minnesota basin and Lake Agassiz owed their

[†] Compare with Geology of Minnesota, vol. i, pp. 470-485, describing the chains of lakes in Martin County, Minnesota, which are apparently due to interchecial water-courses that wereast wholly filled with drift in the last clackin lepoch.

*"The Minnesota Valley in the Iee Age," Proc. Am. Assoc. for Adv. of Science, vol. xxú, 1882, pp. 213-231; also in Am, Jour. Sci., III, vol. xxvii, Jan, and Feb., 1884.

This lake is partially mapped by Prof. Todd in Proc. Am. Assoc. for Adv. of Science. vol. xxxiii, 1884, p. 393.

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The outflow retreat of the northern part eastward into by the further des Prairies an tract of the sa glacial lake fo. Dovre morain stream of the and enters the tion of the wat River would flo the general lev present level o branch of the feet above the leds in the vic waves have act undulating till highest shore 1,345 feet abo expanse of wat depth of the ch before the glac Agassiz, indica Valley had gai already drained the Red River It is evident, esperienced on direction from James River V

Geology of Minnesota, vol. i, pp. 460, 622, 642.

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The modified basin was deith stratified the present at least this ring the interthrough the er part of the at the time inl erosion, so 10 twenty-five and Big Stone by the Milnor etly from the ce in which it n the ice had he water didrift, and was River Warren ept away, and present river. the Minnesota small fraction ily filled by the ght in by tribu-

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f a lake named the James or reaching from 10 to 30 miles course of the had tilled this **Lake** Dakota, that the lake siz owed their

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chains of lakes in our es that were not Science, vol. xxii, dy. of Science, vol. existence to the barrier of the ice-sheet in its retreat. The bed of Lake Dakota has a nearly uniform elevation of 1,300 feet, or is within ten feet below or above this, throughout its length; and during the glacial recession it was covered by a lake whose shores have now a height of about 1.300 to 1,350 feet, probably ascending slightly from south to north, as compared with the present sea level. Professor Todd states that the surface of this lacustrine area in its southern part, from Mitchell to Redtield, is nearly flat till, but thence northward is sund and leves-like silt, while considerable tracts of the eastern border of its north part consist of low dunes.

The outflowing James River was cutting down its channel during the refreat of the ice-lobe, and its ero-ion was so rapid as to prevent the northern part of Lake Dakota from retaining sufficient depth to outflow eastward into the south end of Lake Agassiz when the way was opened by the further departure of the ice, receding from the Head of the Coteau des Prairies and beginning to uncover the Red Rive: Valley. A large tract of the sand and silt beds of Lake Dakota, and of a contiguous glacial lake formed in Sargent County, North Dakota, at the time of the porre moraine, now sends its drainage to the Red River by the head stream of the Wild Rice, which passes north of the Head of the Coteau and enters the area of Lake Agassiz near Wyndmere. The lowest portion of the water-shed on this lacustrine deposit, over which the James liver would flow east to the Wild Rice River is scarcely ten feet above the general lovel of the James Valley or twenty-five feet above the present level of the James River, being at Amherst on the Aberdeen branch of the Saint Paul, Minneapolis and Manitoba Railway, 1,312 feet above the sea. The elevation of the upper portion of the lake bels in the vicinity of Oakes, and the lack of evidence that the lake waves have acted at any greater height upon the adjoining surfaces of undulating till and morainic hills, lead to the conclusion that the highest shore line of the north end of Lake Dakota is not more than Less change of 1.345 feet above the sea, showing that there was only a shallow area of Lake expanse of water above the sea, showing that there was only a sharlow here of lake expanse of water above the plain of lacustrine silt. On the north the lack arassiz, depth of the channel of the inflowing James River, eroded apparently parture of the before the glacial retreat could permit an eastward outlet into Lake ice. Agassiz, indicates that the surfaces of land and water in the James Valley had gained nearly their present relations, Lake Dakota being already drained away, when the Wild–Rice River and the south end of the Red River Valley were uncovered by the recession of the ice-sheet. It is evident, therefore, that the long area of Lake Dakota has esperienced only slight differential changes of level, at least in the direction from south to north, since the departure of the ice. The James River Valley is thus strongly contrasted with the northward

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uplifting that has affected the Red River Valley as shown by the beaches of Lake Agassiz, the highest of which rises from south to north about six inches per mile for 30 or 40 miles at its south end, but a foot or more per mile within 40 miles farther north, and indeed has an average north. ward ascent of about one foot per mile through an extent of 400 miles along the west side of this lake in North Dakota and Manitoba,

As Lake Agassiz gradually extended to the north, following the receding ice-barrier, it received successively by three outlets the drainage of the glacial lakes of the Saskatchewan and Souris basins, These streams took the course of the Sheyenne, Pembina, and Assini boine Rivers, each bringing an extensive delta deposit. With the tire retreat of the ice from the Missouri Coteau a glacial lake began to exist in the valley of the South Saskatchewan in the vicinity of the Elbow, probably outflowing at an early time by the way of Moose Jaw Creek and through a glacial lake in the upper Souris basin, to the Missouri near Fort Stevenson. Later the outflow from the Lake Saskatchewan may have passed to the Lake Souris by way of the Wascana River, after passing through a glacial lake which probably extended from Regina sixty miles to the west in the upper Qu'Appelle basin. When the Dakota icc-lobe was melted back to the vicinity of Devil's Lake, the drainage of Lake Souris passed southeast by the Big Coulée, one of the head streams of the Sheyenne, flowing thence for some time southward by the James River to Lake Dakota, but later eastward and southward by the Sheyenne into Lake Agassiz. A manuscript report of a reconnoissance in North Dakota by Major W. J. Twining, in 1869, describes the valley of the Big Coulée as 125 feet deep and a third of a mile wide, enclosing several shallow lakes along its course. "This great valley," he writes, " preserves its character to within twelve miles of the Mouse [Souris] River, and connects through the elay and sand ridge with the open valley of that stream."

The Sheyenne delta, reaching from the Lightning's Nest fifty miles northwest to the south bend of the Maple River, and having a maximum width of nearly thirty miles to the northeast from the south bend of the Sheyenne, probably covers an area of 800 square miles to an average depth of 40 feet. A large portion of this delta is doubtless modified The Sheyenne drift, which was brought down by glacial streams from the melting defta, formed party of modi, surface of the ice-sheet, their coarser gravel with much sand being field drift, and deposited in the high plains that slope southward along the outer size drift, which was brought down by glacial streams from the melting deposited in the high plains that slope southward along the outer sile of the great moraines that pass south of Devil's Lake, their finer gravel and sand being carried by the Sheyenne to this delta, and their finest silt and clay being spread in the quiet water of the lake over a much larger adjoining area of its bed, from near Breekenridge northward beyond the mouth of the Sheyenne, Much alluvium was also supplied

in depth along sheet, mainly shales. The v according to t delta, or perha sediments that of the Sheyeur valley. It was then was erode interglacial tir with till in the degree its trong true of the Min deita would be When the b water of the r which the Red of water, whiel their tine claye; Agassiz by its d Pembina, and A spread over lar had a surface of formations, muc drainage of the sariace, whethe guishable from those now living of Lake Agassiz the present mar and logs of wood food. Thus the leis at McCaule about 7 and 20 f many fragments Gyndon, Minne other observatio River Valley in drained away, an flow by the riv deposited,* Ev

* Geology of Minn

Lakes of the Saskatchewan and Souris, outflowing to Lake Agassiz by the Sheyenne.

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from the erosion of the Sheyenne Valley, which, with that of the Big coulde, probably averages three fourths of a mile in width and 150 feet in depth along a distance of 200 miles. This channel is cut in the drift sheet, mainly till, and in the underlying easily eroded Cretaceous shales. The volume of the material supplied from it would be equal, according to these estimates, to about three fourths of the Sheyenne delta, or perhaps to three eighths of both the delta and the finer elayey ediments that were deposited farther out in the lake. But the valley of the Sheyenne was doubtless also both a preglacial and an interglacial ralley. It was probably wholly filled with till in the first glacial epoch, then was eroded, chiefly in this drift, to nearly its present size during interglacial time, and was partially but perhaps not wholly refilled with till in the last epoch of glaciation. If it retained in considerable degree its trough-like form beneath the last ice-sheet, as was evidently true of the Minnesota Valley, its erosion and its tribute to the Sheyenne delta would be less than the proportion estimated.

When the bed of Lake Agassiz was gradually uncovered from the water of the receding lake, some parts of its central plain through which the Red River flows probably remained as broad shallow basins water, which that river and its tributaries have since tilled with their time clayey alluvium. The similar clayey silt brought into Lake Agassiz by its delta-forming affluents, the Buffalo, Sand Hill, Sheyenne, Athavian Pembina, and Assimboine Rivers, and others farther north, had been the central part pembina, and Assimboine Rivers, and others farther north, had been the field spread over large areas of the lake bed, but more extensive portions after the had a surface of till, with no such lacustrine deposit. Over these drainage of Lake Acassiz, permations, much alluvium has been laid down along the avenues of drainage of the old lake bed, and it has filled depressions of the original surface, whether of lacustrine sediments or of till, being only distingaishable from the former by its containing in some places shells like these now living in the shallow lakes of the country adjoining the area d Lake Agassiz, remains of rushes and sedges and peaty deposits, as of the present marshes of the Red River Valley, and occasional branches and logs of wood, such as are floated down by streams in their stages of food. Thus the occurrence of shells, rushes and sedges in these alluvial leis at McCauleyville, Minnesota, 32 and 45 feet below the surface, or about 7 and 20 feet below the level of the Red River, of sheets of turf, many fragments of decaying wood, and a log a foot in diameter at terndon, Minnesota, 13 to 35 feet below the surface, and numerous ther observations of remains of vegetation elsewhere along the Red River Valley in these beds, demonstrate that Lake Agass'z had been brained away, and that the valley was a land surface, subject to overfow by the river at its stages of flood when these remains were deposited.* Even at the present time much of the area of stratified

Goology of Minnesota, vol. ii, pp. 529, 530, 663-4, and 668-9.

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elay that almost continuously forms the central part of the valley plain is covered by the highest floods, and probably no portion of it is more than ten feet above the high water line of the Red River and its tributaries. The position of the thick beds of fine silt and clay in the central depression of the Red River Valley shows that they were not mainly deposited by the waters of Lake Agassiz, which must have spread them somewhat equally over both the lower and higher parts of the lacustrine area: but instead appears to prove that at least their upper and greater part was brought by the rivers which flowed into this hollow and along it northward after the glacial lake was withdrawn

BEACHES AND DELTAS.

A brief general description of the beach ridges of Lake Agassiz has material of the been given on page 12 E, their usual height being there stated to be from three to ten feet above the adjoining land on the side that way away from the lake, and ten to twenty feet above the adjoining land on the side where the lake lay, their varying breadth between the bases of the slopes being from ten to thirty rods. The beach ridge is thus a broad wave-like swell, with a smooth gracefully rounded surface Like the shore accumulations of present lakes and of the sea coast these of Lake Agassiz vary considerably in size, having in any distance of five miles some portions five or ten feet higher than others, due to the unequal power of waves and currents at these parts of the shore. The usually moderate slope of the land toward Lake Agassiz was favorable for the formation of beach ridges, and they occur at many successive levels, marking pauses in the gradual elevation of the land and subsidence of the lake. The highest distinct beach ridge of Lake Agassiz has been traced in a continuous course along a distance of more than four hundred miles in Minnesota, South and North Dakota, and Manitoba. In calling it continuous, I mean to say that whenever interrupted, as through its having been carried away by streams or where portions of the lake shore received no beach deposits, it is found a little distance farther along, beginning again at very nearly the same height. Commonly the land upon each side of the beach ridges of Lake Agassiz is till or unstratified clay, containing some intermixture of sand and gravel and oceasional stones and boulders. The material of the beach ridge is remarkably in contrast with this adjoining and underlying till, for it includes no clay, but consists of stratified said and gravel, the largest pebbles being usually from two or three to six inches in diameter.

Their forma-tion by wave action

Size and

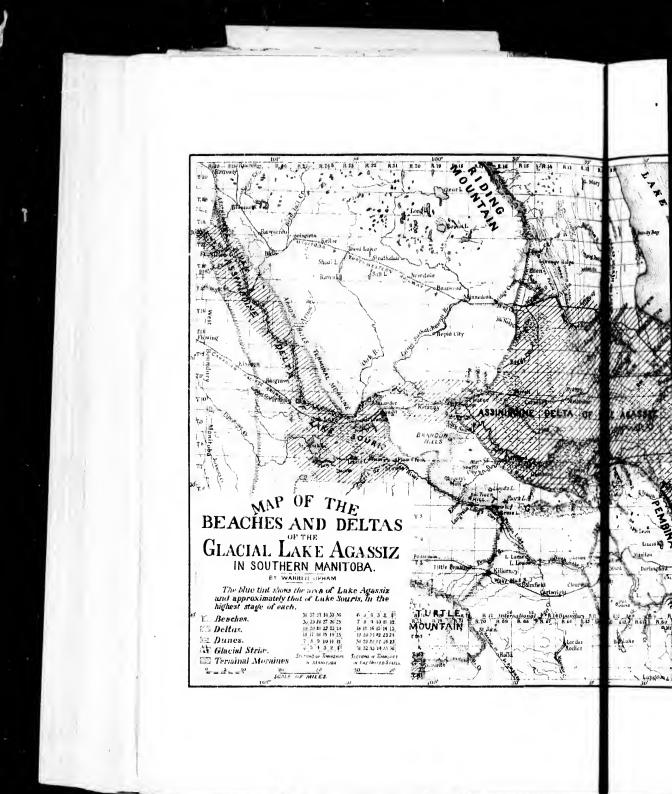
The action of the waves gathered from the deposit of till, which was the lake bed, the gravel and sand of its beaches; and corresponding of the valley plain tion of it is more ed River and its and clay in the at they were not which must have d higher parts of bat at least their chich flowed into e was withdrawn.

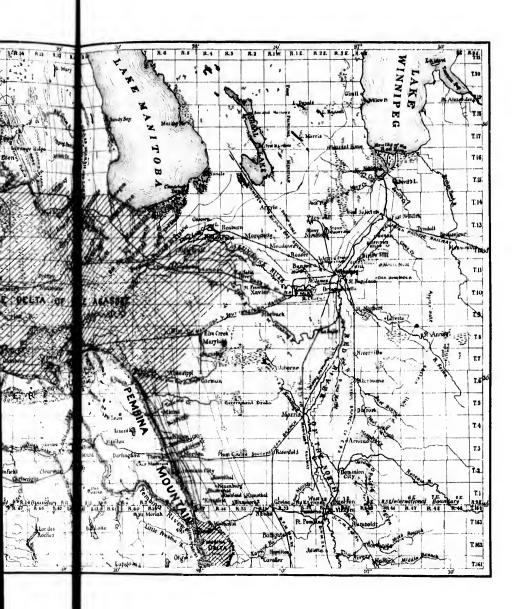
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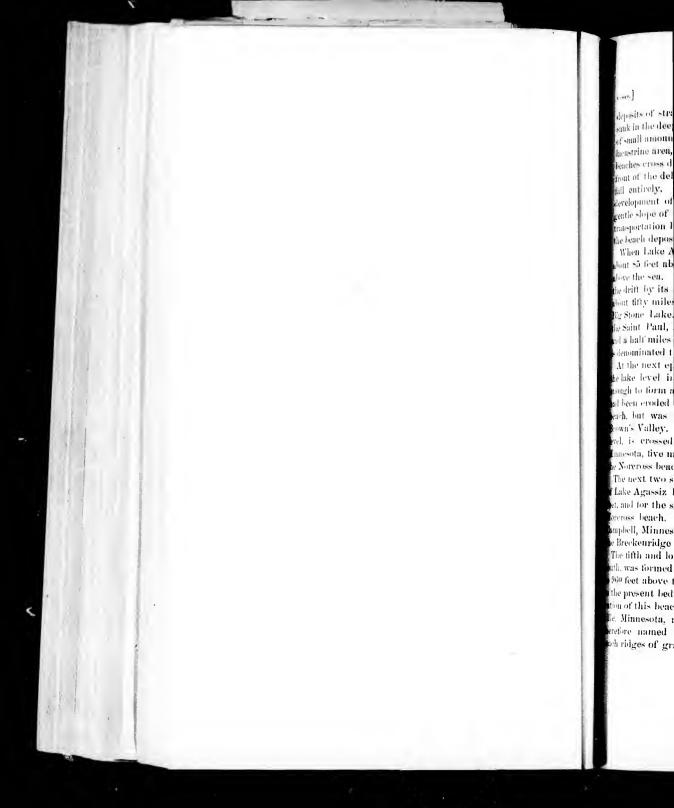
lake Agassiz has there stated to he side that was djoining land on veen the bases of ridge is thus a ounded surface, of the sea coast. in any distance n others, due to rts of the shore, ke Agassiz was occur at many tion of the land h ridge of Lake listance of more rth Dakota, and that whenever by stream- or osits, it is found nearly the same beach ridges of ne intermixture The material

s adjoining and 'stratified sand or three to six

till, which was corresponding d'







BEACHES AND DELTAS.

deposits of stratified chry, derived from the same erosion of the till, suk in the deeper part of the lake. But these sediments were evidently of small amount and are not noticeable upon the greater part of this heastrine area, which consists of a smoothed sheet of till. Where the leaches cross delta deposits, especially the fine silt and chry that lie in front of the delta gravel and sund, they are indistinctly developed or fail entirely. On the other hand, the most massive and typical development of beach ridges is found on areas of till that rise with a gentle slope of ten or tifteen feet per mile. No boulders referable to Absence of transportation by floating ice have been found within or upon any of boulders. the beach deposits of this lake.

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When Lake Agassiz formed its first and upper beach, its outlet was The upper or dout 55 feet above the present surface of Lake Traverse, or 1,055 feet Herman beach, dove the sea. The channel which at this time had been excavated in the drift by its outflow was 40 to 50 feet deep along the distance of dont fifty miles, where are now Lake Traverse, Brown's Valley, and Big Stone Lake. This beach is crossed by the Breckenridge line of the Saint Paul, Minneapolis & Manitoba Railway at a point about one not a half miles northwest of Herman, Minnesota, from which place it denominated the Herman beach.

At the next epoch after that of the upper or Herman beach, when Norerossbeach, helake level in its southern part was again nearly stationary long magh to form a ridge of gravel and sand upon its shore, the outlet of been croded about 25 feet deeper than at the time of the upper each, but was still 60 feet above the present Lake Traverse and hown's Valley. The beach of Lake Agassiz, when it had this lower red, is crossed by the Breckenridge railway line at Norcross, innevota, five miles northwest of Herman; and it is therefore named e Xorcross bench.

The next two series of beach deposits were formed when the outlet Lake Agassiz had been lowered respectively, for the first, 15 to 30 Tintal and tamphell beach the second, 40 to 50 feet below its level at the time of the beaches. Beccoss beach. These beaches take their names from Tintah and amphell, Minnesota, the next two stations northwest of Norcross on e Breckenridge railway line.

The fifth and lowest beach of Lake Agassiz, while it outflowed to the McCauleyvitte wh, was formed after a further erosion of 20 feet, lowering the outlet beach. 960 feet above the sea, and completing the excavation of its channel the present beds of Traverse and Big Stone Lakes. My first obsertion of this beach was three and a half miles northeast of McCauleylle. Minnesota, about fifteen miles north of Breckenridge. It is erefore named the McCauleyville beach. Five distinct series of the ridges of gravel and sand were thus formed by Lake Agassiz at

GLACIAL LAKE AGASSIZ IN MANITORA.

Northward ascent and subdivision of these benches. 58 E

successive stages of height during its process of deepening the channel by which it outflowed southward.

Tracing these beaches to the north, they are found to have a gradial ascent in that direction, diminishing in amount from the highest and earliest to the lowest and latest; and the single beach ridges of the south part of the lake are found to be represented northward by two or three or several parallel beaches. Accordingly, in the tollowing descriptions of the beach ridges observed in Manitoba, those are grouped together which seem to represent the stages of the lake that southward were combined respectively in the Herman, Norcross, Tintah, Campbell and McCauleyville beaches. The Herman beach at the north's thus more or less clearly sublivided into seven, the Norcross and Tintah beaches each become double, and the Campbell and McCauley will beaches each become threefold; so that seventeen stages are recorded in the elevation of the northern part of the area of Lake Agassiz and in the northward subsidence of the water level, belonging to the period of outflow southward by the River Warren.

Beaches formed while Lake Agassiz outflowed northeastward.

In T. 1, R. 5.

Eleven lower beaches were formed while Lake Agassiz outflowed in Hadson Bay; and these are named from localities in North Pakea and Manitoba. The first three are called the Blanchard beaches, and the next three are successively the Hillsboro, Emerado, and Oan beaches, from towns in North Dakota near which they are well developed; while the remaining five receive their names from Manitola, being in descending order the Gladstone, Burnside, Ossowa, Stoneval, and Niverville beaches. The rate of their northward ascent is edge about a sixth or an eighth as much as that of the first Horman beach In all these stages, excepting the lowest one when the Niverville beach was formed, Lake Agassiz extended south of the international boundary.

BEACHES OF THE HERMAN STAGES.

The west shore of Lake Agassiz enters Manitoba two miles west the east line of range five, at a distance of thirty-six miles from the Red River. On the international boundary and for the next ten miles northward the shores of the highest stages of the lake were on the steep wooled escarpment of the Pembina Mountain, the base of which here is 1,100 to 1,150 feet above the sea, rising slightly northward, and the verge of its top 1,300 to 1,400 feet. This ascent, forming the steep face of the Pembina Mountain, is made upon a width of about a quarte of a mile.

Where the Pembina Mountain plateau is ascended by the Somwestern Branch of the Canadian Pacific Railway, and for a distance about four miles south and two miles north of this railway, da principal line of chiefy prairie, are well developed examination of t in the south edge massive rounded fifteen feet in a diits crest, which i with similar outh with similar outh built on its crest, adulating surface the beatch is inter we Cheval Creek,

Swen's house. rest of Mr. Bowe madly than usua Env rods, borde wenty rods, and each is gravel and states also a thir 3, R. 6, where it he elevation of it estis reduced to werbeach ridges and to consist of three inches in d agnesian limestor e Pembina Mour rehaan rocks. T stpart of sees, 16 samment of Pen st thirty miles no at it is the cont aches in Minnesor About a quarter o een to twenty fee me's house, next of eve the sea. It th hth of a mile to t offect or in part wel reaches west difrom Morden to

BEACHES OF THE HERMAN STAGES.

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have a gradual he highest and a ridges of the ward by two or the tollowing ose are grouped that southward , Tintah, Campat the north is a Norcross and and McCanley, teen stages are to area of Lake lovel, belonging en.

ssiz outflowed a n North Daken and beaches, ad erado, and Oas n they are wel s from Manitola soowa, Stonewall al ascent is edy t Horman beach. Niverville beach ational boundar,

wo miles west? c miles from the ne next ten mile ake were on the he base of which y northward, and orming the step f about a quarter

d by the Soats for a distance his railway, %

principal line of escarpment is replaced by a moderate slope which is hiely prairie. Across this tract the Herman beaches of Lake Agassiz are well developed. In order proceeding northward, the first point of examination of the highest beach was sear William H. Oakley's house in the south edge of the S.W. 1 of sec. 26, T. 2, R. 6. It is here a Highest beach masive rounded ridge of gravel and sand, with descent of twelve to R. 6. freen feet in a distance of as many rods both to the east and west from screet, which is 1,253 feet above the sea. Northward this beach, with similar outline, extends to Francis J. Parker's house, which is wilt on its crest, having there also a height of 1.253 feet, in the north ege of the N.W. 4 of this section. Westward from this beach is an mulating surface of till with few boulders. Half a mile farther north beheach is intersected by the deep and broad ravine of Dead Horse "Cheval Creek. Beyond this ravine the beach begins near Samuel B. swen's house. Its elevation one to one and a half miles north-northret of Mr. Bowen's is 1,255 to 1,259 feet, and it is there spread more readly than usual, having a nearly flat surface on a width of twenty to linv rols, bordered on the east by a descent of ten or tifteen feet in venty rods, and on the west by a descent of about four feet. The each is gravel and sand, with till on each side. It has nearly the same states also a third of a mile further north, near the center of see. 10, [3, R, 6, where it is crossed by the road from Morden to Thornhill, redevation of its crest being 1.258 feet, but the depression on the is reduced to only one or two feet. In the same section this and werbeach ridges are excavated beside the railway for ballast, and are and to consist of sand and gravel with pubbles soldom exceeding two directinches in diameter. About half of the pebbles are light gray gnesian limestone, and about half Cretaceous shale, such as forms e Pembina Mountain, with only a small proportion derived from whean rocks. Thenee the highest shore continues north through the spart of sees. 16 and 21, T. 3, R. 6, and in see, 28 comes to the steep argment of Pembina Mountain, with which it coincides along the st thirty miles north-northwest. The elevation of this beach shows t it is the continuation of the highest in the series of Herman whes in Minnesota and North Dakota,

Alont a quarter of a mile east of the foregoing is a parallel beach second herman ken to twenty feet lower, the second in the Herman series. Newton beach in Ts, neshouse, next east of Mr. Oakley's, is built on its crest, 1,237 feet we the sea. It there has a descent of fifteen feet or more within an held be next the second for the best strike with the second second beach in the second second of the best strike within an

where a mile to the east; but on the west the descent is only one or a feet or in part wanting, and τ nearly level surface of sund and addreaches west to the upper beach. In sec. 10, T. 3, R. 6, at the alfona Morden to Thornhill, this second Herman beach has a height

59 е

of 1,241 feet, and another beach at 1,247 feet lies between this and the highest, indicating similar conditions in the fall of the lake level as at the northwest side of Maple Lake in Minnesota, where such an inter vening beach also occurs.

60 E

Three small parallel beach ridges referable to the third stage in the Third Herman Three small parallel beach ridges referable to the third stage in the bench, Is, 2 and Herman series are crossed in the west part of sec. 24, T. 2, R. 6, by the 3, R. 6. road leading northwest from Mountain City. The elevation of their crests is 1,198, 1,202, and 1,205 feet. Two miles further north, near the center of sec. 35 in the same township, William Miller's house's built on the highest of these, at an elevation of about 1,210 feet. His well, sixteen feet deep, is gravel and sand to the depth of twelvefeet with till below. Northward these beaches are traceable through see 2, 11, 15, and the south part of 22, T. 3, R. 6, to Bradshaw's Cierch beyond which they pass, with the other Herman and Norcross beached along the Pembina Mountain escarpment.

Fourthflermen beach, Ts, 2 and 3, R. 6,

The fourth Herman beach passes through Mountain City, in sec.21 T. 2. R. 6, the post-office and the south end of the principal street being on its crest, at 1,191 to 1,192 feet. Twenty-five rods farther east the school-house is a less conspicuous parallel beach, at 1,183 to LIN feet. Both are terrace-like in form, having a descent of three to fin feet or more on the east but only one to two feet or none on the weet The continuation of this shore was also observed, like the preceding through a distance of six miles northward.

Pembina Mountain from Thorn**h**ill to Ircherne

From sec. 28, T. 3, R. 6, the Herman shores of Lake Agassiz coincid with the prominent escarpment of the Pembina Mountain through distance of twenty-nine miles, passing in a nearly straight course nor northwesterly to sec. 30, T. 7, R. 8, about seven miles east-souther from Treherne. Along this distance the base of the escarpmenti 1,100 to 1,125 feet above the sea, and its crest about 1,400 feet. Se from this elevation, the great plain of the Red River Valley on thees when overshading clouds give to it in the distance a dark blue or are color, appears not unlike the vast expanse of the ocean as viewed in an equal height a few miles inland. The highest shore of the glad lake was about half-way up this ascent, and the lower Herman bead and those of the Norcross stage were between this and the base.

Sec. 30 T. 7. R. 9.

At the north end of the Pembina Mountain the Herman shores Lake Agassiz turned from a northward to a westward course, and the sharpest portion of this bend, in sec. 36, T. 7, R. 9, the current along the shore, caused by storms, brought a large amount of gas and sand from their erosion on each side, and accumulated the deposits in a massive ridge which juts out north-northwesterly and or more from the curving line of the escarpment. This gravely sand spit sinks from nearly 1,300 feet above the sea at its southe

where it rests on deposits of the s lake.

Five to six mil in the gradual as Treherne. The ee, 31, T. 7, R. publies mostly o bove the sea. nile south to the nom them by a he second (b) in (a and aa) not le lat uppermost b ountry northwar ts termination be he cast part of th te south from T each just describ nd gravel depos addivisions (b1 ar orth the third H the south edge restat 1.243 and de. Mr. Scarrov oil, 2 feet : inter ravel. 5 feet ; bed ery hard dark bl ell shows an accu rept out by the c med westward. other beach, also 236 and 1.238 feet me. At the sum st of the Little B assive beach dep tion of northwest 220 feet above the oad swell from w ist sides, Arthu is of sand and g m their lower po

BEACHES OF THE HERMAN STAGES.

where it rests on the adjoining highland to about 1.125 feet, comprising $\frac{1}{2}$ densits of the successive Herman, Norcross, and Tintah stages of the lake

Five to six miles farther west the Herman beaches are well exhibited in the gradual ascent that rises to the Tiger Hills one mile south of reherne. The highest beach here crosses the middle of the N.W. ‡ of ee, 31, T. 7, R. 9, where it forms a swell of sand and gravel, with relates mostly of Cretaceous shale, having its crest 1,272 to 1,273 feet tore the sea. In some portions this reaches nearly flat an eighth of a ele south to the base of the Tiger Hills, but elsewhere it is divided om them by a depression of three to five feet. This appears to be the second (b) in the series of Herman beaches, the first of this series and ad not being found here nor farther north. At the time when at appermost beach of Lake Agassiz was formed, this locality and the omtry northward are believed to have been covered by the ice-sheet, stermination being at the tract of morainic drift which overspreads he cast part of the Tiger Hills, as crossed in T. 7. R. 9, by the road to a south from Treherne. About twenty and fifty rods north of the ach just described, two inconspicnous beach lines, terrace-like sand Vicinity of d gravel deposits, are found at 1,266 and 1,254 feet, referable to Treberne. addivisions (b) and bb) of the second Herman stage. A little farther eth the third Herman beach is represented at Irvine Scarrow's house the south edge of sec. 6, T. 8, R. 9. This is a slight terrace with estat 1,243 and 1,244 feet and descent of four or five feet on its north de. Mr. Scarrow's well on this beach, 31 feet deep, consists of black 1.2 feet: interbedded sand and clay, 10 feet; very coarse shale ravel. 5 feet; beds of coarse and fine gravel and sand, 13 feet; and eyhard dark bluish till at the bottom, dug into only 1 foot. This shows an accumulation of shore drift to a depth of thirty feet, rept out by the currents of the lake from the curve where its beaches med we-tward. About an eighth of a mile north of Mr. Searrow's other beach, also referable to the third Herman stage, descends from 236 and 1.238 feet at its crest to 1,230 feet at the base of its northward pe. At the summit of the Manitoba & Southwestern Railway a mile t of the Little Boyne River, and on the slope thence eastward, very sive beach deposits are accumulated, due apparently to the same tion of northwostward currents from the northern end of the Pembina puntain. The summit of the railway is on such a beach, 1,217 to 20 feet above the sea, the fourth in the Herman series, forming a ad swell from which a gentle slope falls on its northeast and southst sides. Arthur Willett's well here goes to a depth of 42 feet in is of sand and gravel, obtaining a plentiful supply of good water m their lower portion, without reaching their bottom. A lifth of a

een this and the stake level as on ro such an inter-

hird stage in the T. 2, R. 6, by the elevation of their rthey north, near Miller's house is t 1,210 feet. Fin th of twelve feet able through sea bradshaw's Greek Norecross beaches

in City, in sec.24 neipal street hing ds thather east at 1,153 to his nt of three to in none on the way ke the preceiva

e Agassiz coincil ountain through light course north iles east-souther the escarpment i 1,400 feet. Se Valley on the est dark blue or aza an as viewed for tore of the glaci r Herman beach nd the base. Herman shores ard course, and R. 9, the current amount of graf ecumulated the rthwesterly an This gravela

a at its southe

61 е

62 E

mile farther east the railway cuts a beach ridge with its crest at light feet, also referable to the fourth Herman stage.

The Assiniboine delta occupies the western border of Lake Agasia from Treherne westward about sixty miles to Brandon and theme northeastward about thirty-five miles to Neepawa. The shore of the lake along these distances is not generally marked by a definite beach ridge, the absence of which seems to be accounted for chiefly by the extreme shallowness of the lake upon the delta, so that powerful wave were not driven ashore by storms. The course of the highest show flighest shore between Treherne and Brandon, belonging to the time of the scrow shore Herman beach, passes first west-southwest along the foot of the T_{lget} Hills to the north and west side of Campbell's Hill in sec. 4, T. 7, R. P. thence southwest and south to the Cypress River near Grange post-office in sec. 18, T. 6, R 12; thence west-northwestward to Oak Creek and along the south side of this creek, within a mile or less from it, nearly to its mouth; and, crossing the Souris in sec. 31, T. 7, R. 16, pass thence northwest to Brandon. Beyond the Cypress a beh of the moderately undulating or in part nearly flat, from two or three to be miles wide, separates this lake shore from the northern border of the Tiger Hills and the eastern and northern base of the Brandon Hills S. Martin's house, in the N.E. 1 of sec. 28, T. S. R. 17, about fifteen miles southeast of Brandon, is built on a small beach ridge of sandat gravel extending from southeast to northwest, only slightly below it. highest stage of the lake, which is marked by a moderately sloping parallel escarpment, about ten feet high, eroded in till a half m southwest of this beach. The unusually smoothed surface of their extending thence west and south to the Brandon and Tiger Hills, a the area crossed by the Souris in its course from Gregory's mill to the mouth of Black Creek, is probably attributable to the deposition of a upper portion in a body of water held between these hills and us northwardly retreating ice-sheet before this area was drained to a level of Lake Agassiz by the retreat of the ice from the east part of the Tiger Hills and the north end of the Pembina Mountain.

Second Her-man beach, Brandon.

trom Trene to Brandon.

In the south part of the city of Brandon the second Herman head marking the stage bb of the table in a subsequent part of this report a well defined ridge of sand and gravel along a distance of about a ma It extends from east to west, passing an eighth of a mile north of a court house, and thence close along the south side of Lorne Avena from First to Fourth Streets. Between Fourth and Sixth Streets it erossed by this avenue, and thence westward lies close on its north side Its structure is shown by sections where it is intersected by Teni Eleventh and Twelfth Streets, exposing a thickness of ten feets obliquely bedded sand and gravel containing abundant pebbles net

(0-45) two inches and two-thirds being ose-fourth C'ret granite- and sel in width and fre rennded wave-lil ranges from 1,2 Twelfth Streets slightly higher vicinity of Bran afforded in the se gravel and sand 12s2 feet above four miles west c more fully notice North of the A from Brandon eac erclose below the and sand, which li amile north of D early at the mid Thence its course scarpment, exter let, and less dist his escarpment w 1,269 deet above famile farther astward is delta s ising thence slow! ne between a m leatiful boulders and and gravel de rea passes north-12 and the east er of sections in ! proximately, the istinct beach ridg allow on the adjo ends of the inequ est, transverse to eache- would be fo avel and sand in cumulated in a di

BEACHES OF THE HERMAN STAGES

- crest at 1.21;

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of Lake Agasiz ion and thence the shore of the a definite beach r chiefly by the powerful waves e highest shore ie of the second oot of the Tige ee. 4, T. 7, R. E. range post-office Oak Creek and s from it, nearly . 7. R. 16, passes s a belt of the o or three to te. **rn b**order of th e Brandon Hill. 17. about fiftee ridge of sand ad lightly below is aderately sloping till a half mie surface of theta d Tiger Hills. gory's mill to the deposition of a ese hills and the is drained to ta the east part ountain.

a Herman beau t of this report, e of about a man aile north of the of Lorne Aveau ixth Streets it on its north sk sected by Tent ss of ten feet at pebbles up? productes and rarely cobbles three or four inches in diameter, about two-thirds being Palaeozoic magnosian limestones, from one-tenth to eacdourth Cretaceous shale, and the remainder mostly Archaean granites and schists. This beach ridge varies from ten to twenty rods is width and from five to ten feet or more in height, having a smoothly numbed wave-like form. The elevation of its crest near the court house nages from 1,260 to 1,269 feet above the sea, and at Eleventh and Twefith Streets it is 1,260 to 1,261 feet. No distinct beach ridge of the glabely higher Herman b stage of Lake Agassiz was found in the teinity of Brandon, but evidence of the lake level in that stage is aforded in the southeast part of Brandon by the delta plateau of coarse gravel and smid at the court house and eastward, which is 1,270 to 12-2 feet above the sea, and by an old water-coarse crossed three to form miles west of Brandon on the road to Kemnay, both of which are more fally noticed in the description of the Assimiboine delta.

North of the Assiniboine the highest shore of Lake Agassiz passes tom Brandon east and cast-northeast by Chater and Donglas, being on Highest shore reclose below the verge of the plateau of till, overspread by delta gravel from Brandon ad sand, which lies close north of the Canadian Pacific Railway. About mile north of Douglas station this shore is marked by a dune hillock. early at the middle of the line between sections 10 and 11, T. 11, R. 17. thence its course is north-northeastward, and is indicated by an eroded scarpment, extending two or three miles with a height of ten to fifteen et and less distinctly observable a few miles beyond. The base of his escarpment where it crosses the south line of sec. 24 in this township 1269 feet above the sea; and the surface at the school-house a sixth is mile farther west is about twenty feet higher. All the area stward is delta sand and gravel; but the escarpment and the country sing thence slowly northwestward are till. The continuation of this he between a moderately rolling surface of till on the west, with leafful boulders and frequent lakelets, and the slightly undulating ad and gravel delta on the east, with low dunes on many parts of its a passes north-northeasterly in range sixteen across the west half of 12 and the east half of T. 13, and thence north through the eastmost grot sections in T. 14, to Stony Creek. It evidently marks, at least proximately, the highest shore of the glacial lake; but it bears no sinct beach ridge nor line of crosion, partry because the lake was so allow on the adjoining delta area, and partly because the prevailing ends of the inequalities in the till surface run nearly from east to et, transverse to the course of the shore currents and drift by which whe would be formed, thus intercepting the scanty deposits of beach avel and sand in their hollows, instead of permitting them to be cumulated in a distinct ridge.

64 E

The Manitoba & Northwestern Railway crosses two beach ridges at Near Neepawa, three and three-fourths miles and three miles west of Neepawa, the crests of which are respectively 1,323 and 1,304 feet above the sea These elevations indicate that they belong to subdivisions of the second Herman stage, in the same manner that this stage is represented by three beach lines at Treherne. Each of these ridges has a height of about seven feet above the adjoining surface, and a width of thirty to forty rods. They consist of sand and gravel, and the railway company has therefore purchased a considerable tract occupied by the lower one of them for its excavation and use as railway ballast. This lower beach probably marks the same lake level as the beach observed at Brandon. having there an elevation of 1,260 to 1,269 feet. Gravel and sand brought into Lake Agassiz by Stony Creek seem to have contributed to the conspicuous development of beach deposits here, while they are wanting or less distinct upon most of the shore southward to Brandon and also northward through the next twelve miles to where the Herman and Norcross shores pass into the steep escarpment that forms the eastern face of Riding Mountain.

BEACHES OF THE NORCROSS STAGES.

Tarough T. 1, R. 5, the Norcross shores of Lake Agassiz lie on the East of Moun-escarpment of the Pembina Mountain; and the first observations of the Thornhall. City and their beaches were in sees. 7, 18 and 19, T. 2, R. 5, where the mountain Thornhall. wall is reduced to a gradual ascent in the vicinity of Mountain City and Thornhill, About a half mile southeast of Mountain City the upper Norcross beach is well displayed at John Borthwick's house, which is built on its crest, 1,167 feet above the sea, in the southwest corner of see, 19. Digging for wells here shows that the gravel and said of the beach extend only to a depth of six or eight feet, there resting on the Fort Pierre shale. From the crest of this beach ridge its slopes fill eight or ten feet within a few rods on the east and about four feet on the west. It is bordered on the west at this locality by a surface strewn with very abundant boulders up to five feet or rarely more in diameter, nearly all being Archæan granites, with perhaps a third of one per cent, magnesian limestone. Generally, however, the surface in this vicinity has few or no boulders; and a shallow depth of ordinary till or of lacustrine deposits overlies the Cretaceous shale. The second Norcross beach, also forming a distinct ridge, lies a third of a make farther east, with its crest about 1,150 feet above the sea. A large exeavation for sand to be used in plastering has been made in this ride, in the south edge of this sec, 19. A mile farther south John W Stodders' house is built on it at an elevation of 1,148 feet. His well

twelve feet dee enters the shull a hard calcar Pieces of the 1 plainly marked i maceable thr vestern Branch miles cast of T Treherne they a About one a Treberne the Ma beach ridge, the fabout five fee farther east it er from which ther the cast. This mack being run from the railway ds to eight rodthat the ridge is fand constitut differ in coarsene or two inches in shale a foot acro etimate, nearly 1 which makes up Tiger Hills, and . mmixed with ot clases of limeste reliowish grav. esiliterous, whi Asiniboine River bout Lakes Mani om the Archaear Continuing north mises sees. 8 am eyond which it i lown surface of t The next definit ear Neepawa, wi ile west of this mer Norcross st a. Close to the

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LEMAN.]

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each ridges at Neepawa, the above the sea, s of the second represented by as a height of th of thirty to lwny company the lower one his lower beach ed at Brandon, ravel and sand e contributed to while they are and to Brandon ere the llerman that torms the

gassiz lie on the observations of re the mountain ountain City and City the upper house, which is thwest corner of and sand of the re resting on the ge its slopes tall out four feet on ty by a surface r rarely more in chaps a third of er, the surface in epth of ordinary ale. The second third of a mile ie sea. A large nde in this ridge south John W. feet. Ilis well

BEACHES OF THE NORCROSS STAGES.

nvelve feet deep, passes through gravel and sand, eleven feet; and then enters the shale, the top of which, to a depth of six to twelve inches, is a hard calcareous layer, including nodules and veins of cale spar. pieces of the hard surface of this layer, thrown out of the well, were plainly marked with glacial strine. The continuation of these beaches straceable through the next seven miles northward across the Southmestern Branch of the Canadian Pacific Railway, passing about three miles east of Thornhili, to Bradshaw's Creek, beyond which to near Treheme they again coincide with the Pembina Mountain escarpment, About one and a half miles east of the Little Boyne River near Treherne the Manitoba & Southwestern Railway cuts the upper Norcross Near Treherne. leach ridge, the crest of which is 1,195 feet above the sea, with a descent dabout five feet on the west and ten feet on the east. A half mile inther east it cuts the lower Noreross beach, with its crest at 1,167 feet, from which there is a descent of ten feet to the west and fifteen feet to the cast. This beach has been extensively excavated for ballast, a spur track being run along its course a quarter of a mile northwestward rom the railway. The excavation, varying along this distance from is to eight rods in width and from five to fifteen feet in depth, shows hat the ridge is composed of interbedded sand and gravel, the layers (sand constituting about half of the entire deposit. The gravel layers differ in coarseness from those that contain no pebbles more than one etwo inches in diameter to others containing water-worn masses of shale a foot across and Archiean cobbles six inches in diameter. By etimate, nearly nine tenths of the gravel is the hard Fort Pierre shale which makes up the principal mass of the Pembina Mountain, the Tger Hills, and Riding Mountain, this shale gravel being often almost amixed with other material; about a twentieth part consists of two tases of limestones, derived in nearly equal proportions from the elowish gray, arenaceous limestone of Niobrara age, plentifully siliterous, which outerops beneath this shale on the Boyne and siniboine Rivers, and from the Palaeozoic limestones of the flat country but Lakes Manitoba and Winnipeg; and the remaining twentieth is on the Archaean rocks that lie east and north of Lake Winnipeg. latinning northwesterly and northerly, this massive beach ridge passes sees, 8 and 17, and the eastern edge of sec. 19, T. 8, R. 9, erond which it is lost sight of on the undulating and partly windlown surface of the Assiniboine delta.

The next definite observations of the Norcross shores of this lake are ear Neepawa, where the Manitoba & Northwestern Railway a half diewest d this station crosses small beach ridges referable to the per Norcross stage, with their crests 1,223 to 1,225 feet above the a. Close to the west is an eroded escarpment of till fifteen feet high, 5

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GLACIAL LAKE AGASSIZ IN MANITOBA,

rising from 1,225 to 1,240 feet. On the other side of the station, between a half mile and one mile east from it, the railway crosses a surface of wind-blown sund with hollows two to four feet deep, the crests of its low dunes being at 1,193 to 1,192 feet. These occupy the level belonging to the lower Noreross beach. The bed of the railway here, formed of the sand of the Assiniboine delta, further worn and redeposited by the lake waves, proves somewhat insecure because of its viability to be channelled by the wind. The road leading northward from Neepawa to Eden and Riding Mountain runs on the crest of the oper Norcross beach ridge through the east part of sees. 21 and 28 1 15, R. 15, three to five miles north of the railway, its crest there havin a nearly constant height of 1,223 feet, with a descent of five or six teet from it to the east and half as much to the west. Thence this beach ridge continues north-northeasterly to the east part of sec. 21 T. 16, R. 15, where it has an elevation of 1,225 to 1,230 feet, with with of about thirty rods and descent of ten to fifteen feet on its east side It next runs north or slightly west of north to Thunder Creek in the south part of T. 17, beyond which its course, with that of the lower Norcross shore, is along the steep ascent of Riding Mountain. In the journey from Eden post-office (S.W. 1 of sec. 22, T. 16, R. 15) to Orange Ridge post-office (N.W. 1 of sec. 32, T. 16, R. 14), a nearly flat surface of 'ill with frequent boulders is crossed upon the width of three miles Letween this beach and the upper Campbell beach, descending in that distance from 1,200 to 1,100 feet, approximately, Boulders and especially abundant within the first mile from the upper Northebeach, whence the erosion of the lake bed supplied its gravel and said This even tract of till would seem most favorable for the accumulation of the beaches belonging to stages of Lake Agassiz between its upper Norcross and upper Campbell levels; but no beach ridge nor othe deposit of gravel and sand, nor line of erosion which sometimes take the place of these to mark a shore line, was seen in the intervening distance. It seems probable that not far south and north from the route of observation the lower Norcross and the two Tintah beaches will be found.

BEACHES OF THE TINTAU STAGES.

Ts, 1 and 2. K, 5.

In proceeding northward from the international boundary the Tinna beaches were first observed near the line between Ts. 1 and 2. R.5 lying on a terrace which forms the lower part of the Pemba Mountain. On the boundary this terrace is about three fourths do mile wide, its eastern margin being an escarpment that rises from he to 1,000 or 1,005 feet; and from its verge it gradually rises 25 to feet in its width, so that its western limit at the base of the ma

12-44. e-carpment ha pentiful bould mostly embedd east side consis is thus shown t mantle of till. terrace widens but it is border the base of wl boundary. In isse of the mou a hird of a mi 1110 to 1,125 f In the S.E. 1 of gravel and same Tintah beach lie efgravel and sa de by till, the feet lower on th the N.E. 1 of s mlerlain by th firm, like the f ension of these monntain, with a South Branch of twenty-five mile. whole extent it] west, as in the lo bodders, but se over-pread with consisting of Cre lacustrine deposi A mile west of ascent of about fo the sea. Within beach, a small ric ase in plastering, fiveor six feet fro extends a conside terrace. The roa mile- across a sor ridges are discer-Herman stages.

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BEACHES OF THE TINTAL STAGES.

f the station, way crosses a feet deep, the se occupy the of the railway her worn and o because of its ing northward he crest of the ees. 21 and 28. its crest there scent of five or t. Thence this part of sec. 23. feet, with with on its cast side. er Creek in the at of the lower untain. In the R. 15) to Orange early that surface h of three mile scending in that

Boulders at upper Notenss gravel and sudhe accumulation tween its upper ridge nor other sometimes take the intervening north from the p Tintah beaches

idary the Tinta s. 1 and 2. R.5 of the Pembia neo fourths du rises<u>i</u>from 1.0 by rises 25 to²² base of the ma escarpment has a height of 1,120 to 1,125 feet. Its surface is till with pentiful boulders, nearly all Archrean, up to five feet in diameter, justly embedded or only projecting a foot or less; but the slope on its est side consists of weathering and pulverized Cretaceous shale, which is thus shown to form the principal mass of the terrace, beneath a thin mantle of till. In the distance of six miles northward across T. 1, this terrace widens to two miles, and its eastern verge sinks to 1,055 feet; bat it is bordered by only a slight escarpment, about fifteen feet high, the base of which is thus at the same level as on the international boundary. In its width of two miles it there rises about 90 feet, to the iese of the mountain escarpment at 1,140 to 1,150 feet. A quarter to a hird of a mile east of this escarpment a line of erosion rises from 1110 to 1,125 feet, approximately, marking the upper Tintah shore In the S.E.] of sec. 5, T. 2, this shore bears seanty deposits of beach eravel and sand, with their crest at 1,110 to 1,115 feet. The leave Tintah beach lies a third of a mile farther east, and is a distinct digravel and sand with its crest at 1,083 to 1,085 feet, bordered on each the hy till, the surface of which is five fect lower on the east and three feet lower on the west. Thomas Kennedy's well, fourteen feet dethe N.E. 1 of sec. 5, T. 2. R. 5, found the till only four feet weep, uderlain by the Fort Pierre shale. This terrace doubtless owes its frm, like the far more prominent Pembina Mountain, to preglacial ersion of these Cretaceous beds. It continues along the foot of the countain, with a width of one and a half to two miles, at least to the south Branch of Tobacco Creek, which crosses it near Miami post-office, menty-five miles north of the international boundary. Throughout its whole extent it has a considerable ascent upon its width from east to west as in the localities noted. Much of its surface is till with many holders, but some portions have no boulders, such tracts being overspread with lacustrine gravel and sand, or perhaps occasionally consisting of Cretaceous shale next below the soil, with no drift nor heustrine deposits,

A mile west of Morden the escarpment bordering this terrace has an accent of about forty feet, with its top approximately 1,070 feet above Morden, the set. Within an eighth of a mile to the west is the lower Tintah leach, a small ridge of gravel and sand which has been excavated for use in plastering, its crest being at 1,085 feet, nearly, with a descent of freor six feet from it to the east and two or three feet to the west. It extends a considerable distance nearly purallel with the verge of the terrace. The road thence to Thornhill ascends slowly in the next two miles across a somewhat uneven surface, on which eight or ton beach ridges are discernible, belonging to the upper Tintah, Norcross, and lleman stages.

The most remarkable feature of this tract is its extraordinary abundance of boulders, nearly all Archaean, usually less than five feet in diameter, but in many places ranging in size to ten feet or nore. Upon an area that extends at least one to two miles both south and north of the road and railway, the surface is as thickly strewn with boulders as are the most typical terminal moraines seen by me in Minnesota and South and North Dakota. Many of these rock-masses, instead of being imbedded in the drift, as is generally the case in this region, project two to three or four feet above the surface, or lie wholly on it with no portion concealed. Here the ice-sheet probably terminated, depositing these boulders in the west margin of Lake Agassi, during the time of its accmulation of the terminal moraine that torms the west part of the Tiger Hills and the Brandon and Arrow Hills. About a mile south and west of Nelson, the lowor Tintah beach ridge.

Near Nelson. hay

East of Treherne

Northeast of Neepawa. having an elevation of 1,085 feet, approximately, lies an eighth of a mile west from the margin of the terrace; and the upper Tintah beach probably extends along its west side, close to the base of the Pembina Mountain, where the elevation is about 1,100 to 1,120 feet. The width of the terrace here is about one and a quarter miles.

A half mile east of the lower Norcross beach near Treherne, the apper Tintah shore seems to be indicated where it crosses the railway by a line of crossion in the Assiniboine delta, with descent approximately from 1,140 to 1,120 feet.

On the profile of the Manitoba & Northwestern Railway the upper and lower Tinthh beaches are apparently shown about three miles and five and a half miles east-northeast of Neepawa, with their cress respectively at 1.158 feet and in two ridges at 1,116 and 1,111 feet above the sea. Within its next three miles northward the upper beach is represented by a tract of low dunes extending through the east edge of T. 15, R. 15, to Snake Creek. Thence the course of these shore line, as shown by the contour, is nearly due north to the foot of the escarment of Riding Mountain in T. 17.

BEACHES OF THE CAMPBELL STAGES.

Along the course of the Cretaceons terrace which borders the based the Pembina Mountain for at least twenty-five miles northward from the international boundary, as described in connection with the Tintah beaches, the upper Campbell shore line, there having an elevation of 1,045 to 1,050 feet, coincides with the low escarpment which forms the east margin of this terrace. A portion of the sculpturing of this escarpment was doubtless done by the waves of the lake; but the main outlines of the terrace as a bench intermediate between the expansed

the Red River attributable to a distinct beac sec. 3, T. 4, R distance of a m the terrace ese 1,055 feet. In ridge, passing eighth to a had 1,655 to 1,060 f fifteen feet on t this stage, or at to twenty feet passes northwe northward thre railway about s

The lower Ca national bound: apper Campbell its crest is 1,03 extends an eight gravel and sand similarly descen twenty-tive rod: eastward. The -hore about thre 34. T. I. where i 1.034 feet, from east and three or to hold nearly th mile or more to About a half m excavated for pl rods wide, with a mately, resting miles farther nor of this beach three T.4. R. 6. It is to thirty rods wie ten feet above Ne sec. 6, T. 5, R. 6, The course of t delta, but their o

Upper Campbell shore trem the international boundary to Treheme.

Abundanı boulders. 68 E

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BEACHES OF THE CAMPBELL STAGES.

extraordinary than five feet feet or more, oth south and y strewn with een by me in e rock-masses. he case in this , or lie wholly robably termi-Lake Agassiz, mornine that d Arrow Hills nh beach ridge, an eighth of a r Tintah beach of the Pembina et. The width UPHAN]

Treherne, the ases the railway approximately

ilway the upper three miles and ith their cress and 1,111 feet the upper beach the cast edge nese shore lines, it of the escarj-

rders the based northward from with the Tintah an elevation which forms the pturing of this e; but the main n the expansed the Red River Valley and the high Pembina escarpment seem clearly attributable to preglacial erosion. The first locality where I observed adjstinct beach ridge of gravel and sand referable to this stage is in sec. 3, T. 4, R. 6, a half mile west of Nelson, and thence through a listance of a mile or more north-northwestward. It lies close east of the terrace escarpment, and has an estimated elevation at its crest of 1,055 feet. In T. 7, R. 8, this shore is marked by a conspicuous beach idge, passing through sees, 22, 27, and the east edge of 33, lying an eighth to a half of a mile west of the Boyne River, with its crest about 1,055 to 1,060 feet above the sea. The descent from the crest is ten to ffeen feet on the east, and five to eight feet on the west. The lake at this stage, or at a slightly higher level, also cut an escarpment tifteen to twenty teet high, with its top at 1,075 feet, approximately, which pases northwestward across sees, 28 and 29 of this township and northward through the east part of sees, 6 and 7, T. S. crossing the milway about seven miles east of Treherne.

The lower Campbell beach in its course northward from the interupper Campbell shore. In sees, 2 and 11, T. 1, R. 5, the elevation of distance. its crest is 1,036 to 1,040 feet. On the west a nearly level surface estends an eighth of a mile to the terrace. On the east a slope of beach gravel and sand sinks to 1,028 feet in about twenty-five rods; and a smilarly descending surface of till continues to 1,015 feet in the next twenty-five rods, beyond which there is a much slower descent castward. The road on the line between Ts, 1 and 2, R. 5, crosses this hore about three eighths of a mile west of the northeast corner of sec. 34.T. 1, where it is marked by a typical beach ridge, with its crest at 1034 feet, from which there is a descent of ten feet in ten rods to the east and three or four feet in ten rods to the west. This ridge was seen tehold nearly the same outline and height through a distance of one mile or more to the south and a half mile north to a small creek. About a half mile west of Morden, where it has been considerably excavated for plastering sand, it has a nearly flat top ten to twenty rols wide, with ascent on this width from 1,036 to 1,040 feet, approximately, resting on the base of the terrace escarpment. Five to six miles farther north, the road from Nelson to Miami runs along the top of this beach through the north half of see. 3 and the S.W. 1 of sec. 10, T.4. R. 6. It is there a broad, low ridge of sand and gravel, twenty whirty rods wide, the elevation of its crest being about 1,035 feet, or ten feet above Nelson. Continuing northward, it crosses the N.E. 1 of sec. 6, T. 5, R. 6, a mile west of Miami.

The course of these shore lines was not traced across the Assiniboine delta but their elevation shows that they lie on its eastward slope

-69 E

where they are intersected by numerous ravines and are doubtless obscured in many places among its dunes. On the Canadian Pacific Railway profile three massive beach ridges, the two higher referable to the upper Campbell stage, and the third to the lower Campbell stage of the lake, are shown three miles to two and a half miles west of Westof Austin, Austin, their crests being respectively 1,087, 1,081, and 1,066 feet above

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The sea. These beaches are each about thirty rols wide, with descendent of ten to twenty feet from their crests to their east bases and half as much to the west. On the Manitoba & Northwestern Railway the upper Campbell beach

is a very massive rounded ridge, thirty to fifty rods wide, along whose eastern slope the railway runs about three miles, from the south side of sec. 6, T. 15, R. 13, north-northwest to Arden. Before the railway was built, the old trail from Winnipeg to the Saskatchewan River passed along the top of this ridge the same distance and to a point about a mile north of Arden, there leaving it and turning to the west. This portion of the trail was a good dry road throughout the year, being this remarkably contrasted with the deep mud along most of its exterduring rainy seasons. Because of this character of the road and the beauty of the smooth beach, which is prairie, without tree or bash, by is bordered on each side by groves, this avenue-like tract received is widely known name, the Beautiful Plain. It is not flat, however, as the name seems to imply; for the crest of the beach ridge, at Arden 1,005 feet above the sea, and not varying more than a few feet above a below this elevation in its course through several miles south and north, is tifteen to twenty-five feet above the nearly straight marginthe woods an eighth to a quarter of a mile east, and seven to ten feel above the more irregular margin of bushes and woods on the west commonly ten to thirty rods distant. The barrier of this beach ridge was sufficient to turn the White Mud River southward three miles along its west side. In a section cut six feet deep close north of Arder for the passage of the railway and in excavation of ballast, the material of this beach is mainly fine gravel with pebbles only a quarter to a third of an inch in diameter, but also includes layers of said and coarse gravel, with pebbles up to two inches in diameter, of which about three quarters are from the Palaeozoic formations of magnesian limestone that occupy the country eastward to Lake Winnipeg,

From Arden this beach extends north-northwest through the northeast part of T. 15 and nearly through the center of T. 16, R. 14. In the north half of T. 16 it has in several places a narrow terrace-like secondary beach on its eastern slope five to ten feet below the crest of the main beach; and it is closely bordered on the west by a low escarpment of till which rises five to ten feet above the beach ridge as torns the man accends slowly heach and escar allusion to the grow in abunda elevation of the line of the N.E. the seat; and of the early part of The lower C southeast corne

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southeast corne is 1,061 feet, w the cast and fiv fifteen miles nor Beantifal Plain between Ts. 16 feet, with descer

The northwar sets, 5 and 8, T, west of north t Thence they traveast part of T, 18 wide separates th

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In the S.W.] indicated by ver above the sea, fi twenty rods cust. and the west half are developed as me has an elevat is a descent of onfive to eight feet : level surface of # melve rods, and western slope of about five feet low five feet or more e About a quarte shore is a line of c distance from wes

Vicinity of Arden.

Beautiful Plai

BEACHES OF THE M'CAULEYVILLE STATES.

are doubtless multian Pacific gher referable Campbell stage ' miles west of ,006 feet above , with descens ses and half as 2144

Campbell beach e, along whose he south side of he railway was a River passed int about a mile . This portion ar, being this at of its extern to road and the ree or bush, by act received is. however, as the at Arden 1,0% v feet above of hiles south and aight marging even to ten fee; Is on the west this beach ridge ard three miles north of Ardea of ballast, the s only a quarter ers of sand and neter, of which s of magnesia innipeg.

t through the of T, 16, R. It, row terrace-like ow the crest of west by a low bench ridge and torms the margin of a flat or slightly uneven expanse of till that accends slowly westward. A post-office situated close west of this back and escarpment in sec. 32, T. 16, is named Orange Ridge, in Orange Ridge, allusion to the orange-red lities (Lilium Philadelphicum, L.) which grow in abundance on the sandy and gravelly soil of the beach. The devation of the Orange Ridge or Beautiful Plain beach on the north line of the N.E. 1 of sec. 32, T. 16, is approximately 1,080 feet above the set; and of the escarpment on the west, which was eroded during the early part of this upper Campbell stage, 1,090 feet.

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The lower Campbell beach is crossed by the railway near the Lower Campoutheast corner of sec. 6, T. 15, R. 13, where the elevation of its crest Arden and is 1,061 feet, with a descent of eight feet in about fifteen rols to orange Ridge, the cast and tive feet in a few rods to the west. Through the next fitteen miles northward it lies a half to two thirds of a mile east of the leantiful Plain and Orange Ridge. East of the latter, on the line hetween Ts. 16 and 17, R. 14, the elevation of its crest is about 1,070 feet, with descent of fifteen feet to the east and ten feet to the west. The northward continuations of the Campbell beaches pass through Ts. 17 and 18, sees. 5 and 8, T. 17, R. 14, to Thunder Creek, and thence a few degrees Rs. 11 and 15, west of north to the Big Grass River in see, 31 of this township. Thence they traverse sees. 6, 7 and 18 in T. 18, R. 14, and the northest part of T. 18, R. 15, where a swamp on the west about two mile wide separates them from the base of the Riding Mountain.

BEACHES OF THE M'CAULEYVILLE STAGES.

In the S.W. $\frac{1}{2}$ of sec. 12, T. 1, R. 5, the upper McCauleyville shore is T. 1, R. 5, indicated by very scanty deposits of fine gravel, 1,006 to 1,007 feet above the sea, from which there is a descent of three or four feet in twenty rods east. Through the east tail of sec. 23, the middle of 26, and the west half of sec. 35 of this $-\infty$ aship, two McCauleyville beaches are developed as small parallel ridges of gravel and sand. The upper each as an elevation of 1,000 to 1,002 feet at its crest, from which there is a descent of one to two feet within two or three rods to the west and five to eight feet in ten or twelve rods to the east. Thence a nearly level surface of \oplus with frequent boulders occupies a width of ten or melve rods, and is succeeded on the east by the second ridge, the western slope of which rises two or three feet to its crest. This is about five feet lower than the upper beach, and has a similar descent of five feet or more on its cast side.

About a quarter of a mile east of Nelson the npper McCauloyville From Nelson to shore is a line of erosion with a descent of five to ten feet within a short Miamidistance from west to east. Four miles thence to the north-northwest

it is a well defined beach ridge running close to the bridge over Boyds. Creek, near the northeast corner of sec. 21. T. 4, R.6; and it continue, but is less conspicnous, through the next three miles northward to the church in the northeast corner of sec. 5, T. 5, R. 6, a quarter of a nile east of Miami post-office. Its crest at Boyd's Creek is eight to ten feet, and at Miami tive feet, above the more massive second or middle McCauleyville beach, which lies a quarter to a half of a mile tarther east, passing north-northwesterly through the west edge of sec. 27 and the east half of sec. 33, T. 4, in which latter it is off-sec, 4 and the west half of a mile to the east, and through the middle of sec. 4 and the west half of sec. 9, T. 5.

Three McCauleyville beach ridges are crossed by the Manitoba k Northwestern Railway on the north side of secs, 32 and 33, T, 14, R, 15 East and north about four miles, four and a half, and five miles southeast of Arden. the elevations of their crests being respectively 1.039, 1.029, and 1.016 feet above the sea. Each of these rises about five feet above the surface on the east. They continue as prominent gravel ridges north-northwestward through the west half of T. 15, and the southwest part of T. 16, R. 13, and through the northeast part of T. 16, the east half d T. 17, and the west half of T. 18, R. 14, to the vicinity of Phillips ranch. In T. 15, R. 13, next east of Arden, the most western and upper one of these beaches is called Lowdon's Ridge from Thomas Lowdon, whose house, the first built on it, is in the middle of the east edge of see, 30. The middle beach appears to be twofold in secs. 29 and 29, Joshua Ritchie's house being built on one of its ridges and the Rose Ridge school-house a quarter of a mile farther east on the other Rose Ridge. About three quarters of a mile east of the Rose Ridge is the lower McCauleyville beach, on which the trail to Lake Dauphin rus, northward through Ts. 15 and 16. Lewis McGhie's house is built on the eastern slope of this beach in the N.E. 1 of see. 28, T. 15. Lowdon's Ritchie's and McGhie's wells, and others in this township on these beach ridges, pass through gravel and sand five to fifteen feet and through th below to total depths of thirty to fifty feet, obtaining water in gravely seams, from which it usually rises ten to twenty feet within a ter hours, to its permanent level.

BEACHES OF LOWER STAGES WHEN LAKE AGASSIZ OUTFLOWED NORTHEASTWARD,

Blanchard beaches, T. 1, R. 4.

On the international boundary the Blanchard shore lines enter Manitoba in the west part of T. 1, R. 4, passing near Kronsfeld in sec.; of this township, and extending north-northwest within about a mile east of Mordon, but they are not marked along this distance by distinc-

leach deposits 1 crosses the Cana it forms a slight delta. On the M beaches appear and three fourth apper two are in quarter of a mil bordered on the by a gentle slop is a beach ridg descent of five fo 969 feet. After Arden to Gladste very flat, except their continuation noted on the plat

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R. 13. The Hillsboro sile of R. 4, and the international about a half mildescent of three above the sea. Northward it pr half miles east of llenry Vork's ho feet. Thence it: east and five fee than along most and tine gravel, Twelve miles fai the S.E. 1 of set Almasippi postascends a few fee a tract of sand w showing that it derived from th delta, within a f Gladstone this b the township pla and 17, and thro The Emerado

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dge over Boot, and it continue, orthward to the uniter of a mile eight to ten feet, cond or middle of a mile faithef a consection of a nearly a quarter and the westhaf

the Manitoba & 33. T. 14. R. 13. heast of Arden 1.029, and 1.016 bove the surface ges north-north outhwest part of the east half of nity of Phillips st western and e from Thomas iddle of the east ofold in sees. 20 s ridges and the ist on the other. ige is the lower Dauphin run.

1015e is built of . 15. Lowdon's p on these beach and through till rater in gravely et within a tew

OUTFLOWED

ore lines enter ronsfeld in sec.; rin about a mile ance by disting

BEACHES OF LOWER STACES.

leach deposits nor lines of erosion. The lowest of these shore lines west the Canadian Pacific Railway a mile west of McGregor, where Mediregor. it forms a slight swell on the gantle eastward slope of the Assiniboine delta. On the Manitoba & Northwestern Railway the three Blanchard heaches appear to be identifiable, being crossed successively two miles and three fourths of a mile west and one mile east of Midway. The opper two are nearly flat tracts of fine gravel and sand, an eighth to a marter of a mile wide, at 994 and 979 feet above the sea, each being hordered on the west by a depression of about two feet and on the east leagentle slope descending four or five feet. The third and lowest is a beach ridge of the usual form, about thirty rods wide, with a descent of five feet both to the cast and west from its crest, which is at 60 feet. After crossing the McCanleyville beaches on the way from Arden to Gladstone, the surface is wholly silt and sand, with fine gravel, Between Arden and Gladstone, very dat, excepting these slight ridges and others at lower levels. In their continuation northward, portions of the Blanchard beaches are roted on the plats of the Dominion Land Surveys through Ts. 15 to 20, R. 13.

The Hillsboro beach enters Manitoba near the middle of the south Hillsboro sile of R. 4, and passes north-northwestward. It is not conspicuous on beach the international boundary, but near the west line of sec. 21. T. 1, R. 4, alout a half mile east of Blumenfeld, it is a noticeable ridge with a East of descent of three to five feet on the east, its crest being about 940 feet Blumenfeid. above the sea. Its sand has there been excavated for use in plastering. Yorthward it passes about a half mile east of Oesterwick, one and a half miles east of Morden, and nearly four miles east of Miami, where Henry York's house is built on its crest at an elevation of about 950 East of Miami. teet. Thence its slopes descend fifteen feet in a short distance to the est and five feet or more to the west, the beach being much larger than along most of its course. Mr. York's cellar and well are in sand and time gravel, but the lower land adjoining on each side is till. Twelve miles farther north this beach passes near Mr. Field's house in the S.E. } of sec. 4, T. 7, R. 6, about three fourths of a mile west of Almasippi post-office. The road from Carman to Treherne there Almasippi, ascends a few feet, and in its next third of a mile northwestward crosses a tract of sand with hollows three to five feet below its highest portions. showing that it was formerly wind-blown. This beach deposit is derived from the erosion of the eastern margin of the Assiniboine delta, within a few miles to the north. On the road from Arden to Gladstone this beach was not noticed, but it seems to be traceable on the township plats northward nearly through the middle of Ts. 15, 16, and 17, and through the west part of Ts. 18, 19, and 20, in R. 12. The Emerado beach lies two to three miles east of the last. In Ts. 1

73 е

Emerado beach.

Rheinland.

Bagot.

On the M. & N. W. Railway

and northward.

74 E

and 2, R. 4, the Mennonite villages of Rheinland, Neuenburg and Rosenthal are partly built on it. At the wind-mill in Rheinland, and thence along its course as seen for a half mile or more to the south. southeast and north-northwest, this shore is marked by an ascent of three to six feet in as many rods from east to west; and from its crest, about 905 feet above the sea, the surface extends nearly level westward The beach consists of loamy sand, while the adjoining land is fine lacastrine silt or clay. On the Canadian Pacific Railway this beach is raised a few feet above the general slope of the Assiniboine delta, passing in a west-northwest course two miles east and one mile north of Bagat The Manitoba & Northwestern Railway crosses it five miles west of Gladstone, where it is a ridge about thirty rods wide, wind-blown in hollows one to two feet below the crest, which is 927 to 929 feet above the sea, with descent of five feet from it to the west and twelves fifteen feet to the east. A lower and less conspicuous beach ridge, alsy belonging to this stage, lies three fourths of a mile farther east, withis crest at 916 feet. The Emerado beach continues north through theeas part of Ts, 15 to 19, R. 12, and through the center of T, 29, to the eas:

Ojara beach.

Gladstone beach.

side of Lake Mary.

Along the course of the Ojata shore, lying between the Emerado and Gladstone beaches, no ridge of gravel and sand nor line of erosion was observed where it was crossed on the international boundary and elsewhere in this exploration in Manitoba, excepting a slight beach ridge, three to five feet high, which runs from Pomeroy in sec. 19, T.5-R. 4, north-northwest through the east part of T. 6, R. 5, passing alon two miles west of Carman.

The Gladstone beach on the international boundary and for several miles thence to the north-northwest is a prominent ridge, having an ascent of ten to tifteen feet in a distance of thirty to fitty rols was from its base to its crest, which is approximately S60 feet above these, The slightly undulating surface of this shore deposit occupies a width of a quarter of a mile or more; and thence westward there is no note worthy descent, but a nearly level expanse. In many shallow pits day to obtain sand for masons' use, the materal of the beach is shown to le tine sand, unmixed with gravel, excepting that very rarely a publicifound enclosed in it, the largest being a half to two thirds of an inchin diameter. This ridge enters Manitoba about one and a half miles we Blumenort and of Blumenort, and crosses sees, 5, 7, and 18, T. 1. R. 2, to Kronstland which the function

Carman.

which is situated upon it. Northward it passes about a mile wester Lowestoft post-office and a mile east of Carman. George Andersonhouse is built on its crest in the N.E. 1 of sec. 31, T. 6, R. 4, two mile. north-northeast of Curman, at an elevation of about 965 feet. It cross the Canadian Pacific Railway near the Rat Creek bridge, and is well

US+14. developed along passing through elevation of its to the northeas course is along of the chain of 1 which lie in se Gladstone this : lacustrine silt, y by a small beac almost due nor beach gravel an Grass Marsh th marsh being app

this stage about

The western nineteen miles w the internationa Lowestoft and th of the Manitoba elevation of the e northwest of Ma gavel and sand farther north it c of Elm Ureek sta at 545 feet, from and seven feet in . crosses this sho Barn-ide, and in hearly through the rige, the crest o two miles north des ent from it of the southwest. Northwestern Ra half-way between to s62 feet above there line is gene is traceable on th the west shore of assing about half this lies near the ale of the lake i orth-northwest.

BEACHES OF LOWER STAGES.

euenburg and Theinland, and e to the south. y an ascent of from its crest. evel westward. ng hand is fine y this beach is e delta, passing north of Bagot e miles west o wind-blown in 929 feet above t and twelvet each ridge, als er east, withits hrough the east . 20, to the east

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he Emerado and s of erosion was boundary and g a slight beach g in sec. 19, T.5 5, passing about

and for several idge, having a o tiny rods wes et above the sea ccupies a width here is no note shallow pits da 1 is shown tole rely a pebble is rds of an inchi half miles west 2, to Kroustla t a mile west of orge Anderson's R. 4, two miles fent. It cross dge, and is well developed along a distance of several miles thence to the northwest, passing through the southeast corner of sec. 12, T. 12, R. 9, where the elevation of its crest is about 875 feet, with a descent of four to six feet to the northeast and one to three feet to the southwest. Thence its course is along the southwest side of the Squirrel Creek marsh and east of the chain of Dead Lakes (a former channel of the White Mud River), which lie in sees. 17, 18 and 19, T. 14, R. 11. A half mile east of Gadstone this shore is marked by a line of erosion in the expanse of laenstrine silt, with slope in a short distance from 882 to 875 feet, and Gadstone. le a small beach ridge of sand with its crest at 878 feet. Continuing almost due north, this Gladstone shore line, occasionally marked by beach gravel and sand, lies a half mile to one mile west of the Big Grass Marsh through Ts. 15, 16 and 17, R. 11, the elevation of the marsh being approximately 865 fee ad of Lake Agassiz here during this stage about \$75 feet above the present sea level.

The western Burnside shore enters Manitoba near Blumenort, meteen miles west of the Red River, but it is not distinctly marked on Burnside meinternational boundary. Passing northward about a mile east of beach Lowestoft and three miles east of Carman, it crosses the Cirman beach of the Manitoba & Southwestern Railway at Maryland, where the devation of the crest of its beach ridge is 844 feet. About a mile northporthwest of Maryland this ridge has been extensively exeavated, its cavel and sand being used for railway ballast. One and a half miles farther north it crosses the main line of this railway about a mile west a Elm Creek station (the junction of the branch), its crest there being a 35 feet, from which its slopes fall ten feet in twenty-five rods east Marvland and ani-seven feet in an equal distance west. The Canadian Pacific Railway Elm Creek. moses this shore about half-way between Portage la Prairie and Bamside, and in the next ten miles of its course, passing northwest mearly through the center of T. 12, R. S, it is marked by a large gravel Near Burnide. silve, the crest of which in the south part of sec. 11, one and a half to promiles north of Burnside, has an elevation of 858 to 860 feet, with key ent from it of six to ten feet northeastward and half as much to the southwest. This beach is similarly prominent on the Manitoba & Northwestern Railway, by which it is crossed and exervated for ballast on the M X X. haf-way between Westbourne and Woodside, its crest there being 860 w. Kanway p-52 feet above the sea. Along the next forty miles the Burnside kore line is generally marked by a well developed beach ridge which is traceable on the plats of the Dominion Land Sarveys parallel with the west shore of Lake Manitoba and four to five miles distant from it, pasing about half-way between the lake and the Big Grass Marsh. It this lies near the line between Rs. 9 and 10 as far north as to the east Elect the lake in sees, 13 and 24, T. 18, R. 10, beyond which it runs orth-northwest.

76 E

GLACIAL LAKE AGASSIZ IN MANITOBA, On the eastern side of Lake Agassiz this shore line is found at "The

it is marked by a low escarpment rising from 835 to 850 feet, consisting

Eastern Burn* "The Ridge," Ridge " about cleven miles east of the Red River and Emerson, where " The Ridge, east of Emer-50.25

Proportion of lin.estone gravel.

of till with frequent boulders, nearly all Archaean, and by a deposit of Ts. 1 and 2, R. 4 E.

gravel and sand a few feet deep, resting on the base of this slope, sa to 840 feet above the sea. In the S.W. 1 of sec. 15, T. 1, R. 4 E., the Burnside beach is a typical gravel and sand ridge twenty to twenty-five rods wide; its crest is 845 feet above the sea: and the descent from it to the east is about three feet and to the west six or seven feet. About a mile farther north, near the southeast corner of sec. 21, the elevation of this beach ridge is \$44 feet, with a descent of one or two feet on the east and ten feet within twenty rods on the west Another mile to the north its elevation is 846 feet, with two feet descent east and six feet west in six rods; next a surface of till, with many boulders, falls about five feet in forty rods to the west: beyond this a tract of grave. and sand continues with the same slope, falling from \$35 to \$30 teet and is succeeded farther west by a slowly descending surface of fi The beach ridge continues with similar features through the east half of sec, 28, excepting a short distance in the S.E. $\frac{1}{2}$ of this section, where it is replaced by a line of erosion in the very rocky till. Through the next three miles the uneven contour causes the beach ridge to h somewhat i regular in its course and size; but it again attains is typical development in sec. 9, T. 2, R. 4 E., where it was exervated several years ago along a distance of a third of a mile for railway ballast, a branch track nearly eight miles long being lail for its transportation to Dominion City. The crest of the beach at Charles Aime, house near the north end of this excavation is 846 to 847 feet above the sea, with a domeshoof two to five feet on the east and six to eight feet in eight to twelve rods west. Its width, including both slopes is fifteen to thirty roots, and the maximum depth of the gravel and sad deposit is about eight feet, lying on till. The coarser portions of the gravel contain pebbles up to three inches or rarely six inches or man in diameter. Nine tenths or a larger proportion of them are magnesian limestone, the remainder being almost wholly Archaean granite and gneiss. This shore line continues north and north-northeast by Green Ridge post-office and through the east part of Ts, 3 and 4, 8, 18, beyond which it has not been traced.

Between the south ends of Lakes Manitoba and Winnipeg the country about Shoal Lake was uncovered by the fall of Lake Agassiz from the Gladstone to the Barnside beach, which latter is crossed by the Winnipeg & Hudson Bay Railway near the southwest corner of sec.35.

Burnside beach T. 14, R. 2, about three miles south of Shoal Lake. The crest of the in vicinity of Shoal Lake. beach is 860 feet above the sea, being ten feet above Shoal Lake. Her

its course is from of till reaching t three miles fart. crosses this beau rols south from combined shore Agassiz, Westw width of one to 1 west through the jownship it curv northwest betwee mentioned, the co 1E. and T. 16, R leach ridges not between it and Sh stage of Lake Ag j- level.

0-sowa post-off R.4. is situated o outhwest to eastelevation from 84 is north side and Pacific Rarlway w this beach, which nilway cut its ma pebbles and subar is or eight inches magnesian limeste bullers, mostly 1 il's limestone, wh both part of T. ortheast, and ther and the north half places joining the proximately par it onward to Ple. eferable to this sta which a broad : cearly a quarter of midings. Its eremalerlying limesto ses the internat astern enters Min

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BEACHES OF LOWER STAGES.

ound at "The nerson, where eet, consisting y a deposit of this slope, sai 1, R. 4 E., the to twenty-five escent from it n feet. Ahout . the elevation wo feet on the nother mile to nt east and six boulders, falls tract of grave, 35 to \$30 feet. surface of til. gh the cast half section where Through the ch ridge to le gain attains is was excavatel tile for railway till for its trans-Charles Aimes S47 feet above and six to eight both slopes, is gravel and sad portions of the inches or more i are magnesial an granite all theast by Green and 1. R. 4E,

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peg the country, egassiz from the erossed by the orner of sec.32 The crest of the al Lake. Hes

its course is from west to east along the verge of a nearly level expanse will reaching to the lake, to which its drainage is tributary. Two or three miles farther east, where the road to Stonewall and Winnipeg cosses this beach, it has a descent of twenty feet in thirty or forty rols south from its crest, the whole slope being gravel and sand, the combined shore deposits of the Burnside and Ossowa stages of Lake Igasiz. Westward the beaches of these stages are separated by a with of one to two miles, the Burnside beach running southwest and mest through the south half of T. 14, R. 3. Near the west side of this ownship it curves northward, and thence passes north and northnorthwest between Shoal and Manitoba Lakes. East of the road before mentioned, the course of this beach is northeastward across T 15, R 1E. and T. 16, R. 2 E., to Pleasant Home post-office. Numerous short leach ridges noted on the township plats northwest of this leach, herween it and Shoal Lake, were probably formed during the Gladstone stage of Lake Agassiz where the highest parts of that area rose above it. level.

i)-sowa post-office, near the middle of the north half of see. 27, T. Res Ossawa beach. R4 is situated on a well defined beach ridge which runs from westonhwest to east-northeast through this township. Its crest varies From the owner deration from 843 to 848 feet, with descent of three to eight fort of a north side and twelve to fifteen feet on the south. The Canadian Pacific Railway was originally constructed from Stonewall due west to his beach, which it cut through in the east edge of 🗠 , 28. In 🀲 nilway cut its material is wholly gravel, in part very coase, containing publies and subangular rock-fragments up to tour inches and rarely exor eight inches in diameter, of which fully ninet on twentieths are pagnesian limestone. On each side the surface all with plentiful lotllers, mostly Archaean granite and gneiss, but including many of is limestone, which is the underlying rock of the region. In the with part of T. 13, R. 3, this beach curves to the south, east and perheast, and thence passes through the southeast part of T. 14, R. 3, with north half of T. 14, R. 2, gradually approaching and in some gases joining the Burnside beach, with which the Ossowa beach is appoximately parallel, lying a half mile to one or two miles southeast aitonward to Pleasant Home. The only other locality where a beach eferable to this stage was observed is on the top of Stony Mountai-Stony Mounwhich a broad smoothly rounded ridge of gravel and sand extends tain. early a quarter of a mile and is the site of some of the Penitentiary addings. Its crest is about 835 feet above the sea, and the top of the aderlying limestone about \$25 feet. The western Ossowa shore line asses the international boundary a few miles east of Gretna, and the stem enters Minnesota about three quarters of a mile west of "The

Ridge," but they are not there marked by noteworthy beach deposits nor erosion.

The main street of Stonewall crosses a conspicuous beach ridge which runs from south-southwest to north-northeast a third of a mile or more Its crest is 820 to 825 feet above the sea, and its depth is about ten feet Only two or three feet of till intervene between this gravel and sand and the underlying limestone, which, thinly covered by drift, rises in a swell here about twenty-five feet above the adjoining country a half mile distant to the east and west. Beach deposits belonging to this stage were not elsewhere observed, but they are doubtless traceable from Stonewali northward through the west half of Ts, 14 and 15, R.2 E. Lake Agassiz at the time of the Stonewall beach probably extended on the flat Red River Valley to a distance of about twenty-five milesouth of the international boundary, being some fifteen feet deep at Emerson, Saint Vincent and Pembina, while over the site of Winniper its depth was about sixty feet.

The road on the east side of the Red River between Winnipeg and Emerson crosses a beach ridge about a half mile southeast of Niverville It has a width of fifteen rods, and its crest, 777 to 778 feet above the sea, is raised about four feet above the adjoining surface of lacustring silt on each side. Beginning near Niverville station, it extends southeasterly at least a mile. Another beach ridge of similar size, with its crest at 780 feet, is crossed by this road a third of a mile farther south. This also runs southeast, holding its ridged form a mile of more, beyond which it is less distinct. Again, a few miles to the south from these, a beach vidge extends along this road in a nearly due south course across the S.E. 1 of sec. 17 and the east half of secs, 5 and 3 T. 7, R. 4 E. It rises two to four feet above the land adjoining on each side, which is partly sloughs with water throughout the year, de elevation of the beach crest being 782 to 784 feet. Other beach deposits at nearly the same elevation occur a mile southwest d Otterburne; a few miles farther to the south in the northeast part T. 5, R. 3 E.; and about a mile east of the Red River opposite to More At the last named locality they are excavated for masons' said. Fr

Morris.

his stage

These here of the southern end of Lake Agassiz in this stage near Morris, its wester shore extended north and northwest to the vicinity of Starbuck, then north and northeast to Little Stony Mountain five miles northwest Winnipeg, and thence nearly due north, passing between Stonewa and Stony Mountain and onward along the west side of Lake Winnip at a distance of a few miles from it. Gravelly and sandy deposits the base of Stony Mountain on its north and south sides are attributable to erosion by the lake, there only a few feet deep, at the time formation of the Niverville beach. Its level was fifteen to twenty fi

original level of which the Nelson probably that the month- of th twenty-one feet a of this shore line around the whole The Pembina d sixteen miles s ir the stream o Lang's Valley, 1 itimately with isimble to give s When the delta stuent from the

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Stonewall beach.

Niverville

From Niver-

ville to Otterbu**r**ne

beach

DELTA OF THE PEMBINA RIVER.

- 79 E

 $_{\rm aluve}$ the surface where Winnipeg is built and about seventy feet $_{\rm aluve\ Lake}$ Winnipeg.

All the beaches thus far described must be referred to the glacial Lake Agassiz, held on its northern side by the barrier of the waning insheet, as is shown by Dr. Bell's description of the outlet of Lake winnipeg and the topography of the adjoining country, which could present no barrier of land so high as the Niverville beach. The old heach of edginal level of Lake Winnipeg, due to the height of the land upon lake Winnipeg, which the Nelson River began to cut its channel in its present course, spabably that of the well defined beach observed by Hind between the months of the Winnipeg and Red Rivers, having " an elevation of wenty-one feet above the present level of Lake Winnipeg,"[#] Traces if this shore line will probably be found at nearly the same height generation the whole lake.

DELTA OF THE PEMBINA RIVER.

The Pembina delta lies wholly in North Dakota at a distance of foutesisteen miles south of the international boundary; but its deposition by the stream outflowing from the Lake Souris along the course of Engle Valley, Pelican Lake, and the Pembina, associates it so inimately with this glacial water-course in Manitoba that it seems ashable to give some description of it here.

When the delta was deposited, the Pembina was swollen by a great effact from the glacial Lakes Saskatchewan and Souris, and thus recived the drainage from the melting ice fields of the Assiniboine and askatchewan region far beyond the present limits of its basin. The minimit delta of gravel and sand brought into the margin of Lake tent and assiz by the Pembina extends twelve miles from north to south and thicker a a maximum width of seven miles, with a maximum thickness sceeding 200 feet. Its average thickness is probably not less than infect. About five sixths of its area of fifty square miles or more lie adof the Pembina River, reaching nearly to the Tongue River. The most elevated point of this delta, as it now remains, is about 25) feet above the sea, near the northwest corner of sec. 11, T. 162. 57, east of the Little Pembina and south of the Pembina River, and is early 300 feet above the junction of these streams, one and a half ile distant toward the northwest. The level of Lake Agassiz in its ghest stage here was 1,220 or 1,225 feet above the sea, being fifty lighest part of whelow this highest part of the Pembina delta, as is shown by the delta about ach line of this level, 1,226 feet, in the central part of sec. 7, T, 162, the upper

Numtive of the Canadian Red River Exploring Expedition of 1857, and of the Assimiboine to skitchewan Exploring Expedition of 1858, vol. i, p. 122.

peach deposits

th ridge which a mile or more, about ten feet, ravel and sand z drift, rises incongling to this ongling to this othess traceable 14 and 15, R, 2 bably extended centy-five miles in feet deep at ite of Winnipeg

Winnipeg and st of Niverville S feet above the ce of lacustrine ion, it extends imilar size, with of a mile farther form a mile c files to the south nearly due south of sees. S and 5, djoining on each t the year, d t. Other beach le southwest ortheast part posite to Mor ms' sand. Fr prris, its weste Starbuck, the les northwest tween Stonewa Lake Winnip andy deposits s are attributa at the time in to twenty

R. 56, where an eastward descent begins. This is the east verge of the nearly flat area of the delta in secs. 12 and 7. Like all of this vast delta deposit, the material here is sand and gravel, covered by a fertile soil. A small proportion of the pebbles of this gravel is limestone; a large part is Cretaceous shale; but more was derived from Archaen formations of granite and gneiss.

On the road from Olga to Walhalla the crest of the east margin of this delta is crossed in the north part of sec. 33, T. 163, R. 56, about two miles sontheast from Walhalla. Its elevation is 1,190 to 1,196 feet above the sea. This is a beach accumulation, belonging to the third Herman stage. Toward the west and southwest the undulating delta plateau, mostly covered with bushes and occasional trees, is tea to thirty feet lower for a width of one to one and a half miles averaging about 1,175 feet. Northeast from the crest of this road a short descent is made to a prairie terrace 30 to 60 rods wide, varving in elevation from 1,182 to 1,169 feet, but mainly within two feet above or below 1,175. In general the verge of this terrace is its lowest portion. Thence a very steep descent of 169 feet is made on the roa

First Pembina Mountain.

80 E

from 1,173 to 1,004 feet, this being the very conspicaous wooded escarpment called the "first Pembina Mountain." It is the eroled front of the great Pembina delta, the eastern part of which, original descending more moderately, has been swept away by the waves and shore currents of the lake during its Norcross, Tintah, Campbell, and McCauleyville stages. From this sec. 33 the "first mountain" extends southeast to sees, 13 and 24, T. 162, R. 56, and northwest across the Pembina, passing close southwest of Walhalla and onward to sees.] and 3, T. 163, R. 57. Its highest part is intersected by the Pembia River, above which it rises on each side in bluffs of gravel and said 200 to 250 feet high, with their crests a half mile to one mile apar From this upper portion the delta slopes down gradually toward the southeast and toward the northeast and north, extending only two p four miles north of the Pembina.*

Sources of the gravel.

In the gravel of this delta, as seen in the bluffs of the Pembina near Walhalla and at noteworthy springs two miles to the south on the

* The first Pembina Mountain was visited by D. D. Owen in 1848. He describes it as follows " Pembina Mountain is, in fact, no mountain at all, nor yet a hill. It is a terrace of tablela the ancient shore of a great body of water that once filled the whole of the Red River Valley On its summit it is quite level and extends so for about five miles westward to another terrat the summit of which I was told is level with the great buffalo plains that stretch away towar the Missouri, the hunting grounds of the Sionx and the half-breed population of the Red River -Report of a Geological Survey of Wisconsin, Iowa and Minnesota, 1852, p. 178,

Both the first and second Pembina Mountains were examined in 1857 by Palliser, who say the flat Red River Valley and the Pembina delta :-" This plain, no doubt, had formed at a time the bed of a sheet of water, and the Pembina Hill, consisting of previously deposit materials, was its western shore."-Journals, detailed reports, &c., presented to Parliament, b May, 1863, p. 41,

[S+AV.] south side of t shale, of other dark trappear nearly equal ro in the same be erosion of its st and was oceasi material-; but the overlying o mos- agute are landed agates y water-wearing, delta gravel at leds of this kin fragments is no this region and The depositio tage of Lake A of sediments be Talley they wer more than fifty ice-heet cansed permitted the So his delta cease channels cut thro of the steep escar of this tirst Peml swept southward. they were deposi the Tongue River west of Cavalier. secumulated, min iver, were carrie central part of the mount nearly a eaches across the Bat on the west e robably because oth south and no orth to Gardar a om two miles no al onward.

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(54W.] DELTA OF THE PEMBINA RIVER.

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east margin of R. 56, about two 0 to 1,196 feet ng to the third the undulating nal trees, is ter a halt miles, t of this road a s wide, varying two feet above ce is its lowes; ade on the roal picuous woodel t is the eroded which, originally the waves and 1. Campbell, and untain" extends west across the ward to sees, b by the Pembia gravel and said one mile apar. aally toward the ling only two to

ne Pembina nea ne south on the

escribes it as follows a terrace of table lash the Red River Valley and to another terras at stretch away toward tion of the Red River, p. 178, by Palliser, who says?

by had formed at a of previously deposits ted to Parliament, be

south side of the river, the pebbles of some beds are mainly Cretaceous shale, of others mostly limestone, and of others granite, gneiss, and dark trappean rocks. In the aggregate, these three classes have a nearly equal representation; and they are more commonly intermingled in the same beds. The shale was doubtless chiefly derived from the ension of its strata along the glacial water-course from the Lake Souris, and was occasionally deposited in layers almost unmixed with drift materials; but the other constituents of the gravel were derived from the overlying drift and from the melting ice-sheet. White quartz and moss agate are frequent, and bits of silicified wood occur rarely; but no landed agates were found. Numerous pieces of lignite, rounded by Fragments of water-wearing, from two to four inches in diameter, noticed in this lignite. dela gravel at the springs, have caused some to look for workable leds of this kind of coal in the vicinity; but the proportion of these fragments is no greater than in the glacial drift generally throughout his region and for hundreds of miles to the south.

The deposition of this delta took place during the highest Herman Time and sage of Lake Agassiz. It seems to have been very rapid, the supply deposition. of ediments being so great that about the mouth of the Pembina Talley they were accumulated in a fan-like sloping mass to a height of more than fifty feet above the lake level. When the recession of the itesheet caused the cessation of its supply of modified drift, and remitted the Souris to flow as now to the Assiniboine, the growth of his delta ceased; and its subsequent history is that of the deep dannels out through it by the Little Pembina and the Pembina, and whe steep escarpment sculptured on its east side. From the erosion Erosion and athis first Pembina Mountain large amounts of gravel and sand wero redeposition. swept southward, notably during the Campbell stages of the lake, when be were deposited in a very massive curving beach ridge that crosses he Tongue River in the west part of T. 161, R. 55, about seven miles metor Cavalier. In the Herman stage, while the delta was being accamulated, much fine clay and silt, brought by the same glacial Laenstrine silt iver, were carried farther and spread upon the lake bed along the fin estral part of the Red River Valley, perhaps extending in appreciable mount nearly a hundred miles southward to the belt of till that nucles across the valley at Caledonia and forms the Goose Rapids, faton the west edge of the lacustrine area this fine sediment is absent, metably because of currents trending off shore; and the surface is till is south and north of the gravel and sand delta, as from Park River oth to Gardar and Mountain and nearly to the Tongue River, and on two miles north of the Pembina to the international boundary al onward.

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DELTA OF THE ASSINIBOINE RIVER.

At Brandon the Assiniboine enters the area of Lake Agassic and thence the gravel and sand delta of this tributary extends eastward seventy-tive miles to Portage la Prairie, northeastward fifty milest Gladstone, and east-southenstward eighty miles to Almasippi just office, nine miles west of Carman. On the northwest this deita , bordered by an expanse of moderately undulating or rolling till which rises slowly above the ancient lake level and stretches northwestway from Brandon, Chater and Douglas to the Little Saskatchewan and Oas Rivers. From Brandon to Douglas the boundary of the delta is close north of the Assiniboine and the Canadian Pacific Railway; but at Douglas the line dividing the delta sand and gravel and the adjoining surface of till turns north-northeastward and extends about tweater miles in a nearly direct course toward Neepawa, then bends northwar in the east part of Ts, 13 and 14, R. 16, and crosses Stony Creek a ter miles west of Neepawa. Between Brandon and the mouth of the Souris the delta reaches three or four miles southwest of the Assimilate being there also bordered by a smoothly undulating or rolling tracttill, but the morainic Brandon Hills rise prominently within a le miles farther west. From the Souris east to the Cypress, a distancenearly twenty-five miles, the southern margin of the delta is similar divided from the Tiger Hills by a belt of undulating and robing which averages about five miles in width. Farther to the east delta deposits abut directly upon the northern base of these hills to Cypress River by Holland and Treherne to the north end of the Pembina Mountain. Thence to the southeast the head streams of Boyne, after their descent from the plateau of the Pembina Mountain cross the southeastward extension of this delta to Almasippi. The portion, however, is not probably a part of the delta as it was at a deposited, but has been derived from the crosion of the eastern neg of the original delta by the waves of the lake in its later and successively lower stages, being transported thence southward by sh currents. The same lacustrine action has doubtless extended the dea of gravel and sand generally five to tifteen miles eastward beyon! original area, thereby giving its eastern face a more gradual sk As thus enlarged, its east boundary runs north from Almasiped Portage la Prairie, curving eastward between these places; and then it passes west-northwest to near Gladstone, Arden, and Neepawa. 1 eastern base of the delta, where it adjoins the flat expanse of the la River Valley and the country bordering the lower Assiniboine a Lake Manitoba, has an elevation of 850 to 900 feet above these while the high delta plateau, which was submerged only about it par tilenboro and

Extent and boundaries.

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feet or less by shoals and low the sea. The already noted, from Treherne about 1.300 squ thirds as much than 2,000 squa The thickne which generall within modera localities, howe through the de and wells mus Better measures supplied by the are eroded in th delta platean be especially nume springs issue nea and beds and t Creeks which the 200 to 300 feet n delta is a turther at the verge of th lei-on the Assi leta gravel and mages from 100 the greater part dickness of this seventy-five feet. anarea of 2,000

Fifty miles eas entace of the delt where it has not 1240 feet above th tear the centre o restward, between lightly undulating tith frequent slou more in extent,

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DELTA OF THE ASSIMIBOINE RIVER.

feet or less by the lake when it was being deposited, and was in part High plateau shouls and low islands, has an elevation from 1,200 to 1,275 feet above define of the the sea. The western and southern limits of the platean are those of each. already noted, and on the east its boundary runs north and northwest from Treherne to Sydney and Neepawa. The area of the platean iabout 1,300 square miles, and the eastern slope adds to this fully two hinds as much, making the total area of this delta somewhat more than 2,000 square miles.

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The thickness of the Assiniboine delta is seldom shown by wells, Thickness and which generally obtain a plentiful supply of water upon this area within moderate depths, ranging from ten to tifty feet. In some pralities, however, near the great valley that the Assiniboine has cut through the delta, the plane of saturation probably lies much deeper. and wells must be sunk a hundred feet or more to obtain water. Batter measures of the depth of these gravel and sand deposits are supplied by the valleys of the Assiniboine and other streams, which are croded in their deeper portions 100 to 200 feet below the top of the deta plateau before reaching the underlying till. Deep ravines are specially numerous on the northern part of the delta, where many grings issue near the plane of junction between the porous gravel and and beds and the till, giving rise to the Squirrel. Pine and Silver creeks which flow northeast to the White Mud River. The descent of 200 to 300 feet made within a few miles upon the eastern face of the deta is a turther indication of its thickness, which reaches its maximum a the verge of the plateau. In the vicinity of the onterop of Niobrara leison the Assiniboine in sec. 36, T. S. R. 11, the thickness of the deta gravel and sand appears to be about 200 feet; and it probably mages from 100 to 200 feet along the outer limit of the plateau through the greater part of its extent of more than fifty miles. The average dickness of this very extensive delta is probably between titty and eventy five feet. Computing its volume for an average of fifty feet on marca of 2,000 square miles, it is found to be about twenty cubic miles.

Fitty miles east-southeast from Brandon the highest portions of the Elevation of reface of the delta south of the Assiniboine and east of the Cypress, the plateau of the Assiniboine stward beyond: where it has not been heaped in sand hills by the wind, are 1,225 to detta. 1240 feet above the sea, the latter being its elevation in a broad swell Jaces; and there was the centre of sec. 24, T. S. R. 11. Ten to twenty miles thence I Neepawa. Is presward, between Cypress River and Glenboro, the elevation of the xpanse of the lightly undulating surface of the delta is mostly 1,235 to 1,245 feet, Assiniboine all with frequent sloughs and permanent ponds, up to a quarter of a mile et above the sectimore in extent, lying at 1,225 to 1,235 feet. These ponds abound d only about it was Glenboro and for four miles east. Along the Canadian Pacific

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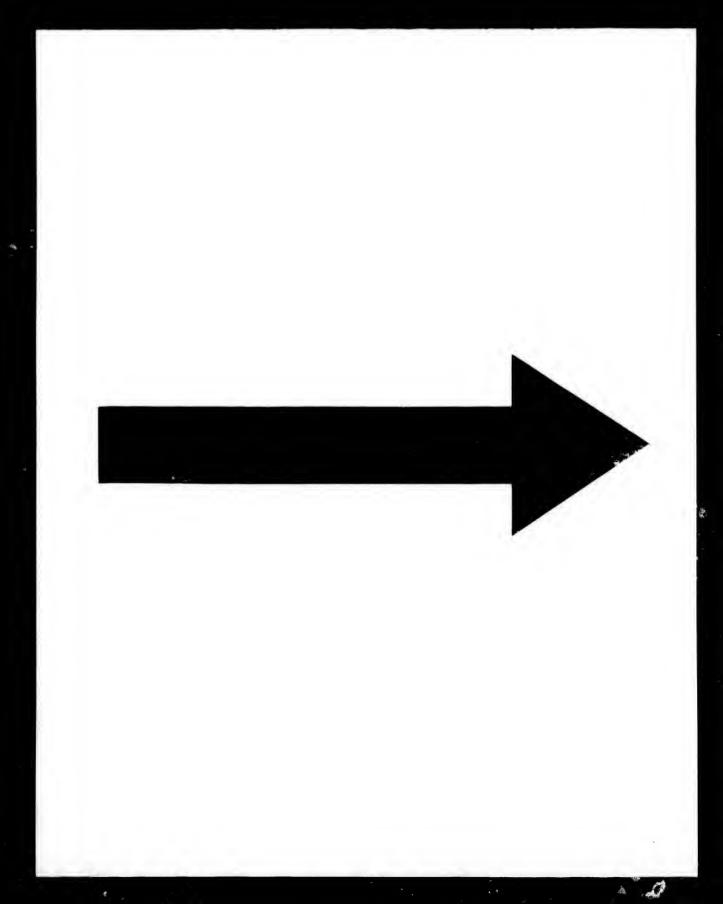
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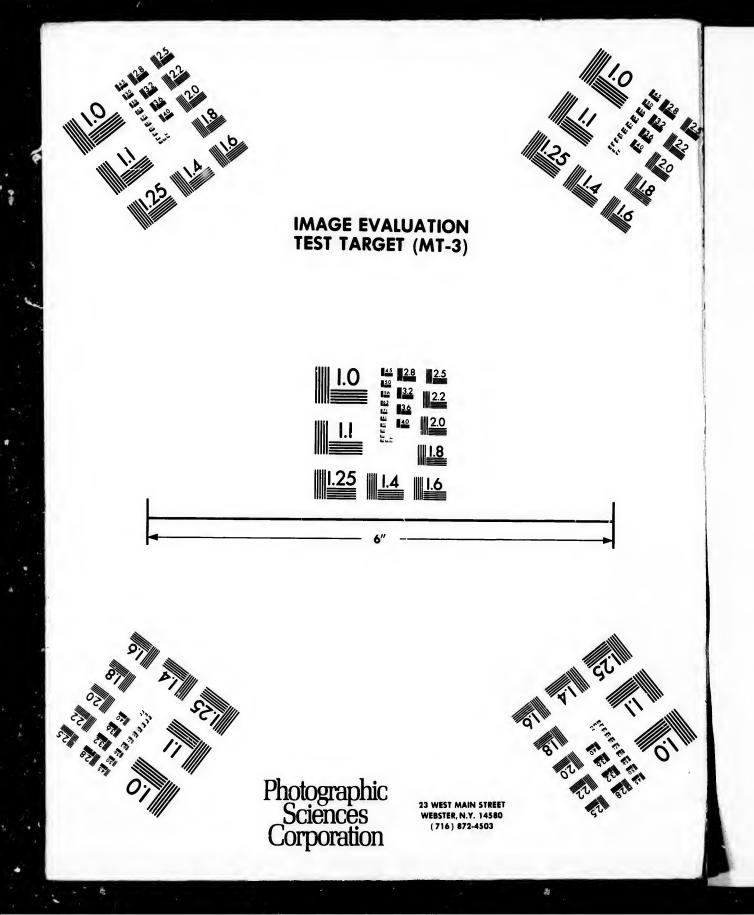
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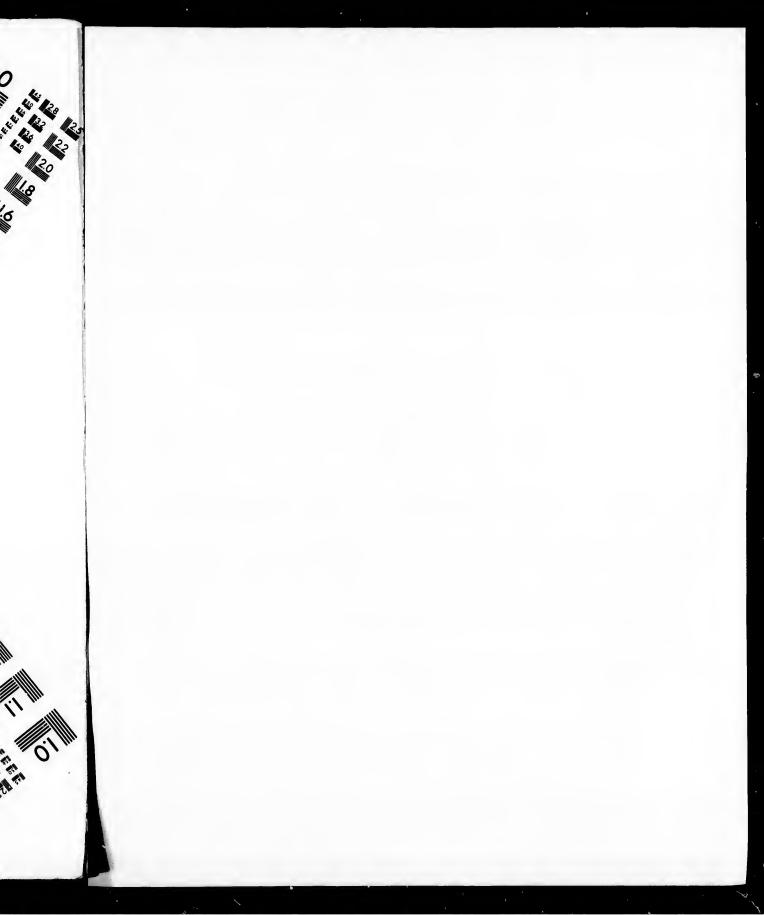
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Railway from Sydney westward by Melbourne, Carberry, and Sewell. to Douglas, twenty to twenty-five miles north of the foregoing, the undulating delta ranges in elevation from 1,230 to 1,275 feet; and it holds the same height through twenty-five miles northward, to within three miles southeast of Neepawa. Adjoining the undulating and rolling area of till which borders this part of its area on the west, its expanse of gravel and sand slowly rises northward from 1,265 and 1,270 feet two to three miles northeast of Douglas to 1,275 and 1,280 feet between Willow or Boggy and Spring Creeks. These elevations represent the plateau before mentioned, which forms the greater part of this delta.

While the extensive area of this plateau, reaching fifty miles from east to west and nearly the same distance from north to south, is thus so uniform in its elevation that its deposition must be attributed to stages of the lake when its level was not much higher, probably those

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North of the Assiniboine.

Highest portion a considerable tract lying on both sides of the Assiniboine in the of this delta in vicinity of Brandon and Kemnay, upon which delta deposits closely Brandon and Kemnay, associated with this plateau ascend from a few fact to 105 c in a distance of twelve or fifteen miles from east to west. A mile north of Brandon the bluff on the north side of the Assiniboine rises about 140 feet above the river to 1,300 feet, approximately, above the see, It consists of till to a height of 100 feet or more; but its crest and the surface thence northward for five miles is mostly undulating grave and sand to a thickness of 10 to 20 feet, thinly covering the till, which forms the surface farther north. Eastward this bluff, eroded by the Assiniboine since the deposition of this stratified gravel and sand, extends along the north side of the railway by Chater and Douglas, having a height of about 75 and 50 feet, respectively, at these stations. but declining only slightly in the elevation of its crest, which is 1.25 to 1,290 feet. Delta gravel and sand, and on some portions fine silt cover a width of three or four miles thence northward through the south half of Ts. 11 of Rs. 18 and 17, having an elevation at their northern limit 1,300 to 1,290 feet above the sea, beyond which the surface, gradually ascending northward, is till. The most eastern point of this higher delta deposit is in sec. 14, T. 11, R. 17. Measure thence to its western limit on the north side of the Assiniboine half-wa between Kemnay and Alexander, its length is twenty-four miles. width north and south of Brandon is about twelve miles. Through the Assiniboine has eroded its valley, and has carried it away, cuttin also into the underlying till, upon a large area from Brandon cast Chater and Douglas and thence south nearly to the Brandon Hills. South of the river, at the court house in the southeast part of Brando

very course g delta, contain diameter, form rising to 1,28 half to three n from 1,290 to which slope continuous, a f of a mile in w through the so three miles, on area eroded b 1,250 feet to 1, of the formatio of Lake Agass miles west of course of simil shalf mile in passing from t Creek. Its bec the erosion her fill, is about 1, b stage of Lak below the adjo west. In three to 60 feet, and a half miles to Thence the sur including near west, is till. Many portion

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have been char feet high, mostl plants, but in p obtaining a foot of this area the occur in secs. upon a width of Assiniboine. C dunes extend t Both these trac and thence wes slope. Even w

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DELTA OF THE ASSINIBOINE RIVER.

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ry, and Sewell, to regoing, the 275 feet; and it ward, to within andulating and on the west, its from 1,265 and 1,275 and 1,259 these elevations the greater part

tifty miles from to south, is thus be attributed to r, probably those Vecpawa, there is ssiniboine in the deposits closely 125 feet above it st. A mile north boine rises about y, above the sea. t its crest and the undulating gravel ng the till, which ff, eroded by the gravel and sand, ater and Douglas. at these stations. est, which is 1.275 portions fine silt, ward through the elevation at their beyond which the most eastern pein R. 17. Measure siniboine half-wa ty-four miles. It niles. Through d it away, cuttin n Brandon east Brandon Hills. st part of Brandon

very coarse gravel and sand of this higher part of the Assiniboine delta, containing water-worn cobbles up to six and eight inches in dameter, form a plateau mostly 1,270 to 1,275 feet above the sea, but rising to 1,282 feet at a distance of one mile to the east. One and a half to three miles west of Brandon, a similar plateau varies in height South of the from 1,290 to 1,305 feet. Between these small plateaus or plains, Assiniboine. which slope about five feet per mile to the east and were once continuous, a former water-course, diminishing from a half to a quarter of a mile in width, passes southeast from the valley of the Assiniboine through the south part of Brandon and thence continues east nearly three miles, opening in sec. 7 or 8, T. 10, R. 18, upon the broad lower area eroded by the Assiniboine. The bed of this old channel is at 1,250 feet to 1,255 feet, and it appears to have been eroded at the time 'ormer waterof the formation of the Herman beach bb in Brandon, when the level course of Lake Agassiz was approximately at this height. Three to four miles west of Brandon, the road to Kemnay crosses another watercourse of similar character, diminishing from one and a half miles to shalf mile in width within two miles from northwest to southeast. passing from the Assiniboine Valley to the head of Baker's or Stony freek. Its bed, which is strown with plentiful boulders, showing that the erosion here extended through the stratified gravel and sand to fll, is about 1,270 feet above the sen, and marks nearly the Herman stage of Lake Agassiz, being about 30 and 40 feet, respectively. below the adjoining areas of delta gravel and sand on the east and west. In three miles westward to Kemnay this delta expanse rises 50 to 60 feet, and continues to ascend more slowly in the next three and abalf miles to 1,390 and 1,400 feet in secs. 1, 12, and 13, T. 10, R. 21. Thence the surface for the next six miles westward about Alexander, izeluding nearly all of this township and the east edge of that next west, is till.

Many portions of the fine sand deposits of the Assiniboine delta have been channelled and piled by the wind in dunes from 10 to 75 fet high, mostly covered with bushes and ascanty growth of herbaceous plants, but in part destitute of vegetation, which is prevented from obtaining a foot-hold by the drifting of the sand. On the southeast part of this area these sand hills, seldom exceeding 30 or 40 feet in height, oveur in sees. 1 to 4, T. 7, R. 7, and are thence frequent northward upon a width of ten miles northeast of the Boyne and southeast of the Assiniboine. On the north side of the Assiniboine the most eastern danes extend to within three miles southwest of Portage la Prairie. Both these tracts he on the lower part of the eastern slope of the delta, and thence westward dunes are found here and there over this entire slope. Even where no distinct hillocks and ridges have been formed,

the surface is often channelled and ridged in hollows and elevations of a few feet, though now wholly grassed or covered with bushes or small poplar groves. Upon the delta plateau tracts of dunes. commonly raised 20 to 40 feet above the general level, interspersed with occasional smooth areas where the original surface remains undisturbed, extend on the south side of the Assiniboine from the Cypress to the Souris, occupying a width that varies from one to five miles. Their southern limit is about four miles north of Holland, three miles north of Cypress River station, and two miles north of Glenboro. One to four miles west of the mouth of the Souris, an isolated tract of dunes about three miles long from southeast to northwest is crossed by Spring Creek near its mouth. North of the Assiniboine much of its delta plateau is occupied by dunes, which extend north to the White Mud River. Their most northern area is a belt that reaches north of this stream through secs. 12, 13, 24 and 25. T. 15, R. 15, to the junction of Hazel and Snake Creeks. But the northwestern part of this plateau includes a belt of smooth and fertile land, several miles wide, extending from Carberry north and northwest to the limit of the delta. Also, from Douglas and Chater southeastward a belt of good agricultural land, free from dunes upon a width of three to five miles, reaches tifteen miles along the northeast side of the Assiniboine. On the extreme western and highest part of this delta conspicuous sand hills rise 60 feet above the adjoining surface, with their crests about 1.445 feet above the sea, in sees, 6 and 7, T. 10, R. 20, two to three miles southwest of Kemnay; and lower hillocks of wind-blown sand continue from these two miles to the southeast,

Delta and dunes of La Sonris in the vicinity of Griswold.

Within six miles west from the dunes last noted and from the Lake boundary of this Assiniboine delta, after crossing a belt of till that reaches about three miles east and the same distance west from Alexander station, the Canadian Pacific Railway thence west to Griswold, Oak Lake and Virden, lies upon the delta which was brought into the Lake Souris by the Assiniboine. In Ts. 9 and 10, R. 22, and T. 9, R. 23, including the vicinity of Griswold, this deposit consists of fine clayey silt and sand, having a moderately undulating or rolling surface with broad smooth swells elevated 10 to 30 feet above the depressions, their tops being 1,400 to 1,435 feet above the sea. Three to seven miles southwest of Griswold this delta has been much channelled and uplifted by the wind in sand hills, which thence continue ten miles southeast along the north side of Plum Creek to sec. 11, T. 8, R. 22, four miles west of Plum Creek village. The crest of these dunes are 1,420 to 1,430 feet above the sea, being 30 to 4 feet above the adjoining surface. Nearly all of them are now covered by grass and bushes.

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An ancient the Big Sloug wile, but in it from southwesomis and the ts west end abont half' a m outh side of t water ranges varies from tw rise in gentle s the general lev by streams; outflowed at or lake north of t the opposite di Brandon glacin the departure of this channel, to gent gladial Souris outflow Pembina Rive: Tiger Hills and the Souris, cut the Souris now Brandon Hills, during its rece onthowing wes Sough. As soc Hills wholly nn were merged in south through t at down nearly east and north Lake Agassiz, lake by the re Hills, received portion of the Kennay, consi he and partly o east from the L the latter is spre Kennay, and up

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Tracts of dunes.

DELTA OF THE ASSINIBOINE RIVER.

with bushes or acts of dunes. el, interspersed urface remains boine from the from one to five rth of Holland, miles north of the Souris, an m southeast to North of the y dunes, which orthern area is a 2, 13, 24 and 25. reeks. But the nooth and fertile h and northwest er southeastwar] width of three to ast side of the art of this delta, ng surface, with and 7, T. 10, R. ower hillocks of southeast. 1 and from the belt of till that ance west from thence west to elta which was Ts. 9 and 10, R. old, this deposit ately undulating ed 10 to 30 feet 5 feet above the is delta has been lls, which thence f Plum Creek to lage. The crests being 30 to 40 are now covered

d elevations of

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An ancient water-course, now occupied by a body of water called the Big Slough, thirteen miles long and mostly twenty to fifty rods connection when but in its west part about three-fourths of a mile wide, extends source and from southwest to northeast nine miles through this delta of Lake Agassiz by souris and thence continues four miles east through an area of till. is west end is two miles southwest of Griswold, and its east end about half a mile east of Alexander, its whole extent being on the outh side of the railway. Its elevation in the stages of low and high rater ranges from 1,385 to 1,388 feet, and its depth at low water raries from two to six or eight feet. The shores of the Big Slough sein gentle slopes tifteen to twenty feet in twenty to thirty rods, to the general level, not having the usual steepness of banks undermined by streams; yet it doubtless marks the course of a stream that outflowed at one time westward into Lake Souris from a small glacial lake north of the Brandon Hills, and of a later stream that flowed in the opposite direction, eastward from the basin of Lake Souris into the Brandon glacial lake, before that became merged in Lake Agassiz by the departure of the ice-sheet. The succession of events indicated by his channel, together with that of the present Souris and with the gent glacial water-course of Lang's Valley, is as follows. Lake Saris outflowed eastward by Lang's Valley, Pelican Lake, and the Pembina River, until the receding ice formed a lake north of the Tizer Hills and east of the Brandon Hills, which, outflowing south to the Souris, cut a deep gorge through the Tiger Hills moraine, where the Souris now flows through it to the north. Similarly, north of the Brandon Hills, a lake was probably held by the barrier of the ice during its recession from Alexander east by Kemnay and Brandon, automing westward to the Lake Souris by the course of the Big sough. As soon as the continued glacial recession left the Brandon Hils wholly uncovered from the ice, these lakes on the east and north were merged in one, and the outflow from the lake so formed passed both through the Tiger Hills to Lang's Valley until that channel was at down nearly to 1,350 feet. During this stage of a continuous lake est and north of the Brandon Hills, this independent part of Lake Agassiz, before it was merged with the main body of this hke by the recession of the ice from the east end of the Tiger lills, received an extensive delta, already described as the highest partion of the Assiniboine delta in the vicinity of Brandon and Kennay, consisting partly of modified drift from the retreating he and partly of fine sand and silt brought by a stream then flowing est from the Lake Souris delta along the Big Slough. The tribute of the latter is spread over an area of several square miles southwest of Kemnay, and upon it are raised the conspicuous dunes of sees, 6 and

7, T. 10, R. 20. With the retreat of the ice northward from Treherne. the Brandon lake was lowered nearly 100 feet to the level of Lake Agassiz ... its Herman b stage. For a short time the Souris probably continued to flow southeastward through Lang's Valley until the deposition of the alluvium, perhaps ten or fitteen feet thick, brought into that valley by Dunlop's Creek four miles east of the Elbow of the Souris, raised a barrier a few feet higher than the gap that had been cut through the Tiger Hills north of the Elbow, whereby the river was turned through this gap, which it has since eroded 100 to 150 feet deeper.

The modified drift and alluvium that form the plain of coarse gravel and sand sloping eastward from Kemnay to Brandon and reach alone the north side of the Assiniboine to Douglas, were probably deposited mostly while the barrier of the waning ice-sheet stretched from the Tiger Hills to Riding Mountain, enclosing on its west side a lake that afterward became the bay of Lake Agassiz covering the Assiniboine delta, but was then held about a hundred feet above Lake Agassiz, to which it outflowed by the way of Lang's Valley and the Pembina The deposition of this highest part of the Assiniboine delta, lying above the Herman bb beach observed in Brandon, appears to have been in progress through a considerable period, beginning when this Brandon glacial lake was held at an elevation of about 1,400 feet, and continuing while it was lowered nearly 150 feet. During this time the Brandon lake had three outlets: first from its two parts respectively westward by the Big Slough and southward across the Tiger Hills moraine; second, from the whole lake, when these parts became confinent, br the southward one of these outlets, namely, the gap where the Souris now flows through the Tiger Hills; and third by confluence with Lake Agassiz, when this was permitted by the recession of the ice. Much modified drift was probably brought into the Brandon lake by drainage along the course of the Little Saskatchewan; and it is significant that in the line of continuation of the valley of that stream the plain between Kemnay and Brandon is crossed by a broad water-course, which was evidently eroded after this lake became merged in Lake Agassiz thereby falling nearly a hundred feet below its former level when outflowing through Lang's Valley, but before the Assinboine had cut its broad valley through this delta. More exactly, as before noted, this water-course seems referable to the Herman b stage of Lake Agassiz, defined, to the 1 and the similar water-course about twenty feet lower, passing through matof Emerson the west and south parts of Brandon, was probably formed during the Red River Valle Herman bb stage. During these two stages of the lake the principal miles east-southe expanse of the Assiniboine delta was formed, lying only slightly below aestrine sedime the levels which the lake then had.

At the time had already en and as Lake continued, cut 300 feet deep, channel to a n Pacifie Railw Brandon, neur Agassiz and th on each side of be made by ea slope south of favorable poin: west, where th greater part of ice-sheet on th Riding Mount: Bird Tail Cree was deposited of the lake, as principal expa was melted av The erosion of considerable pr Agassiz, to tho: delta was under which its outer farther into the

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By this erosid earlier transpor and sand were b Tiger Hills an ediment of the extending to the the internationa ill from the ea he Assiniboine d

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History of the formation of the Assimiboine

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from Treherne, a lovel of Lake Souris probably alley until the bt thick, brought he Elbow of the p that had been hereby the river 1 100 to 150 feet UPHAN.]

of coarse gravel and reach along obably deposited retched from the t side a lake that the Assiniboine Lake Agassiz, to nd the Pembina, delta, lying above to have been in hen this Brandon et, and continuing time the Brandon etively westward r Hills moraine; ame confluent, by where the Souris fluence with Lake of the ice. Much h lake by drainage is significant that the plain between course, which was in Lake Agassiz ormer level when

DELTA OF THE ASSINIBOINE RIVER.

At the time of formation of the Herman bb beach, the Assiniboine channel of the had already eroded a deep and wide valley in its delta at Brandon; and as Lake Agassiz sank to successive lower levels this crosion continued, cutting at least the lower part of the great valley, 200 to and feet deep, in which this river flows above Brandon, and wearing itchannel to a nearly equal depth through its own delta. The Canadian pacific Railway crosses the Assiniboine about two miles east of Brandon, near the division between the main area of its delta in Lake lyassiz and the deep portion of its upper valley. There the high land m each side of the river recedes, allowing the descent to the stream to he made by easy grades on each side, and supplying upon the gradual slone south of the river the beautiful site of Brandon. No other so favorable point for this crossing exists within sixty miles to the east or west, where the river flows in a deeper and narrower valley. The greater part of this delta was modified drift derived from the molting inesheet on the upper part of the basin of the Assiniboine and on Billing Mountain, being carried down from the latter area by the End Tail Creek and the Oak and Little Saskatchewan Rivers. It was deposited in this delta chiefly during the early Herman stages of the lake, as is indicated by the elevation of the outer part of its mincipal expanse; and its deposition continued until the ice-sheet was melted away on Riding Mountain and the upper Assiniboine. The erosion of the Assiniboine Valley above Brandon also supplied a considerable part of the delta. During the ensuing stages of Lake Agassiz, to those of Gladstone and Burnside, the border of this great delta was undergoing erosion by the lake waves and shore currents, by Erosion by which its outer portion was spread in more gentle slopes, extending Lake Agassiz. farther into the lake, and much of it was swept southward along the shore.

I lake by drainage By this erosion of the sloping face of the delta, and especially by is significant that earlier transportation into the deep water of the lake while the gravel the plain between and sand were being deposited in its western embayment between the course, which was liger Hills and Riding Mountain, a large expanse of fine clayey in Lake Agassi, ediment of the same origin with this delta was spread far into the lake, prmer level when attending to the east beyond the Red River and to the south beyond simboine had cut he international boundary. This deposit of lacustrine silt covers the before noted, this fifther the eastern and southeastern limits of the delta, as before of same origin of Lake Agassi; defined, to the low ridge first east of the Red River, about ten miles ; passing through ast of Emerson, while similar sediments cover the central part of the formed during the Red River Valley southward to Goose Rapids, more than a hundred ake the principal rides east-southeast from this delta. Toward the north and northeast rily slightly below must be south a busequent alluvial deposits associated with he Assiniboine dolta cover the nearly flat country north from Burnside,

Between Portage la Prnirie and Lake Manitoba.

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Portage la Prairie and High Blutt to Lake Manitoba. On this area the water-shed between the Assiniboine and Lake Manitoba is very low, and the river has sometimes overflowed its low banks, sending part of its floods north to the lake, which in turn in its highest stages has occasionally become for a short time tributary to the lower part of this river. But the transportation of the silt in the lake was of less extent

Adjoining areas in this direction than to the east and south, as is shown by areas of dill of till.

on both sides of the Big Grass Marsh west of Lake Manitoba, and from Ts. 13 and 14, R. 5, southeast of this lake, eastward to Shoal Lake. Stonewall, and Solkirk.

Five to ten miles west of Portage ln Prairie till with frequent boulders forms the surface, or is only overlain to the depth of a tew feet by the sediments associated with this delta. Again, ten miles farther west, the sandy eastern slope of the delta in the vicinity of McGregor shows very rarely projecting boulders, the size of the few noticed being from two to six feet in diameter. They probably lie on till that has been somewhat eroded by the lake waves, so that these boulders are not embedded in it as usual, while the sand and silt afterward spread there on the surface are not sufficiently thick to conceal them. No boulders were elsewhere seen on the general surface of the delta and of the great area of associated lacustrine silt, nor in any observed sections of these deposits.

CHANGES IN THE LEVELS OF THE BEACHES.

The successive shore lines of Lake Agassiz are not parallel with each other and with the present levels of the sea and of Lakes Winnipeg and Manitoba, but have a gradual ascent from south to north, which is greatest in the earlier and higher beaches and slowly diminishes through the lower stages of the lake, being at last only slightly different from the level of the present time. On the west side of Lake Agassiz the elevations of its beaches have been determined by continuous leveling, referred to sea level by railway surveys, through a distance of more than 300 miles from its mouth at Lake Travers northward to near Riding Mountain in Manitoba; and the accompany ing table shows approximately the stages of the lake during the formation of these shore lines, in their relations to each other and u the present level. These stages of the water surface have been assume to coincide generally with the foot of the lakeward slope of the beat ridges, and with the base of eroded shore escarpments, the crests of th beaches having had a variable height from five to fifteen feet above the lake, corresponding with their less or more massive development while the escarpments rose from the water's edge ten, twenty, or rare thirty feet.

In this table on at its mout end of Lake T equidistant fro Emerson, and (of Lake Trave greater than th in the observed because, us will subsidence of t west to northmore western c examined com letween the thi The letters a. part of Lake A outh end. Sev are found to bec and a correspon abordinate stag the two stages c publication of th The lake shor northward ase Lake Traverse, a a the third dist whole ascent the rom slightly les lightly more the ix lower stages eem to be united if the lake, the r nately 30, 40, 60 ourse of these : niles. On the in bout 55 feet belo le outlet and c etween these str Between the se eaches, the Rive e upper Nore

"U.S. Geological Sm

Projecting boulders,

Stages of Lake Agassiz during the formation of its beaches. , F=1 V.

LEVELS OF THE BEACHES.

On this area the oba is very low. , sending part of ghest stages has ower part of this 7as of less extent n by areas of till nitoba, and from to Shoal Lake.

Il with frequent epth of a tew feet ten miles farther nity of Metiregor ew noticed being e on till that has hose boulders are afterward spread mceal them, N of the delta and of observed sections

EACHES.

parallel with each Lakes Winnipeg to north, which is slowly diminishes ast only slightly west side of Lake termined by com arveys, through a nt Lake Traverse id the accompany lake during the each other and to nave been assume slope of the beach s, the crests of the een feet above the ive development , twenty, or rard

In this table the estimated stages of the lake are noted for comparison on $_{on}$ at its month, where it outflowed by the River Warren at the north thread farmed and of Lake Traverse, and on four lines of latitude which are nearly Grand Fork quidistant from each other, passing through Fargo, Grand Forks, Giadstone. Emerson, and Gladstone, respectively 75, 150, 224, and 308 miles north I Lake Traverse. Though the fourth of these intervals is somewhat meater than the others, it may still be considered equivalent to them the observed elevations and northward ascent of the lake shores, beause, as will appear farther on, the northward rise of the land and absidence of the lake had their maximum increase from south-southmest to north-northeast, or nearly in that direction. Therefore the more western course of these beaches in the northern part of the area examined compensates approximately for the additional distance

letween the third and fourth of these groups of observations, The letters a, b, c, d, represent successive benches along the northern Successive art of Lake Agassiz, which are merged in a single beach toward its stages ignated by outhend. Several of the benches thus noted in a preliminary report * letters. refound to become double in some parts of their northward extent; al a correspondence in notation is here preserved by designating abordinate stages by double letters, as aa, bb. There are also added he two stages of the Tintah beaches, which were discovered after the ablication of that report.

The lake shore belonging to the highest or Herman stage a has now Northward methward ascent of about 35 feet in the first 75 miles north from ascent of the Like Traverse, about 60 feet in the second 75 miles, and about 80 feet lines. the third distance of 74 miles to the international boundary. Its hole ascent thus in 224 miles is 175 feet, by a slope which increases on slightly less than a half of a foot per mile in its southern third to lightly more than one foot per mile in its northern third. Through is lower stages represented by separate beaches northward which eem to be united in the single Herman beach along the southern third the lake, the northward ascent is gradually diminished to approximately 30, 40, 60, and 70 feet in the four portions of the observed surve of these shore lines, amounting thus to 200 feet in about 300 iles. On the international boundary the lowest Herman stage dd is but 55 feet below the Herman stage a, while the probable erosion of he outlet and consequent lowering of the south end of the lake eween these stages appears not to have exceeded ten feet.

Between the series of the Herman beaches and that of the Norcross aches, the River Warren eroded its channel about fifteen feet; and e upper Norcross shore ascends northward in these successive

"f.S. Geological Survey, Buttetin No. 39, p. 20.

STAGES OF THE GLACIAL LAKE AGASSIZ, WESTERN SHORE

			Mouth of Lake Arassiz aufflowing by the River Warren, at the north end of Lake Traverse.	On the latitude of Fargo and Wheatland, North Dakota, 75 miles north of Lake Traverse.		())) the latitude of Grand Forks and Larinore- North Dakota, 150 miles porth of Lake Traverse-		the the international boundary, 224 unles north of Lake Traverse.		On the latitude of Glad stone, Arlen and Nee- pawa, Mantobu, 200 Fraverse, Praverse, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	
Ибленка.			Feet above the sea.	Feet above the sea.	North ascent from Lake Traverse.	Feet above the sea.	North ascent from Lake Traverse.	Feel above the sea.	North accent from Lake Traverse	Feet above the sea.	North need from
outhward.	Herman berches.	a b bb c d dd	$1055 \\ 1055 \\ 1050 \\ 1050 \\ 1045 \\ $	1090 1090 1085 1085 1085 1080 1075 1075	35 35 35 35 35 35 30 30	$\begin{array}{c} 1150\\ 1145\\ 1135\\ 1132\\ 1132\\ 1125\\ 1117\\ 1115\\ \end{array}$	95 90 85 82 80 72 70	$\begin{array}{r} 1230\\ 1222\\ 1212\\ 1205\\ 1190\\ 1180\\ 1175 \end{array}$	155 145 135	1315 1295 1275 1255 1245	おのの
outflow -	beaches. Tintah	{	1030 1025 1015	1055 1050 1035	25 25 20	1090 1080 1065	60 55 50	1145 1130 1105	105 90	1215 1185 1150	10
stages during outflow southward.	benches. Campbell beaches.	$\begin{cases} c, \dots \\ au, \dots \\ b, \dots \\ \vdots \end{cases}$	1000 990 985 980	1017 1000 995 988	17 10 10 8	1045 1015 1010 1000	45 25 25 20	1080 1045 1035 1022	55 50	1120 1080 1070 1055	
112	$\begin{array}{c} \text{MeCauleyville} \\ \text{beaches.} \\ \end{array} \begin{cases} a & \dots \\ b $		970 965 960	977 971 963	7 6 5	987 981 975	17 16 15	1007 998 990	- 33	1035 1023 1012	1
Stages during outflow	$ \begin{array}{c} \begin{array}{c} & \\ & \\ \\ \end{array} \end{array} \left\{ \begin{array}{c} Blanchard \\ beaches. \\ c_{1}, \ldots, c_{n}, \ldots, c_{n} \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ b \\ c_{n}, \ldots, c_{n} \\ c_{n}, \ldots, c_{n} \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ b \\ c_{n}, \ldots, c_{n} \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ b \\ c_{n}, \ldots, c_{n} \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ b \\ c_{n}, \ldots, c_{n} \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ b \\ c_{n}, \ldots, c_{n} \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ b \\ c_{n}, \ldots, c_{n} \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ b \\ c_{n}, \ldots, c_{n} \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ b \\ c_{n}, \ldots, c_{n} \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ c \\ c \\ c \\ c \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ c \\ c \\ c \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ c \\ c \\ c \\ c \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ c \\ c \\ c \\ c \\ c \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ c \\ c \\ c \\ c \\ c \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ c \\ c \\ c \\ c \\ c \\ c \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ c \\ c \\ c \\ c \\ c \\ c \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ c \\ c \\ c \\ c \\ c \\ c \\ \end{array} \right\} \left\{ \begin{array}{c} a \\ c \\$		(945)* (935) (925) (915) (882' (860) (840) (822) (810) (795) (755)	950 940 928 918	(5) (5) (3) (3)	960 948 935 923 890 865 845 827	(13) (10) (8) (8) (5)	960 947 935 902 877 857 837 822	(22) (20) (20) (17) (17) (15)	980 965 965 920 920 920 920 920 920 920 920 920 920	

⁴⁵ Figures in parentheses in the first column give approximately the elevations which stages of the lake during its outflow northward would have had at Lake Traverse, if the there had been low enough to permit the lake to extend south to its former outlet. From estimated elevations the northward accents of these stages, also in parentheses, are oken so as to be directly compared with the northward accents of the beaches that were formed in the lake outflowed southward, showing the changes which were gradually taking place in levels of the beaches of Lake Agaasiz during the whole time of its existence.

(F+44. distances abou entire distance is a third of a f for per mile in sightly reduce is 160 feet. 1 between the N of the lake leve 25 feet on the 1 Tintah stage a distances from same distances feet, in total 90 and 28 feet, in about 5, 10, 15 Warren from th end of which th vertical distanc of Gladstone 1 attributable to level on account of northward as outhern part o iches per mile From the tin outflow of Lake northeastward c how a descent Niverville beach fice remained, Winnipeg. The putlet decreases samined north opproximately f outh to Lake ? but 50 feet to love the level of tiles from Lake Vinnipeg. The e lowest McCa outhward, and bove the presen

LEVELS OF THE DEACHES.

Bances about 25, 35, 55, and 70 feet, amounting to 185 feet in the entire distance of 308 miles. In the most southern quarter its ascent sathird of a foot per mile, and this gradually increases to nearly one for per mile in the most northern quarter. These rates of ascent are lightly reduced in the second Norcross stage, where the total ascent is 160 feet. While the outlet was being eroded probably five feet teween the Norcross stages, the combined rise of the land and decline Northward athe lake level were about 10 feet on the international boundary and Average Breet on the latitude of Gladstone. The lake shore belonging to the bell, and eCanleyvlile Entah stage a ascends about 20, 30, 40, and 45 feet in the successive shere lines. stances from south to north, amounting in total to 135 feet; in the ame distances the Campbell a shore ascends about 10, 15, 30, and 35 iet, in total 90 feet; the McCauleyville a shore ascends about 7, 10, 20, and 28 feet, in total 65 feet; and the McCauleyville b shore ascends dout 5, 10, 15 and 22 feet, in total 52 feet. The erosion of the River Warren from the Norcross a stage to the McCauleyville b stage, at the ed of which the southward outflow ceased, was about 70 feet; but the rertical distance between the shore lines of these stages on the latitude f Gladstone is about 200 feet, the difference of 130 feet being aribitable to the northward rise of the land and the fall of the lake relon account of the diminished attraction of the ice-sheet. The rate therthward ascent is reduced to less than an inch per mile along the outhern part of the lowest McCaulevville shore, and to three or four thesper mile along its northern part, the average being two inches. from the time of this lowest beach formed during the southward aflow of Lake Agassiz to the time of the first beach formed during its ortheastward outflow, the lake fell only about 15 feet. Thence there now a descent, on the latitude of Gladstone, of about 220 feet to the liverville beach, below which Lake Agassiz, while its northern barrier fice remained, fell about 45 feet more before it was reduced to Lake Tinnipeg. The northward ascent of these shore lines of northeastward Northward ulet decreases only very slightly in the distance of 75 or 80 miles ascent of of the samined north of the international boundary, the change being formed during proximately from 20 feet to 15 feet or less, that is, to the rate of lludson Bay. bont two inches per mile. If these stages of the lake had reached outh to Lake Traverse, they would probably show a decrease from but 50 feet to 25 feet or only 20 feet in their total northward ascent

love the level of the present time along the distance of more than 300 iles from Lake Truverse to the south ends of Lakes Manitoba and innipeg. The whole descent on the latitude of Gladstone, between e lowest McCauleyville beach, where Lake Agassiz ceased to outflow unhward, and the original level of Lake Winnipeg, about 20 feet bive the present surface of that lake, is about 280 feet, of which

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homolary. 24 mile north of Lake Travers

North ascent from Lake Traverse Fret above the sea. I t corts

167 1212 162 1315 25 1205 155 1295 24

1190 145 1275 1180

1145 115 1215 18

135 1255

130 1245 2

105 1185 1

90 1150 1

S0 1120 1

55 1080

50 1070

42 1055

 $\begin{array}{c} 37 & 1035 \\ 33 & 1023 \\ 30 & 1012 \end{array}$

995

953

Feel above the sea

1230 175 1222

1175

1130

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975 (30) 5)

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0 1080

(8) (8) 935 (20) 902 (20) 920 \$95 5 877 (17) 857 (17) 575 (5)837 (15) 855 (12) \$40 822 805 (10) \$20 775 the elevations which ake Traverse, if the ormer outlet. Fromth parentheses, are obtain es that were formed lually taking place in

stence.

probably 25 or 30 feet may be due to the northward rise of the land and diminution of gravitation toward the ice-sheet, while about 250 feet are due to the gradual lowering of Lake Agassiz by its successive outlets to Hudson Bay.

The depth of Lake Agassiz above the present surface of the soul successive The depth of Lake Winnipeg was about 600 feet during its higher Herman

Agassizatione end of Lance of the upper Norcross stage, 440 feet at the upper Tintah stage, 370 feet at the upper Campbell stage, and 325 feet and 300 feet in the upper and lower McCauleyville stages, being this reduced to half of its earlier depth before it ceased to flow to the south During the lower stages of outflow to the northeast, the depth of Lake Agassiz above Lake Winnipeg decreased to 285 feet at the upper Blanchard stage, about 240 feet at the time of the Hillsboro beach, 216 feet in the Emerado stage, and successively about 185, 165, 145, 156 110, and 65 feet in the Ojata, Gladstone, Burnside, Ossowa, Stonewall and Niverville stages. By nearly proportionate gradations the areas Lake Agassiz was diminished through these successive stages, having when the outflow to Hudson Bay began probably about half of its maximum extent attained during the formation of the Herman beaches

Exploration of the beaches formed on the east side of Lake Agasi

Proportionate decrease in area.

Comparison with the eastern shore nes in Minnesota

has been mostly limited to Minnesota, because the eastern part of the lake area in Manitoba is covered by forest and is almost wholly without settlements or roads, so that for the present a survey of the shore line there is impracticable. For the same reasons the upper shores Minnesota have not been exactly traced east of Maple Lake, which is twenty miles east-southeast of Crookston. Within the prairie are across which the highest eastern shore has been surveyed and is elevation determined by levelling, its northward ascent is about 11 feet in 140 miles, from 1.055 feet above sea at Lake Traverse to 1.5 feet at the north side of Maple Lake. As on the western shore of Lak Agassiz, the rate of ascent gradually increases from south to north ranging from six inches to one foot per mile in its southern portion about 75 miles, and from one foot to sixteen inches per mile farthe north. Before the lake in Minnesota had fallen below its highe eastern beach in the south half of its explored extent, the rise of the land and diminished attraction of the waning ice-sheet had caused slightly lower parallel beach, three fourths of a mile to one and a h miles distant, to be formed through the northern third of Clay Country and this secondary beach, sometimes double or treble, is observable several places along the next 30 miles northward. At the northwa side of Maple Lake definite beach ridges belonging to the Herm stages of Lake Agassiz lie successively about 8, 15, 30, and 45 fe below its highest beach. Yet all these shore lines were formed white stent of approx

the relative h with only sl secondary hen from Lake Tr have been exp of 140 miles, about 65 feet averaging neu accents of th Minnesota, and lake during it pearly as on th of the western feature of the to east similar diminishing in on the latitude Herman stage 3 teet in abou very nearly ha llerman -tage-Norcross shore let in about GC aly three or fe hese stages app le north. Th orthward, in 1 Wahpeton and Agassiz, the asc 5 miles; at the the outlet, it is 50 miles north These observa ad east shores, ad surfaces of 1 absequent time scent from sou that greater th ae north course ne foot per mile ot to sixteen in evel which in it

d rise of the land , while about 250 by its successive

face of the south is higher Herman feet at the upper , and 325 feet and tages, being thus flow to the south. the depth of Lake feet at the upper illsboro beach, 216 185, 165, 145, 136 **)**ssowa, Stonewall, dations the area of sive stages, having · about half of its e Herman beaches lo of Lake Agasia astem part of the iost wholly with y of the shore line e upper shores i do Lake, which it n the prairie are surveyed and in scent is about 11 e Traverse to Ll? stern shore of Lak om south to north outhern portion h es per mile fartle below its higher ont, the rise of the -sheet had caused le to one and a hi ird of Clay County de, is observables At the northwe ng to the Herma 15, 30, and 45 fe were formed whi

LEVELS OF THE BEACHES.

de relative heights of the land and the lake continued stationary or with only slight change, not sufficient for the formation of any secondary beach ridge, along a distance of some 75 miles northward from Lake Traverse and Herman. The Norcross beaches in Minnesota have been explored and their height measured through the same extent #140 miles, in which the upper Norcross beach ascends northward shout 65 feet by a slope that increases slightly from south to north, averaging nearly six inches per mile. In like manner the northward acents of the Tintah, Campbell, and McCauleyville beaches in gianesota, and of the lower beaches formed on this east side of the lake during its outflow to the northeast, show a gradual decrease nearly as on the west in North Dakota and Manitoba. But comparison of the western and eastern shores reveals another very interesting The eastern the fature of the levels of this glacial lake, namely, an ascent from west western shore to east similar to that from south to north, but of less amount and lines. iminishing in a similar ratio between the successive stages of the lake. on the latitude of Larimore and Grand Forks the ascent of the highest lleman stage of Lake Agassiz above a line now level is approximately steet in about 70 miles from west to east, the rate per mile being terv nearly half as much as from south to north; and in the later flerman stages it is diminished to about 30, 25, and 20 feet. On the Vorcross shore lines this ascent toward the east is approximately 10 in about 60 miles, and it is reduced in the McCanleyville stages to my three or four feet in about 50 miles ; yet it continues through all dese stages approximately half as much per mile as the ascent toward le north. The rate of ascent eastward also increases, like that onhward, in proceeding from south to north. At the latitude of Valueton and Breckenridge, 35 miles north from the mouth of Lake gassiz, the ascent of its highest stage is 10 feet from west to east in Smiles; at the latitude of Fargo and Moorhead, 75 miles north from beoutlet, it is 15 feet in 50 miles; and at the latitude of thrand Forks, immles north from the outlet, it is 33 feet in 70 miles.

These observations, with those of the northward ascent of the west ad east shores, indicate that the changes in the relations of the land ad surfaces of level during the existence of Lake Agassiz and through absequent time have given to the former levels of this glacial lake an cent from south-southwest to north-northeast, its rate being somethat greater than that noted in following the shores in their nearly ne north course. The maximum rates of northward ascent of about Maximum te foot per mile observed in North Dakota and Manitoba, and of one ascent of the stages of Lake of to sixteen inches per mile in Minnesota, therefore belong to a lake Agassiz loward vel which in its northern portion differs from the present level by an northeast. cent of approximately one and a half feet per mile toward the north-

Chauges in relative elevations nearly or quite completed during the existence of Lake Agassiz.

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northeast. Similar north-northeastward ascent continues through the successive lower stages of the lake, in which its amount north of the international boundary is reduced to about four inches per mile at the lowest stage of southward outflow; and probably it was not more than two inches per mile when the course of the Nelson River was uneor. ered by the receding ice-sheet.

Nearly the entire amount of the changes in the levels of the beaches of Lake Agassiz was evidently contemporaneous with the existence of this lake, taking place gradually, but apparently progressing comparatively fast between the stages marked by the formation of definite beaches, which doubtless belong to times when these changes advanced very slowly or were interrupted by intervals of repose. Great as were these modifications of the geoid surface of level, causing a differential uplift of the highest western shore of the lake in Manitoba to the extent of 175 feet at the international boundary, 265 feet at the latitude of Gladstone, and about 400 feet at latitude 51°52' on the east side of Duck Mountain, 200 miles north of the international boundary, in the relation of the land to the water level, as compared with the vicinity of Lake Traverse, they were yet almost or perhaps quite complete before the ice-sheet was so far withdrawn that it was no longers barrier to prevent free drainage from the basin of the Red River and Lake Winnipeg. During the subsequent postglacial epoch, to the present time, only very slight changes, or possibly none, have take place in the relative elevations of the part of this area where the beaches of Lake Agassiz have been traced with levelling in Minnesota North Dakota, and Manitoba; and if there have been such small pos glacial changes, they were merely a continuation of the geoid more ments which accompanied the recession of the ice-sheet and a recorded by the successive shore lines of this lake,

the great plains,

Further important evidence is supplied by this survey of the beach Relation to the of Lake Agassiz in respect to the limitation in time and in area of the protection and of the Cordillera region, comprising the Rocky and Sier region and of Nevada Mountaine, and of the cordillara to the second Nevada Mountains, and of the great plains which stretch from the Rocky Mountains east to the border of the Red River Valley. It somewhat higher elevation of the eastern than of the western sha lines of this lake proves that its area during the recession of their sheet of the last glacial epoch and since then has not participated this extensive uplift, which increases from east to west across a plains. Prof. Joseph Le Conte has shown that the Sierra Neva range and other portions of the Cordillera region obtained agree part of their elevation within the glacial period; * and Pro

Chamber Missis-ip interglac plain- be received compariwestern u ice-heet.

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Conside leaches, r area exan through t pre-ent ge these chan toward the shore lines straction fa great o north in iminished portion of roceeded Ind-on Bar origid tha aised when onsist chie. lifferential lese chang letion duri is hypothe oth the eas 40 miles the om -outh derable in at is, of no the seem to

sixth annual declogical and logical Survey Similar oscillar in thus ascribed aste and Time suphischen Ge

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^{*} American Journal of Science, 111, vol. xix, pp. 176-100, March, 1880; and vol. xxii, 167-181, Sept., 1886. Compare also J. S. Diller's observations on the time of the uplifting faulting which produced the Sierra Nevada, Eighth annual report of the U.S. Geolar Survey, pp. 428-432.

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ontinues through the amount north of the iches per mile at the it was not more than on River was uncor. J-42.11.

levels of the beaches with the existence of ly progressing comformation of definite iese changes advanced epose. Great as were causing a differential e in Manitoba to the 265 feet at the latitude '52' on the east side of ional boundary, in the ared with the vicinity rhaps quite completed at it was no longers of the Red River and tglacial epoch, to the sibly none, have taken of this area where the levelling in Minnesota e been such small pos ion of the geoid move the ice-sheet and a ke.

the Rocky and Sier which stretch from the ed River Valley. Th he recession of the is has not participateli ast to west across t at the Sierra Neva egion obtained a gre period; * and Pro

larch, 1880; and vol. xxsila the time of the uplifting report of the U.S. Geoleg

LEVELS OF THE BEACHES.

chamberlin and Salisbury conclude that the upper portion of the gisissippi basin was raised 800 or 1000 feet during the principal interglacial epoch.* Simultaneously with these movements, the plains between Lake Agassiz and the Rocky Mountains doubtless received a considerable part of their slope of ascent westward; but opparison of the opposite shores of Lake Agassiz indicates that the western uplift was probably completed before the departure of the last ice-heet.

Consideration of the character of the changes in the levels of the eaches, resulting in a greater ascent upon the northern part of the area examined than farther south, and gradually approximating grough the successive stages of the lake to parallelism with the me-ent geoid surface of level, led me in my earlier studies to attribute hese changes almost wholly to gravitation of the water of the lake these changes almost where to generate the present relations of the old Gravitation of overall the ice-sheet. The cause of the present relations of the old Gravitation of the lines seemed to be discovered in the explanation that at first this the ice-sheet, graction had a large effect upon the lake level because of the nearness the changes in traction had a large effect upon the lake level because of the nearness the changes of the second gagreat depth of ice on the east in northern Minnesota and on the beaches. orth in British America, but that afterward it was gradually iminished to a comparatively small influence when the southern ortion of the ice-sheet had been melted and the attracting force proceeded from the region far north between Lake Winnipeg and ladson Bay, † Under this view the earth's crust was believed to be origid that it was not depressed by the vast weight of the ice nor nised when relieved of that weight, and the changes were believed to musist chiefly in the differential subsidence of the lake level, not in the interential elevation of the land basin." The general uniformity of lese changes in their direction and extent, and their probable comation during the departure of the ice-sheet seemed to accord with s survey of the bench all hypothesis. The exact comparison of the shore lines observed on time and in area of the oth the east and west sides of the lake, extending for its upper stages miles from south to north in Minnesota and more than 300 miles on south to north in North Dakota and Manitoba, shows no condetable irregularity in the rates of northward and eastward ascent, n of the western short at is, of north-northeastward ascent of the former lake levels, which is seem to be attributable to gravitation toward the waning ice-sheet, ther than to a progressive elevation of the land, for that would be

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Syth annual report of the U.S. Geological Survey, p. 314.

Geological and Natural History Survey of Minnesota, Eleventh annual report, p. 152; U. S. decical Survey, Bulletin No. 39, p. 18.

similar oscillations in the relative heights of sea and land, associated with glaciation, have achasa-cribed to ico-attraction by Adhemar, in Révolutions do la Mer, 1840; by Croll, in arte and Time, 1875; and by Penek, in Schwankungen des Meeresspiegels, Jahrbuch der staphischen Gesellschaft zu Munchen, bd. vii, 1882.

expected to present noteworthy irregularities upon so large an area. It is probable, however, that close scrutiny of the shore lines will disclose small divergencies, within limits of a few feet, from the uniformity of slopes which they should have for agreement with this explanation: and it is to be noticed that the highest shores in the vicinity of Treherne, Brandon, and Neepawa have more nearly a northward than north-northeastward ascent, also that a slightly disproportionate increase in the ascent of the highest Minnesota shore line in the next ten or fifteen miles north of the Bnffalo River was ascribed to the proximity of a portion of the ice-sheet on the east, where it was forming the Fergus Falls and Leaf Hills moraines. Though it now appears true that the greater part of these changes of level are due to the differential rise of the land, the gravitation of the lake toward the ice sheet certainly operated in conjunction with that cause, contributing to the full extent of its competency in producing the results observed.

Mathematical ice attraction. Woodward.

Mr. R. S. Woodward, of the United States Geological Survey, has investigation of worked out the mathematical problem of determining the effect of any added mass, as an ice-sheet, upon the earth's surface, to disturb the levels of the sea and of lakes,* Assuming an ice-sheet with a rada extent of 38°, or about 2,600 miles, and a central depth of 10,000 feet from which the depth decreases at first slowly and then more rapid to its border, he finds that the average slope within one degree of the border of the ice would be about five inches per mile, or less than on third of the north-northeastward ascent of the highest shore lines Lake Aga-siz in the north part of the area where they have been explored. Comparing the premises in this problem with the probability conditions affecting this glacial lake, it seems sure that the Nor American ice-sheet in its maximum extent during the last glaci epoch covered not more than one fourth so great area, its extent bein equivalent to a spherical circle with radius of 1,000 miles, or at the ma 1.300 miles; but, on the other hand, it is probable that the maximu depth of this ice-sheet somewhat exceeded 10,000 feet, and that t area of this great depth was a belt extending eastward from a fi hundred miles north or northeast of the south part of Lake Agassiz a distance of about 1.000 miles east-northeast, lying thus much near than in the assumed case of Mr. Woodward's investigation. The small area and less total mass of the ice-sheet attracting Lake Agassizm have been offset by the nearer position of a large part of its mass h in the assumption of the problem, so that possibly its influence mi

> * U. S. Geological Survey, Sixth annual report, pp. 201-300; and Hulletin No. 4, " Form and Position of the Sea Level." Compare also Prof. Edward Hull's computations." the Effect of Continental Lands in altering the Level of the adjoining Oceans," Ged Magazine, Dec. III, vol. v, pp. 113-115, March, 1888.

bea- great in the present t gravitation of highest shore at the most in ttains a max his belongs t eet per mile. erels of the be emaining three outh to north, the earth's i Among the c he land on wh e earth's erns arming and e operficial porti emperature of els situated r aring the tim etemperature ezing point. a av have atfect einfluence of geotherms, w e land surfac merature of at Lake Tr teian waters terior, In lil perticial portio 32°, at which ding the ice, t the temperatu ter permeatin ceed 15° from in of Lake A tison County, amount at W

Geological and Nati C. A. Schott in Smit as of the l'nited tha for 1882, p. 318

LEVELS OF THE BEACHES.

arge an area. It ines will disclose the uniformity of this explanation; the vicinity of a northward than disproportionate e line in the next is ascribed to the vhere it was form. igh it now appears el are due to the ike toward the ice ise, contributing to esults observed. ogical Survey, has ng the effect of any face, to disturb the sheet with a radial lepth of 10,000 feet d then more rapid in one degree of th ile, or less than on ghest -hore lines ere they have been m with the probabl ure that the North ing the last glaci rea, its extent bein miles, or at the ma e that the maximu) feet, and that t astward from a fe t of Lake Agassiz ng thus much near gation. The small g Lake Agassizm part of it- mass th its influence mi

Let a great in producing an ascent of the lake level above the level of the present time; but, if this mathematical investigation is reliable, grivitation of the lake toward its ice-barrier could not give to its lights shore a northward ascent of more than a few inches per mile, at the most not so much as half a foot, whereas its observed ascent rains a maximum rate of one foot to sixteen inches per mile, and his belongs to a north-northeastward ascent of fully one and a half kelper mile. A quarter part, or perhaps less, of the changes in the reds of the beaches is therefore referable to ice attraction; while the maining three quarters, amounting to about 130 to 300 feet, from out to north, in western Manitoba, belongs to differential elevation (the earth's crust.

Among the conditions producing changes in the height and slopes of Effect of he hand on which Lake Agassiz lay are the cooling and contraction of temperature of be earth's crust by the ice-sheet and glacial waters, and the subsequent the earth' arming and expansion owing to the amelioration of the climate. The the ice-sheet. perficial portion of the earth's crust in the Red River Valley has a mperature of 47° to 42° Fahrenheit, as shown by the water of artesian al situated respectively at Ada and Donaldson, Minnesota,* But ging the time when this district was covered by the ice-sheet, etemperature of the underlying land surface was reduced to the reging point, 32° Fahrenheit, and a similar lowering of temperature a have affected the crust to a considerable depth. largely through einfluence of percolating water, eausing a slight depression of the geotherms, with consequent contraction of the rocks and loworing of e land surface. By comparison with the present mean annual aperature of the Red River Valley, ranging approximately from at Lake Traverse to 33° at Winnipeg,† it is evident that the usian waters before noted receive part of their heat from the earth's erior. In like manner probably the interior heat kept the pericial portion of the earth's crust beneath the ice-sheet as warm 32°, at which temperature the earth's heat would be continually thing the ice, though doubtless at a very slow rate. The differences the temperatures of the earth's crust, due to the ice-sheet and to ter permeating downward from it, would not therefore probably reed 15° from that of the present time in the southern part of the in of Lake Agassiz, and would decrease to 10° at Donaldson in tion County, the most northwestern in Minnesota, and to even a amount at Winnipeg. The extent to which these slight changes

id Bulletin No. 45, "15 I Hull's computations," joining Oceans," Ged 99 в

Geological and Natural History Survey of Minnesota, Eleventh annual report, pp. 147, 148. C.A.Schott in Smithsonian Contributions to Knowledge, vol. xxi, 1576; Atlas of the Tenth as of the United States; Report of the Department of Agriculture and Statistics of msha for 1832, p. 318.

in the crustal temperatures would depress the land while it was ited covered and raise it when the ice was withdrawn depends on the ratios of contraction and expansion of the underlying rocks. These ratios have been experimentally determined in the case of various building stones, and computations therefrom indicate that only a very small amount of sub-idence and elevation of the land could be cause in this way.* The total elevation so produced was probably not more than fifty feet in the southern part of the Red River Valley and na more than thirty feet at Winnipeg, and its slight differential effer would be in the opposite direction to that which has given to the beach of Lake Agassiz their northward ascent. This element in the causalia of the changes of elevation appears to be comparatively insignificant in itself, and its small component in the oscillation of the shore line would be opposed to that for which we are seeking an explanation.

Probable de secent of the beaches upon the departure of the icesheet.

100 E

It seems to be very clearly indicated, however, by the grada pendence of the diminution in the northward ascent of the beaches until the lowest an northward latest have nearly the level of the present time, that these progressi changes of elevation were directly dependent upon the departure of the ice-sheet, with which great geologic event they were contemporaneou As already noted, these changes were so directly proportionate with the glacial recession that the northward ascents of the successi beaches were at first referred to the diminishing gravitation of the la toward the ice-sheet; but, apart from the inadequaey of this can determined by Mr. Woodward's investigations, the great extent of a highest beach and its relation to terminal moraines marking stages the glacial recession sufficiently demonstrate that other causes com buted even more than ice attraction to produce the changes obser in the levels of the beaches. In the discussion of this subject to presented in the monograph of Lake Agassiz for the United Sa Geological Survey, there remain to be considered, as probable can first, the relationship between the earth's crust and its interior whi may have permitted a sinking of the crust beneath the vast weight the ice-sheet and a re-elevation when that weight was removed, a second, oscillations which may have occurred without dependence the glaciation. For the discrimination of these movements, it will very instructive to notice the changes of elevation that have h going forward at the same time in other parts of the North Amen and European glaciated regions, and also in various areas which never thus ice-laden. If Lake Agassiz is found to be an inst where nearly all these changes are apparently referable to glacia there will be no lack of opportunity for comparing it with

> *T. C. Chamberlin in Sixth annual report, U.S. Geol. Survey, p. 302, and in paper read the Philosophical Society, Washington, March 13, 1886 : G. K. Gilbert, in Am. Jour. Sci vol. xxxi, p. 297, April, 1886.

regions where dent crustal n

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RECORDS OF WELLS.

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regions where the effects due to glaciation are combined with indepentent crustal movements. *

RECORDS OF WELLS.

The following notes of common wells in various parts of Manitoba how in considerable detail the character and order of the drift deposits, all in a few instances of the underlying rock formations. Nearly retywhere an ample supply of good water, permanent throughout the ear, is found at a moderate depth. In the Red River Valley and restward it usually is hard water, us is also the water of springs and treams, containing so much dissolved earbonate of lime that it cannot eusel satisfactorily for washing with soap. For this use rain water commonly collected from the roofs. When this is stored in large steins, it is more desirable also for drinking and cooking than the ten somewhat alkaline well water, which, however, is seldom found the injurions to health.

But wooden well-curbing, commonly pine, which has been often used wells often But wooden well-curbing, commonly pine, which has been often used wells often this region, soon contaminatos the water, especially if it is notably by decay this region, soon contaminatos the water, especially if it is notably by decay this region, soon contaminatos the water, especially if it is notably by decay this region, soon contaminatos the water, especially if it is notably by decay this region, soon contaminatos the water is not be drawn from curbing. Eddy, the water becomes too foul in smell and taste to be drank, en by cattle, and it may be the cause of sickness before reaching this are. If bricks, stone, or iron or coment pipe are used for lining wells. If the water in them is frequently renewed by being largely drawn on, it is entirely wholesome and palatable, and is well adapted for arly all uses, excepting for washing with soap, as before mentioned, of or steam-boilers, in which the large amount of scale deposited whit in evaporation is objectionable.

Artesian or flowing wells are obtained near the Red River, as in Artesian wolls. Winnipeg and southward, whore water often rises to the surface m layers of sund and gravel in the drift.

Winnipeg. About forty wells have been bored by the city anthorisof Winnipeg for supplying water for domestic use. Mr. H. N. ttan, the city ongineer, states that about a dozen of these wells go to the bed-rock, which is limestone, while the others derive their ter from layers of quicksand in or beneath the till. Several of them the west part of the city are artosian, but eastward the water rises by to five or ten feet below the surface. The water is considered of edquality for drinking and cooking, but it contains much mineral tter in solution, chiefly the sulphates of lime and magnesia.

302, and in paper reads thert, in Am. Jour. Sc.

These Quaternary changes of level have been partly considered in a paper on the "Probable well Glaciation," forming an appendix of Prof. G. F. Wright's Lee Age in North America,

Attuvial and drift deposite.

Character of the till.

Underlying limestone. 102 E

Alluvial stratified clay extends to a depth that varies from three to ten feet or more. This is underlain by the glacial till or boulder-clay, which encloses thin veins and layers of fine gravel and sand, and frequently is underlain by sand and gravel, but in many places extends to the limestone. The upper part of the till here shows an imperfect stratification, due to its deposition in Lake Agassiz, and contains a less proportion of boulders and gravel than its lower part, which is very hard, and is therefore commonly denominated "hard pan." The depth to the limestone varies from thirty to sixty feet in the west part of the city, and increases to about seventy-tive feet eastward.

One of these wells, bored in the west edge of the city, close north a the Assiniboine and one and a half miles west of the Osborne stree bridge, went 32 feet in stratified clay and till, and then 100 feet is limestone, mostly of light buff or cream color, obtaining water of god quality at 132 feet, which rose to five feet below the surface. The bed-rock is nearly like that which outcrops at Lower Fort Garry and East Selkirk.

General section of superficial deposits at Winnipeg.

A general section of the superficial deposits at Winnipeg is noted by J. Hoyes Panton as follows, from information supplied by Mr. Piper known as having an extensive experience in well-boring through the city.

"1. Surface mould, one to four feet, dark color, and exceeding fertile.

"2. 'Yellow gumbo,' two to three feet, a very sticky form of yellow ish clay, which usually holds considerable water.

"3. Dark gray elay, thirty to fifty feet thick, with boulders scatten throughout; some of them four feet in diameter, and chiefly gneissä and no doubt derived from Laurentian rocks.

"4. Light-colored clay, one to three feet, containing many sma stones.

"5. Hard pan, two to ten feet, a very solid and compact form, elay.

" G. Sand, gravel, and boulders, five to twenty-five feet.

"7. Angular fragments, one to three feet, usually limestone, a largely derived from the solid rock which lies immediately below it.

"This loose material is far from being uniform, and varies so main its arrangements that scarcely any two borings show the same it tribution. Sometimes there is little or no hard pan, while in our parts it is several feet thick. However, as a usual thing, these set forms of strata are passed through in boring, and varying in thickness to the number of feet already mentioned."*

* Report of the Department of Agriculture and Statistics, Manitoba, for 1882, p. 176.

Saint Bon Winnipeg, O on the Exhi-36 feet, its lo bedrock at

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Neerville, and till; wan bis village bed-rock; ba of about 100 Four miles this same T. ' ville beach, p shale, 30 feet, In the S. W Freesen has a into the shale, wells in this M 107 feet.

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RECORDS OF WELLS.

Sum Boniface. Wells in St. Bonifaco are nearly the same as in Winnipeg, on the opposite side of the river. The deepest learned of is on the Exhibition Ground, 156 feet deep, being stratified elay and till, 36 feet, its lowest 10 feet very hard and compact; sand, 44 feet, to the helrock at S0 feet; then limestone, of light eream color or nearly white, penetrated 76 feet and extending below.

<u>y</u>_{iccreille}. Thomas W. Craven, hotel; well, 65 feet deep, in alluvium and till; water rises to fifteen feet below the surface. Other wells in this village have nearly the same depth or less, none coming to the bel-rock; but it was reached by a well a third of a mile east at a depth of about 100 feet.

Four miles sonth-sontheast of Niverville, in the N. E. ‡ of sec. 5 in his same T. 7, R. 4 E., Cornelius Freesen's well, situated on the Niverville beach, passed through alluvium and glacial drift, 65 feet, and spale, 30 feet, obtaining an ample artesian flow of excellent water.

In the S. W. $\frac{1}{4}$ of this section, a half mile from the foregoing, Adam Flowing wells freesen has a similar flowing well, 107 feet deep, which went 37 feet monite Reserve into the shale. This is said to be the deepest of about twenty flowing Red River, wells in this Mennonite Reserve, their range of depth being from 40 to 107 feet.

Dominion City. James Spence, Victoria Flour Mills: flowing well, for feet deep, in alluviat clay and till, the latter very hard below the depth of 120 feet; bed-rock not reached; water brackish, flowing feely, not used.

The common wells of this trange, 12 to 16 feet deep, have good water which seeps from the alluvial elay.

The Rosean River has much softer water than the wells and most of Soft water of the Roseau. the Roseau the short streams of this region, so that the railway tank at Dominion By taking water from the Roseau, is preferred by the locomotive engineers above any other source of water on this branch line.

Emerson. Wells in Emerson range from 10 to 25 feet in depth, in fluvial clay, and obtain water tolerably good for drinking and cookbg bat it is very hard and unsuited for laundry use.

West Lynne. Hudson Bay Company's steam flouring mill: well, 108 ket deep; dug 68 feet in alluvial and lacustrine clay, and bored 40 feet wer, apparently in the same deposit. The only water found, not wough to supply the engine, is that which seeps from the clay, coming limit wholly within the first twenty feet below the surface. The clinary wells in this village, 14 to 18 feet deep, obtain good water reping in sufficient amount for domestic use.

Artesian wells near Letellier and on the Low farm. An artesian well Brackish the French Reserve at the center of T. 2, R. 1 E., near Letellier, wells of the why miles northwest from Emerson and West Lynne, is 250 feet Red River.

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deep, not reaching the bed-rock. It supplies brackish water, which is drank by eattle. Another artesian well of similar depth is on the L_{eqg} farm, about twelve miles west of Morris, the water of which is strongly saline.

West Selkirk. The well at the Lisgar House, 100 feet deep, reached the bed-rock, which is limestone, at 65 feet.

Stonewall. J. B. Rutherford's flouring mill: well, 82 feet deep, colsisting of bench gravel and sand, 10 feet; till, 2 feet; and limestone, including red shaly beds, 70 feet, to the bottom, where the drill [e] one foot and water rose immediately to 22 feet below the surface. Several other wells in Stonewall have had a similar experience, obtaining water which rises from hollows in the limestone.

T. 15 R. 2 E. William Andrew, S. E. $\frac{1}{2}$ of sec. 7: well, 94 feet deep; till at the surface and to a depth of 11 feet; and limestone, s3 feet, mostly hard and of light buff color, but enclosing some 25 feet of [ie], dish shaly beds between the depths of 45 and 70 feet. There are several such wells in the same vicinity.

Between Pleasant Home and Gimli. Mr. Andrew states that, about twenty-five miles northeast from the last, a well between Pleasant Home and Gimli has been sunk 120 feet, wholly in the glacial drift, not reaching the bed-rock.

Rosser. The railway well at Rosser is 29 feet deep, in till, which forms the surface there and east to Little Stony Mountain; water rises fifteen feet from a sandy layer at the bottom.

T. 11, R. 1 E. Robert D. Bathgate, sec. 27: well, 60 feet deep: fill, 24 feet, from which alkaline water seeps; and light buff, hard line stone, 36 feet, and continuing lower; water of good quality rises from the bottom to 20 feet below the surface. Other wells in this vicinity mostly get good water in veins or thin layers of sand and gravel contained in the till.

St. Francois Navier. On Mr. Nanton's ranch, about ten miles we of Headingly and a quarter of a mile south of the Assiniboine, a we 114 feet deep passed through alluvial clay, 14 feet; till, 34 feet: line stone of light cream color, 47 feet; and reddish limestone, 19 feet Brackish water rises from the bottom to 14 feet below the surface.

Meadow Lea, sec. 30, T. 13, R. 2. Wells in this vicinity range from 20 to 95 feet in depth, and are wholly in till, not reaching the bed-reaction of the sector of the sec

T. 13, R. 6. Charles Cuthbert, sec. 21, ten miles north-northead from Portage la Prairie: well, 16 feet deep: soil and loamy situ water in quicks and and fine gravel. The surface here is only a fe feet above the high water level of Lake Manitoba.

Portage la Prairie. The common wells are 12 to 16 feet deep, being orders, 46 feet black soil, 2 to 4 feet; then yellowish gray loamy silt, the allowing usedy 15 to 25 f

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of the Assiniboine, in which fragments of driftwood, as small limbs of mees, are occasionally found; to water in quicks and and fine gravel. The deepest well here is that of the Manitoba and Northwestern Railway tank, which reaches 30 feet, to till at the bottom, obtaining a very large supply of water.

T. 12. R. S. Kenneth McKenzie, jr., in the north edge of sec. 2, elese west of Rat Creek: well, dug 86 and bored 72 feet, to a total depth of 158 feet: soil, 2 feet; sand, 4 to 5 feet; yellow till, 4 feet; blue till, 76 feet, easy to excavate, with scanty intermixture of gravel, hat containing occasional stones up to one foot or more in diameter, indoubtedly true till, for the surface generally through the south part of this township has plentiful embedded boulders up to two or three feet in diameter; below was "hard pan," a more indurated deposit of fill very hard to dig or pick, bored or drilled 72 feet, and found to vary nuch in its husdness through this depth, some portions being much setter than where the boring began. A seam of sand and fine gravel, about an inch thick, was noticed between the upper part of the till, which was dry, and the harder lower portion. At the bottom the drill smek a harder layer, which was called rock. It was probably shale, of the drill, being dropped a few times upon it, seemed in danger of becoming stuck so that it could not be removed. Water rose from the bettom within the first day to a depth of 20 or 30 feet in the portion of the well that was dag; and within a few days it reached its permanent level about 20 feet below the surface. It does not sink below this level in dry seasons, but in wet seasons it rises to seven feet below the surface, near the bottom of the sand. It is somewhat salty, so that it's not suitable for house use; but it is drank freely, and with no ill effect, by horses and cattle during the entire winter.

A quarter of a mile south of this, Mr. McKenzie's father has a similar well as to its depth and succession of deposits passed through prock, but it obtains a less ample supply of water. Both wells are \$4 feet, approximately, above the sea; and the top of the bed-rock is coordingly about 706 feet above the sea level.

Gludstone. Wells vary from 10 to 15 feet in depth, in sandy fine . Water abundant and of excellent quality.

Anden. In the vicinity of Arden wells are 10 to 50 feet deep, the etion being till, excepting where this is overlain by beach deposits on 5 to 15 feet thick.

Necpura. John A. Davidson & Co., store: well, 60 feet, the deepest athe town; soil, 2 feet; gravel and sand of the Assiniboine delta, 12 let; and till, dark bluish, with the usual proportion of gravel and milders, 46 feet, and extending below; water good. Other wells, ustly 15 to 25 feet deep, reach till at nearly the same depth.

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T. 13, R. 16. The deepest wells in this township go 50 to 70 feet wholly in till; but commonly a sufficient upply of water is found within 30 feet or less.

Carborry. Wells 10 to 20 feet deep in ... , the Assiniboine delta: plenty of good water.

Chater. At the elevator, 42 feet, and at the hotel, 31 feet, wholly in till, yellowish above and dark bluish below; water rose several feet.

Brandon. Wells 10 to 30 feet deep, in delta gravel, underlain by till; good water.

Carman. Depths 10 to 15 feet, in alluvial elay with sundy layers, good water. Two miles sonth of Carman, James Stewart's and George E. Laidlaw's wells are respectively about 100 and 120 feet deep probably passing through the alluvial and lacustrine clays and glacial drift, to underlying Cretaceous shales. The water of the deeper of these is too brackish for house use, but is drank by cattle.

Treherne. In the vicinity of Treherne wells vary from 15 to 50 feet in depth, the section being beach and delta deposits of stratified gravel and sand; excellent water.

Holland, Wells at Holland are 10 to 20 feet deep, in till to shale which is reached at about 10 feet; water good, generally better from the shale than from the drift. Shale is not encountered by wels farther north, on the Assiniboine delta. In the adjoining Tiger Hills on the south, the depth to shale varies commonly from 2 or 3 to 10 ar 15 feet.

Cypress River and Glenboro. Depths 10 to 17 feet, in fine silt, the delta of the Assiniboine; water good, issning from quicksand.

T. S. R. 18. Rounthwaite post-office, sec. 14: well, 20 feet deep soil, 2 feet; yellowish gray till, 13 feet; harder blue till, 5 feet and lower; water seeps, plentiful and good.

T. 7, R. 17. Williamson, Dignum & Co., farmhouse in sec. 3: web dug 30 feet and bored 32 feet more; seen while the boring was it progress at depth of 62 feet; all till, mostly yellowish, to that depth This is half a mile north of the northern base of the Tiger Hills, an elevation of about 1,350 feet above the sea.

Lang's Valley. Langvale post-office, at James Lang's house, see 2 T. 6, R. 18: well, 18 feet deep : all gravel and sand, with quick-an at the bottom. This is on the bed of the channel of outflow to the Pembina from the glacial lake in the Souris basin.

Plum Creck. Wells in this village, at the junction of Plum Cree with the Souris, are 10 to 30 feet deep, in till, not reaching bed-rock but outcrops of the Fort Pierre shale occur on the Souris near by, Gretna. Common wells, 10 to 20 feet deep, in alluvial and lacustri

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ion of Plum Cree reaching bed-rock Souris near by. ryial and lacustris RECORDS OF WELLS.

elay, obtaining a scanty supply of water. A boring is said to have teen made here for the railway tank, to a depth of 150 feet, without finding a supply of water, and it is now pumped from the Pembina giver.

Rheinland. Wells 15 to 20 feet deep, in somewhat sandy heastrine day; excellent water.

 \tilde{T} 2. R. 5. John Johnston, see. 3: well, 22 feet; soil, 2 feet; yellowish till, containing boulders up to five feet in diameter, 20 feet; to gravel with water which rises from it two or three feet. This is letween the Campbell and Tintah beaches, on the low terrace at the foot of the Pembina Monntain escarpment. Other wells near show that this terrace consists of the Port Pierre shale, thinly covered with glacial drift.

Morden and Nelson. Wells 10 to 25 feet deep, in till; water frequently alkaline.

Thornhill. The wells of Thornhill and vicinity are S to 25 feet deep, their material being till, with sandy streaks from which water seeps. The till is yellowish to a depth of about 15 feet, and dark blush below. Shallow wells, stopping in the yellow till, have better water than those that pass into the blue till.

Darlingford. David Brown, S. E. $\frac{1}{4}$ of sec. 6, T. 3, R. 7: well, 30 feet; soil, 2 feet; till, 28 feet, its lowest six feet mostly débris of the Fort Pierre shale; to quicks and at the bottom, from which water rose in a few hours to 10 feet below the surface.

Manitou. Canadian Paeific Railway well, 175 feet deep, wholly in the Fort Pierre shales, excepting about five feet of soil and drift at the surface. The common wells are 20 to 30 feet deep, going into shale at 5 to 12 feet from the surface; water good.

Suint Leon, sees. 34 and 35, T. 4, R. 9. In this village wells are 10 to 15 feet deep, being till to a depth of 6 to 12 feet, and extending into shale below; water good. Other wells in the vicinity are 10 to 30 feet deep, reaching the shale usually less than 15 feet below the surface.

Mocbray, Snowplake, and Star Mound. Wells in this district, 'T. 1 of Rs. 8, 9, and 10, are commonly 15 to 30 feet deep, in till, or in many assessing several feet into the underlying Fort Pierre shale; good water is found in both formations.

Pilot Mound. In the village of Pilot Mound wells are 15 to 20 feet keep, commonly passing into the shale at ten feet; water good.

West of Pelican Lake. The deepest wells within a few miles southwest of Pelican Lake, on the nearly level expanse of till about 15th feet above this lake, often reach shale at 25 to 30 or 40 feet; but many get good water at 10 or 15 feet in the overlying till.

GEOLOGIC AND AGRICULTURAL RESOURCES.

The great fertility of the soil in this district, its water-power, the value of its timber for building purposes, manufactures, and fuel, of its stone for construction and lime-burning, and of its deposits of elay $f_{\rm br}$ brick-making, are its chief natural resources.

Solland subsoil.

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L. Over nearly the entire prairie portion of Manitoba, both in the lacustrine area of Lake Agassiz and upon the higher and more undulating or rolling country that stretches thence westward, a sandy clay, often with some intermixture of gravel and occasional boulders, forms the soil, which has been colored black to a depth of one or two feet below the surface by decaying vegetation. The alluvial and lacustrine beds, or the glacial drift, the same as the soil, excepting that they are not enriched and blackened by organic leeay, continue below, being usually yellowish gray to a depth of tenor fifteen feet, but darker and bluish beyond, as seen in wells. The glacial drift contains many fragments of Createcous shale, magnesian limestone, granites, and crystalline schists; and its fine detritus, and the silty deposits carried into Lake Agassiz by its tributaries, are mixtures of these rocks pulverized, presenting in the most advantageous proportions the mineral elements needed by growing plants.

Agricultural products Wheat has been the principal crop, but stock-raising and the dairy have also received much attention. A large variety of crops is profitably enlivated throughout the region, including wheat, one, gurden fruits and vegetables, potatoes, and hay. The natural prairie supplies rich pasturage for the herds of the first immigrants; but it is rapidly becoming mainly occupied by farms and brought undecultivation.

Water-power and manufactures. Valuable water-powers are available on many of the streams especially in the wooded northern and eastern portions of Manitola. The rapids and waterfulls of the Winnipeg River, with its magnificent reservoirs of the Lake of the Woods and Rainy Lake, besides a multitude of smaller lakes, will doubtless some day become the sites of large manufacturing cities, where the wheat of the prairies will be male into flour, and the timber of the adjoining forests will be manufacture into lumber, furniture, and various wooden wares. While agricultarwill be the lending occupation in the prairie region, more diverse industries will grow up in the wooded country on the east.

Even the prairie has important resources of fuel in its belts of timber.

which border streams and lakes, and also extend along the escarpment

of the Pembina Mountain and cover the Tiger Hills and Turte

Mountain. With the more full settlement of the prairie, however,

some systematic plan may be adopted for securing coal or wood by

Fuel.

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railway fro than now. Quarries

East Selkir partly for bridges, and mottled and much when newly quart drying no st in masonry. is mostly we The Volunte tion of this s situated clos of six or eight supplies of s of being quan Stony Mount Similar stone R.2 E., on la wall. The or 36. T. S. R. 1

The quarry years ago for to it from the at the time of bel-rock whit collecting and drift throughoriginally der enrents of the drift also con foundations of Nearly ever

are utilized in yards in Saint Winnipeg, probusiness began stripped off to fect of yellowis for brick-maki tempering. Th

URCES,

vater-power, the s, and fuel, of its posits of clay for 1+44.

ba, both in the igher and more estward, a sandy assional boulders. th of one or two the alluvial and il, excepting that y, continue below, on feet, but darker ift contains many nee, gratuites, and y deposits carriel es of these rocks proportions the

ing and the dairy dety of crops is ling wheat, oats, he natural prairie aigrants; but it is a brought under

of the streams, ions of Manitoba, ith its magnificent

 Lake, besides a ecome the sites of airies will be made 1 be manufacture!
 While agriculture ion, more diverse e east.

its belts of timber. ng the escarpment Hills and Turtle prairie, however. c coal or wood by GEOLOGIC AND AGRICULTURAL RESOURCES.

railway freight in large amounts, and therefore at much lower cost than now.

Quarries of magnesian limestone have been extensively worked at Quarried stone, East Selkirk, Stonewall, Stony Mountain, and Little Stony Mountain, partly for lime-burning, but also in large amount for foundations, bridges, and buildings. The East Selkirk stone, which is beautifully mottled and banded, is easy to cut when first quarried, but hardens much when its moisture dries out. It contains so much water that newly quarried blocks in winter are damaged by freezing ; but after drving no such frost fracture is observed where this rock has been used in masoury. By exposure many years the streaked contrast in color is mostly weathered out, the brown portions losing their darker color. The Volunteers' Monument in Winnipeg is a fine example of the adaption of this stone for ornamental purposes. The quarry at Stonewall, inated close east of the village, has been opened to an average depth fsix or eight feet on an area about fifteen rods square. Inexhaustible applies of stone of the most durable quality, in many portions capable of being quarried in blocks of large dimensions, outerop there and at Stony Mountain, and have been much used for building in Winnipeg. Similar stone has been slightly quarried on the N.E. 1 of sec. 4, T. 15, R 2 E., on land of Allen Bristow, nine miles north-northeast of Stonewall. The outcrop of Cretaceous limestone on the Assiniboine in sec.

32. T. S. R. 11, has also been quarried in small amount.

The quarry of Little Stony Mountain was actively operated several Lime, years ago for burning lime, a spur track about a mile long being laid wit from the Canadian Pacific Railway; but work had been suspended at the time of this survey in 1887. Besides the outcrops of the bel-rock which thus supply lime, it is conveniently obtained by collecting and burning limestone boulders that occur in the glacial drift throughout all the prairie district of Manitoba, having been originally derived from these rock-formations and distributed by the currents of the ice-sheet. The more abundant granitic boulders of the diff also commonly serve the immigrant for the construction of bundations of farm buildings and for the walls of cellars and wells. Nearly every part of the province also has beds of brick-elay, which Bricks. are utilized in proportion to the demands of settlement. Four brickvards in Saint Boniface, on the east side of the Red River opposite to Winnipeg, produced in total in 1887 about four million bricks. This business began to be extensively developed there in 1880. The soil is stripped off to a depth of two feet, beneath which the next two or three feet of yellowish, horizontally laminated, somewhat sandy clay is used for brick-making. It requires no further admixture of sand for tempering. The bricks, which are cream-colored and very durable, are

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ULACIAL LAKE AGASSIZ IN MANITOHA.

sold at \$11 to \$12 per thousand, loaded on the cars or delivered in the city of Winnipeg. Another brick-yard in Saint James, close southwest of Winnipeg, makes about 1,500,000 bricks yearly. The light cream color of these bricks, like those of Milwaukee and of most brick-yardin Wisconsin, Minnesota, and North Dakota, is due, as shown by President Chamberlin, to the calcareons and magnesian ingredients of these glacial clays derived in part from magnesian limestone formations, which unite with the iron ingredient to form a light-colored silicate. instead of the ferric oxide which in other regions destitute of magnesias limestone gives to bricks their usual red color.

The follow and Lake Su of the ice-sl country whe derived chieff Surveys of C the true or as the observati Minnesota by tolave been of

Hudson Str Cape do., Ashe's about do., Cape P to th do., south 1 do., Digges Ottawa Isla Bay.. East coast sively do., from Ca and ti lat. 58 side of it is probable t etlow during ring a somewh lting of the ice East coast of

entran entran mostly but in tion .. The light cream most brick-yard, e, as shown by in ingredients of stone formations, t-colored silicate, thte of magnesian

delivered in the close southwest

APPENDIX I.

COURSES OF GLACIAL STRLE.

The following table of glacial strike in the region of Hudson Bay and Lake Superior and westward shows the directions of the currents of the ice-sheet within the basin of Lake Agassiz and upon the centry where it lay as the barrier or dam of this lake. They are derived chiefly from the reports of the Geological and Natural History Surveys of Canada and of Minnesota, and are all reduced to refer to the tue or astronomic meridians. Unless they are otherwise credited, the observations in British America are by Dr. Robert Bell, and in Minnesota by the present writer. All are in the area that is supposed tohave been covered by the ice-sheet of the last glacial epoch.

Hudson Strait and Bay.

Hudson Strait, Port Burwell, ten miles southwest from	
Cape Chudleigh	S. 85° E.
do., Ashe's Inlet, on the north side of the strait,	S. 65° E.
do, Cape Prince of Wales, on the south side, opposite	1. 00 1.
to the last	E. to N. 70° E.
doa south part of Nottingham Island	S. S0° E.
do., Digges Island, off Cape Wolstenholmo	N. 55°-75° E.
Ottawa Islands, in the northeast part of Hudson	
Bay N. 75° E., N. 40°-20° E.	, and N. 5° W.
East coast of Hudson Bay, northern part, succes-	
sively, proceeding southward N. E.	, N. and N. W.

do, from Cape Dufferin southward to Hopewell Head

and the most northern of Nastapoka Islands, in

hat, 58° to 57° N., near the middle of the east side of Hudson Bay, numerous localities, S. 70° , 60° and 35° W.

It is probable that the first two of these courses record the direction of the edw during the time of maximum depth and area of the ice-sheet, or pring a somewhat later stage; and that the last belongs to the time of final eding of the ice.

East coast of Hudson Bay, thence southward to the

entrance of Richmond Gulf, nu	merous localities,
mostly between	S. 65°-75° W. and N. 75° W.,
but in two localities, probabl	y a later glacia-
tion	S. 35°-45° W.

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East, Cairn Monntain Island, Richmond Gulf, several	
localities, mostly N. 60°-70	w w
but in one place varying from this to	
do., from Richmond Gulf and Little Whale River	
southward to Esquimaux Harbor, many	
localitiesN. 80° W. to	s ur
do., thence to Red Head, fifty-seven miles northeast	5 m.
of Cape Jones, eight localities W. to S. 75	
and one locality S. 55	
do., Red Head Island N. 70	
do., thence southward to forty miles south of Big	. <i>н</i> .
River, many localities	
but on the southwest oxtremity of Long Island,	W.;
near Cape Jones, strike bear in every direction	
from S 70° W around but W and C Constant	
from) E.
The two prevailing directions are aboutS. 45° W. and S. 15	'E.;
the former being probably the older, but perhaps	
deflected to the south from the direction of the	
glacial current when the ice-sheet was thickest,	
and the latter, with further deflection sonth-	
eastward, belonging to the closing stages of the	
glacial period. An island off the southwest	
point of Long Island has three sets of glacial	
strike S. 60° W., S. 40° W., and S. 20	₽ E.
East coast of Hudson Bay, from forty miles south of	
Big River southward along the east coast of the	
south half of James Bay, many localities S. 30°-55°	W.;
but in one locality, about three miles northwest	
of the Paint Hills, three sets of glacial strike	
occur, bearing N. 75° W., S. 55° W., and S. 30°	W.
The first probably records approximately the course of	
glaciation here when the ice attained its greatest	
area, belonging thus to a striation which was	
chiefly effaced by a later glacial movement to	
the southwest during the departure of the ice-	
sheet. Again, at the Paint Hills, two sets of	
glacial strike are found, bearingS. 75° W. and S. 35-	<i>II</i> . •
and on Governor's Island, at the mouth of East-	····,
main River, the course is	w
Marble Island, northwest part of Hudson Bay S. 15°-25	
West coast of Hudson Bay, east side of the mouth of	E.
Churchill River	L.
do., two and a half miles east from the last	
do., five miles east from the month of Churchill	
	12
River	Ľ,

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Region

Churchill do., four 1 Riv do., six ar Chu Little Chr and Łak io., outlet fron do., Eagle the The courses of the ice-shee southerly cours Along the hune its r do., Broad mile also. do., thence do., Upper porti do., southw do., Chain-o Lake, the o do., on Gras the w localit but i (Stink do., between localit and or do., Sipi-wes mostly also, ii do., Sipi-wesl southw but in : do., southwes do., from Sip Lake, s

do., Pipestone localitie 8

APPENDIX I.

CHAY.

N. 60°-70° W., S 45° W.

. 80° W. to W.

V. to S. 75° W.,

60° and 70° W.;

S., to S. 40° E.

. and S. 15° E.;

7., and S. 20° E.

S. 30°-55° W.;

, and S. 30° W.

and S. 35- W.;

S. 75° W.

S. 5° E.

S. 15° E.

S. 20° W.

S. 15°-25° E.

S. 55° W.

N. 70° W.

Region of the Churchill and Nelson Rivers, Lake Winnipeg, and southwest to the Assimiboinc. Churchill River, at Fort Churchill..... S. 30°-40° W. do, four miles below the month of the Little Churchill do, six and eleven miles above the month of the Little Churchill River..... S. 10°-15° W. Little Churchill River, three localities, four, thirteen and eighteen miles below Was-kai-ow-a-ka Lake, respectively S. 40° W., S. 80° W., and N. 85° W. do, outlet of Lower Recluse Lake, various directions from S. 15° W. to S. 50° W.; also, W. do, Eagle F bid, two miles in a straight line below The courses to the west, or nearly so, probably mark the motion of this part file ice-sheet during the time of its greatest depth and extent; while the outherly courses show its deflected motion during the tinal melting. Along the Nelson River, Third Limestone Rapid, a hundred miles by the course of the river above its mouth..... S. 30°-50° E. do, Broad Rapid, five miles long, eleven to sixteen miles above the last, mostly S. 50° W. ; also S. 15° W. and S. 55°-75° W. do, thence to Middle Gull Rapid, numerous localities. S. 55°-80° W. do, Upper Gull Rapid, and thence to the middle portion of Split Lake, numerous localities N. 85°-75° W. do., sonthwestern part of Split Lake, two localities .. S. 85° W. do, Chain-of-rocks Rapid, three miles above Split S. 85° W., Lake, one set, probably the older the other..... S. 10° E. do., on Grass River, tributary to the Nelson River from the west a few miles above Split Lake, numerous but in one place, at the outlet of Witchai (Stinking) Lake N. 75° W. do., between Split Lake and Sipi-wesk Lake, numerous S. 55°-75° W., localities, mainly..... and occasionally W. do, Sipi-wesk Lake, outlet and northeastern part, S. 70°-75° W.; mostly also, in numerous localities..... S. 45°-65 W. do, Sipi-wesk Lake, average course throughout the southwestern half of the lake S. 55°-60° W.; N. 85° W. but in some places..... 8. 65° W. do., southwest extremity of Sipi-wesk Lake do., from Sipi-wesk Lake to the outlet of Pipestone S. 55°-65° W. Lake, six localities..... do., Pipestone and Big Reed Lakes and vicinity, five localities..... S. 40°-55° W. 8

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Along the usual boat route from Hudson Bay by	
Hayes and Hill Rivers to Lake Winnipeg, Fix	
miles below the Rock, Hill River	S. 12° E.
do., the Rock, Hill River	S. 10° E.
Dr. Bell reports also at this locality another and older	
set of stria	N. 79° W.
do., Borwick's Fall, and one mile above White-mud	
Fall, Hill River, both within a few miles	
southwest from the Rock, respectively, S. 18° W.,	and S. 28° W.
do., Knee Lake, numerous localities	S. 35°-60° W.
do., from Knee Lake to Pine Lake, seven localities	8. 45°-60° W.
do. from Pine Lake and Molson's Lake to Great	
Playgreen Lake, many localities	8. 35°-60° W.
Around God's Lake, southeast of the foregoing route,	
140 to 180 miles east-northeast from the north	
end of Lake Winnipeg, many localities	
(Cochrane) S. to S. 52° W., mostly	
but in two localities	8. 80° W.
Between Jackson Bay, on Uxford Lake, and the	
southern part of God's Lake, seven localities	
(Cochrane)	S. 25°-40° W.
Around Island Lake, about forty miles south of God's Lake, many localities (Cochrane)	¥ 160 a.c. 11
Between Hudson Bay and Lake Winnipeg, along the	S. 10°-36° W.
Severn, Fawn, Poplar and Beren's Rivers, on	
almost all exposed rock-surfaces (A. P. Low).	
generally	8. W.
varying only a few degrees from this on either	14 W.g
side.	
Month of Lake Winnipeg and its vicinity, several	
localities	S. 40°-45° W.
East shore of Lake Winnipeg, Spider Islands, on the	
adjacent mainland, and at the Shoal Islands,	
about thirty and forty-five miles sorth from the	
north end of the lake	S. 30°-40° W.
do., Poplar Point, four miles southeast of Poplar Point,	
and opposite to George's Island, a few miles	
farther southeast	S. 30°-35° W.
do., four localities near the mouth of Berca's River,	
half-way from the north to the south end of	
the lake	S. 57°-60° W.
do., near the mouth of Beren's River (Panton)S. V	
do., east side of Beren's or Swampy Island (Panton)	S. W.
do., Rabbit Point, near the Narrows	S. 18° W.
do., Black Bear Island, also near the Narrows	0 0 10
(Panton)	S. S. W.,
intersected by other glacial strize, bearing	S. S. E.
"he letter agreeing in direction with string charged	of Skapowall St

The latter, agreeing in direction with strike observed at Stonewall, So Mountain and Little Stony Mountain, near Winnipeg, appear to belong th

East shore and locali Stonewall, in Stony Mount Little Stony Assiniboine (Upha and in Athahasca Ri Mountain Pe above Fort Chipewy also on Fort Ch The following of id are communic North shore of the Bur do. twenty mi do., half-way do, twenty mi do, H. B. post On the western

basal portion of southeast in the

lake do, twenty mi post at 1 do, IL B. post the east On the western fifteen m of Athab Junction of Per Wollaston Lake North shore of wostern 4 Jackfish Lake, and Reime

And Kenne River.... North end of H observatio do., month of H, East shore of Re do. half-way fro lake....

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	I. partici	n of the divergent glacial current which co	ntinned south and
	hanst itt	the Minnesota lobe of the last ice-sheet.	
S. 12° E.	East sho	re of Lake Winnipeg, between the Narrows	
►. 10° E.	an	d the mouth of Winnipeg River, numerous	
	lot	alities	S. 40°-45° W.
N. 795 W.	Stonewal	l, in many places (Panton, Upham)	S, 20°-25° E.
	stony Me	emtain (Panton, Upham)	S. 20°-25° E.
	Little Ste	ony Mountain (Upham)	S. 25° E.
nd S. 28° W.		ine River, sec. 36, T. 8, R. 11, in three places	
. 35°≁60° W.		pham)	S. 4°-8° W.,
45°-60° W,	an	in one place	S. 10° E.
5. 35°-60° W.	Athalatsc	a River and Lake, Wollaston and Reindeer Lakes to Cumberland House.	, and southward
. 15°-40° W.;	Mountai	n Portage, Athabasca River, seven miles	•
8. 80° W.		ove the mouth of Clearwater River	
15. 00 11,		S. 54° E., or more proba	abiy N. 54° W.
		pewyan, near the mouth of Lake Athabasca,	
8. 25°-10° W.		so one mile west and eight miles sonthwest of	
·· • • •	Fe	rt Chipewyan	S. 78°-83° W.
8. 10°+36° W.	al are com	ing observations, to Cumberland House, are by municated by Dr. Robert Bell, having never be	Mr. A. S. Cochrane, Fore been published.
		ore of Lake Athabasca, ten miles north from	0.046.11
		e Burntwood Islands	S. 81° W.
S. W.,	do, twei	aty miles west of Black Bay	S. 61° W.
		ke	S. 43° W.
		nty miles west of the Hudson Bay Company's	C. 40 11.
1 A A		st at Fond du Lae	270 and 210 W
S. 40°-45° W.		B. post, Fond du Lac, tifty miles west from	a jand of w.
		e east end of the lake	S. 53° W.
		western outlet of Wollaston (Hatchet) Lake,	
		teen miles east from its mouth at the east end	
8. 30°-40° W.		Athabasea Lake	S. 85° W.
		of Porcupino River with the western outlet of	
(1. 000 UE0 W		ollaston Lake, fifty miles east of Athabasca	
S. 30°-35° W.		ake	S. 75° W.
		ore of Wollaston Lake, half-way between its	
S. 57°-60° W.		estern and anstern outlets	S. 27° W.
N. and S. S. W.	Jackfish	Lake, about half-way between Wollaston	
S. W.	ar	d Reindeer Lakes, by way of Hatchet Lake	
S. 18° W.		iver	S. 17° W.
64 10 MT	North e	end of Reindeer Lake (average of numerous	
S. S. W.,	• of	oservations)	S. 31° W.
S. S. E.		ath of Hatchet Lake River	S. 17° W.
at Stonewall, Sta		ore of Reindeer Lake, Porcupine Point	S. 24° W.
pear to belong to the		way from the north to the south end of the	
pear to belong the	la la	ke	S. 18° W.

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Eabamet I. Inlet of Stu Attawapish miles from do., lowest o do., on lim monti do., on lime of stri and ti

do, en lime

abont river. de, southern below and in ioregoi Around Lake comme other ward s and th from ... Along and ne bog Lake, me Lac des Mille sturgeon Lak commo but in c Minnietakie 1 several Abram's Chut Islands in the

seve

but

also,

Man Maminiska Patawonga

South end of Reindeer Lake, and on its outlet	S. 150 W.
Churchill River, near Frog Portage, 110 miles north- northwest of Camberland House	S. 40 [±] W.
do., at a small lake ten miles east from the mouth of Isle à la Crosse Lake	S. 150 W
On the cance route, seventy miles north of Cumher-	
land HouseS.	16° and 26° W.

do., fifty-five miles north of Cumberland House S. 26° W. As on the lower part of Churchill River, before noted, the more westery courses of this list are believed to indicate the glacial motion when the ice half its maximum depth, or nearly that, continuing probably through the greater part of the epochs of glaciation; and the southward currents seem referable to deflection during the recession of the boundary of the ice-sheet, most of the earlier westward striac being thereby effaced.

From Hudson Bay to Lake Superior and the Lake of the Woods,

On the route of Dr. Bell from James Bay to Lake	
Huron, commonly S. 5° E	to S. 57 W.;
rarely varying to	8. 25° E.
Between James Bay and the east end of Lake	
Superior, from Long Portage of the Missinaibi	
River to Mattagami Lake, both belonging to the	
Moose River system, mostly	S. S. W.
do., Wasquagami Portage, Missinaibi River, two	
setsS. 15° W.,	and 8 60° F
The last is doubtless a local deflection, belonging to the t	
sheet was being melted away.	
do., Missinaibi River, east of Brunswick Lake	8. 15° E
do., around Mattagami Lake	S. 30-65 W
do., Lake Manitowick, on Michipicoten River	S. 30° W.
do., Long Portage of the Michipicoten River, six	
miles east of its mouth	S. 40 W
North shore of Lake Superior, Falls of St. Mary, and	
thence twenty miles south (Agassiz)	S. S. E.
do., twenty-tive miles north of the Falls of St. Mary,	
and thence to the northeast angle of the lake,	
seventy-five miles east of St. Ignace Island,	
many localities (Agassiz)	8.
do., fifty miles east of St. Ignace Island (Agassiz)	S. S. W.
do., St. Ignace Island, and the same twenty-five miles	
east (Agassiz)	S.
do., southwest side of Nipigon Bay (Agassiz)	S. S. W.
do., islands in Thunder Bay (Agassiz)	S. W.
do., between Thunder Bay and Pigeon River	
(Agassiz)	8.
Isle Royale, Lake Superior, numerous localities	
(Desor)	S. 20°-75° W.
Along the Pie River, tributary to Lake Superior	S. 20°~30° W

A	(Jaiv.] APPENDIX I. 11	17 е
S. 15° W.	Kenogami or Long Lake, at the head of the Kenogami	
	River, tributary to Albany River, many	
S. 40° W.	localities S. to S. 25° W.	
S. 18º W.	"The grooving is as well marked on the tops of the highest hills as in	n the
5. 15° W.	ralleys."	
° and 26° W.	In the country northwest of Kenogami or Long Lake,	
S. 26° W.	several localities S. 30°-40° W	` .
the more westerly	Mong the Kenogami River, mostly	
when the ice hal	but varying to S. and S. 60° W	
rough the greater	Lake t doseph, mestly S. $30^{\circ}-45^{\circ}$ W.	
s seem referable to	also, in two localities S. 15° W. and S. 60° W	· ·
-sheet, most of the	Albany River between Lake Saint Joseph and	
	Maminiska Lake, three localitiesS. 20°, 25°, and 40° W Maminiska Lake	
1.1	Manimiska Lake	
the Woods.	Eabamet Lake, two localities	
	Inlet of Sturgeon Lake, Boulder River	
	Attawapishkat River, respectively 3, 13, 22, and 23	·
E. to S. 5° W.;	miles below the junction of the two channels	
8. 25° E	from the lake of the same name S. 60°, 42° 22°, and 15° W	۲.
	do, lowest exposure of Archaean rocks	Е.
	do, on limestone about 75 miles from the southern	
	month of the river	v.
S. S. W.	do, on limestone nine miles below the last, two sets	
	of strike, the older	
V., and 8 60° E	and the newer	E.
e time when their	do., on limestone at the head of Lowasky Island,	
8. 15° E.	about 44 miles from the southern mouth of the river	1.
4		· · ·
2 002 W	do, southern channel or Lowasky River, four miles below the last, the older strike	
. г. анг н. х	and newer strice varying in course from the	• ,
S. 40° W	ioregoing to	N.
d	Around Lake Nipigon two sets of glacial strike are	
5. S. E.	common, and are often found crossing each	
у,	other on the same rock surface. The south-	
e,	ward set, which is the older, varies from S. 18° E. to S. 25°. W	ſ.;
d,	and the westward and newer set varies	
8.	from	w.
•• S. S. W.	Along and near Kaministiquia Rive	
les	bog Lake, mean of several localities (Hector) S. 10° V	
··· · · ·	Lac des Mille Lacs, mean of several localities (llector) S. 5°	Е,
	ingeon nake, any mines southeast of Lonory nake,	
		,
ver S.	but in one locality S. 50° V	w.
	Minnietakio Lake and vicinity, west of Sturgeon Lake,	w
ties 8, 20°-75° W	several localities	
S. 207-10° W		
•••	Islands in the infidule of Abrain's Lake 5, 40"	11.4

۲

Lonely Lake (Lac Seul), three localities
do., three other localities, respectively 10, 13, and 16
miles east of the Hudson Bay Company's post.
do., east extremity of the lake S. 45 W.
Reot River, tributary to the east end of Lonely Lake,
two localities
English River, below Lonely Lake, five localities S. 30°-60° W.
and one locality S. 50- W.
Winnipeg River, several localities S. 20°-55- W
Around the Lake of the Woods, observations in about
180 localities by Dr. A. C. Lawson and assistants,
and in about 60 localities reported by Dr. G. M.
Dawson, "the great majority," i.e., 82 per cent. S. 35°-55° W.
but 13 per cont. are S. 10°-34 W.
and 5 per cent. are
Only four localities showed courses more westerly
than S. 65° W. ; one of these is on the southeast
side of Big Island, where strike bearing
intersect others bearing S. 37 W.;
on the west side of Bigsby Island, which, like
the preceding, lies near the middle of Sand
Hill Lake (the southern and largest part of the
Lake of the Woods), double sets of striæ were
observed in two places, respectively. N. 80° W. and 8, 20 W_{α}
and N. 83° W. and S. 33° W.
and on a point projecting from the south shore
in the southwestern part of this Sand Hill Lake,
strife bear S. 70° and 65° W.
with others

Probably the bearings S, 10° E, to S, 20° or 30° W. belong to the line a maximum depth and area of the ice-sheet; the prevniling southwestern course, to later glaciation; and the more westerly deflections to the time of final meline of the ice.

Minnesota.

North shore of Lake Superior southwesterly from	
Pigeon Point, numerous localities (Norwood and	
Whittlesey)	S. 25°-45° W.
Duluth (N. H. Winchell)	W. S. W.
Otter Track, Sucker (or Carp), and Long Lakes, in	
northeastern Minnesota, south of Hunter's	
Island (Winchell)	8. W.
Vermilion Lake, two places (Winchell), about	S. 20° W.,
and in another place (Winchell)	8. 40° W.
Vermilion Lake (Whittlesey)	S. 15° W.
Pike River, tributary to Vermilion Lake, two places	
(Winchell)	10° and 20 W.

"LHTA']

In T. 59.

The follow Winchell, not Vermilio do., three Birch La sec. 30, T Sec. 35, T Sec. 37, T. Basswood Ima Lake Island in

Knife Lak The two-foll report, for 1887 East end o Island in 1

Sec. 11, T.

Mr. Horace following glacic variation :— Little Fork

Rainy Rive Rainy Lak North faH Lake Bowstring I in T. do, a shori glacia Deer River juncti T. 62.

Big Fork, ab River do., in or ne The southeasty Fork belongs to t outheast from the outheast from the

Bel River Valley Lower Falls o Elbow Lake, Pelican Lake localitic Net Lake, in 1

Trout Lake, n

118 E

4.

:111	18.	55	<i>W</i> .	
		45		
50°	and	45	W.	
5.	30°	-60	W.	
	S.	50	W.	
×.	20°		W.	

and N SU W.

S. 35°-55° W.;
 S. 10°-34 W.;
 S. 56°-83′ W.

8, 75 W. 8, 37 W.;

a

9 N. and S. 20 W., J. and S. 35 W.; o S. 70° and 65 W., S.; also, S. 10 E. belong to the time southwestern course o time of final metric

> S. 25°-45° W. W. S. W. S. 20° W.

S. 20° W. S. 40° W. S. 15° W.

, 10° and 20° W.

;+4V.]	APPENDIX I,		119 в
In '	T. 59, R. 14, about twenty miles south-southeast of Vermilion Lake (Winchell), estimated	30° '	w.
Winche	following, to Knife Lake, inclusive, are observations by ell, noted in his Fifteenth annual report, Minn., 1886, pp. 38. million Lake, twenty localities	5-6 : -24°	w.
Bir	reh Lako	22° 5. 8° 12°	W. E.
Sec Bas Im	8 27, T. 63, R. 10	15° 15°	W. W.
Nu Ku	e. 11, T. 64, R. 7	. 25° . 30° . 48°	w. w.
The t	two following are from Prof. N. II. Winchell, in his Sixte for 1887, p. 114 :	enth	annua
Ea Isl Mr. followin	ast end of Delta Lake, west of Ogishke Mnneie Lake. S land in Pseudo-Messer Lake	. 25° . 40° 8, no for m	W. tes the
Lit Ra Ra	• •	°-42° . 32° °-64°	W.
lio		. 30° 4. 30°	
		5. 50° o due	
Bi	g Fork, about three miles above the mouth of Deer River	Dne	
The Fork b	a, in or near sec. 35, T. 150, R. 25	he so	or Big ath and
kalde Rel Ri	ers and gravel of limestone from those lakes and the lowe iver Valley southeast to this stream and to the mouth of Ra	er pai	rt of the .ake.
EI	wer Falls of Prairie River, sec. 34, T. 56, R. 25, how Lake, T. 64, R. 18, two localities8, 26° W. and 8 dican Lake, mostly in Ts. 64 and 65, R. 20, four	:. 28°	8. W.
		°-36° °-24°	

Sand Point Lake and Sturgeon or Namekan Lake
(Whittlesey)S. W. to S. 55 W.
Rainy Lake (Whittlesey)S. 40°-60° W., and W. S. W.
Big Fork of Rainy River, about 82 miles from its
month (Whittlesey) So E
This seems to be near the locality noted by H. V. Winchell about three nile
above the month of Deer River.
Hinckley, Pine County S. and S. 5 W.
Watab, Benton County S. 15 W.
Sank Rapids, Benton County, namerons places S. 45°-55 W.;
but in one place S. 15 W.
Sauk Center, Stearns County, forty miles west of the
last S. 40° E.
Minneapolis, several places S. 5°-28° E.
One to seven miles southeast from Big Stone Lake,
numerons places
Granite Falls, several places
Beaver Falls S. 66° E.
In the valley of the Minnesota River two miles below
Larch Cooley
One and a balf miles west of Fort Ridgely
Redstone, near New Ulm S. 25° E.
Jordan, at mill of Foss, Wells & Co S. E.
Posen, Yellow Medicine County S. 50° E.
Echo, Yellow Medicine County S. 50°-55 E.
T. 111, R. 38, Redwood County S. 50°-60° E.
Stately, Brown County S. 50°-55° E.
Germantown, Cottonwood CountyS. 30° E., S. 50° E., and S. 70° E.
Amboy, Cottonwood County, mostly S. 35°-50° E;
but also rarely deflected to S. 70° E.
In one place all these courses intersect on the same surface.
Delton, Cottonwood County, numerous localities,
mostly
also, in one place, all courses from S. to S. 80 E.
intersecting on the same surface.
Sehma, Cottonwood County S. 182-22 E.
Amo, Cottonwood County S. 30°-32 E.
Dale, Cottonwood County S. 20 ² -34° E.
Adrian, Watonwan County S 20°-30 E

Mach care o Lake Agas peach other been used as are found to a their reliabilit leginning of exceeding tive deir protiles lave copied fra abulated ; but del from the sken much in rateful ackno The plane of tated through always design ammits from v tbridges. Th oted when it is dinary low sta Altitudes of 1 fwater-shed, w ternational b osultation. P Ithis Survey, a apeditions, wl Ilway surveys ose to the sea es, whether of I the amount rit, are noted.

7. to 8, 55 W. and W. 8, W. 8, 80 E.

il about three miles

S. and S. 5 W, S. 15 W, S. 45°-55 W, S. 15 W,

S. 40 E.

8, 5°-28, E 8, E 8, 45°-50° E 8, 60° E 8, 60° E 8, 60° E 8, 60° E 8, 25° E 8, 50° E 8, 50° E 8, 50° E

S. 50°-60° E. S. 50°-55° E. E., and S. 70° E. S. 35°-50° E. S. 70° E. Acc.

> S. 15°-40° E; S. to S. 80° E.

S. 18°-22 E. S. 30°-32 E. S. 20°-34 E. S. 20°-30 E.

APPENDIX II.

TABLES OF ALTITUDES.

Much care has been taken to determine the elevations of the beaches Addinged from at Lake Agassiz with the greatest possible accuracy, in their relation rativary peach other and to the sea level. The railway surveys which have been used as the basis for my levelling along these ancient beaches are found to agree very closely with each other, giving assurance of their reliability throughout the basin of Lake Agassiz, as stated at the legisning of this report, within probable limits of error nowhere acceding iive feet. By the coartesy of the engineers of these railways, their profiles have been mostly submitted to my examination, and 1 have copied from them the greater part of the notes which are here abilities in the profiles by the engineers or their assistants, who have also much interest in this work, and to whom I desire to express my gateful acknowledgments.

The plane of reference in the following tables, and for the altitudes Reference to ated throughout this report, is the mean tide sea level. Heights on level, always designate the top of the rail in front of passenger stations, at annuits from which the grade descends both ways, and at the middle (bridges. The lowest and highest known stages of water in rivers is ited when it is given on the profiles; but in many instances only the adiary low stage is recorded.

Altitudes of lakes, rivers, hills, mountains, and depressions in lines lakes, rivers, mountains, and (watershed, within the basin drained to Lake Agassiz north of the lines of watertenational boundary, are also here tabulated for convenient assiltation. Portions of these lists are compiled from former reports (this Survey, and from Hind's Narrative of the Canadian Exploring quelitions, which was published in 1860. Wherever subsequent liway surveys have supplied means for more accurate reference of reset to the sea level, the needed corrections have been made. In all ses, whether of railways or other lists, the source of observations, of the amount of change from the original, if any, with the reasons ril, are noted.

CANADIAN PACIFIC BAILWAY.

A published profile of this railway gives the elevation of Lake Se; erior as 5% feet above the sea, while on the profiles in the engineers' offices it is shown as 600 feet. Assuming the mean of these figures to represent the mean lake level, a uniform addition of three feet is here made to the eastern part of the profile, extending from Port Arthur to Eagle River station, to accord approximately with the mean elevation of Lake Superior, 601.56, determined by the *V* hide States Lake Survey.

The profile shows a discrepancy of eight feet close west of Eagle Biver station, 232 miles west of Port Arthur, on account of which its elevations thence west to Cross Lake require a subtraction of five feet, which is here made, to agree with the foregoing. Again at Cross Lake, 334.4 miles west from Port Arthur, a discrepancy of five feet to be added is found in the profile, so that its original elevations thence west to the Red River and south to Emerson are here equid without change, being in accord with the corrected profile on the east.

The main line from East Selkirk to the junction of the Emerson branch deseast of Winnipeg, and this branch, extending from Saint Boniface to the international boundary, are supplied by Collingwood Schreiber, chief engines and general manager of the Cumadian government railways, and are on dasame system of leveling with the main line from Port Arthur to East Selkir, which, however, is subject to the slight adjustments mentioned. This who series thus adjusted is surely correct within very close approximation, as a shown by its exact agreement at Emerson with the Saint Paul, Minneap-East Manitoba Railway and with levelling by the United States Engineer G_{equ} along the Red River of the North.

Two smaller discrepancies also appear in the profile, but are here neglected At 117 miles from Port Arthur (close west of Scott's River) and thence weigh subtraction of two feet is indicated; and at 256.5 miles (close west of Parrywed) and thence west, a subtraction of one foot. If these were taken into account, is west part of this profile would be lowered three feet; but it seems more probabilit that it should agree with the elevation of Emerson determined by surveys a the United States.

A large discrepancy is found between the eastern system of levelling and in which begins at Winnipeg and extends west to the Rocky Mountains. In latter includes the branches west of the Rod River at Winnipeg and westwal also the Manitoba & Northwestern Railway and its branches, which refer the elevations to that of the Canadian Pacific profile at Portage la Prairie. It system east of the Red River is reliable, as already stated; and levelling for Saint Boniface station (754 feet) to the Louise bridge (752 feet, instead of 255 the profile extending westward) shows that the system west of the Red Emrequires a uniform addition of twenty-four feet, which is here made in the laof elevations at Winnipeg and thence west. With this correction, the Soft western Branch from Winnipeg to Gretna agrees with the Saint Pa-Minneapolis & Manitoba Railway at the international boundary; the soft from this branch at Resenfeld to Emerson agrees with the Emerson brand and the West Selkirk branch agrees with the main line east of the Red Rive

Between P Peterson, cha East Selkirk railways, Ott

> Lake Sup 1888, 8tc. M Lake Sup 4.9 fee Port Arth Monto Melntyre Neebing o Fort Willia Kamin mon wate

Fort Willia Kaministio water, Murillo

summit, gr Lofoden ... Pepression, sammit, en Strawberry 990–993

Kaministiq Kaministiq 982–996 Mattawan **1**

1082-108 Subshine Cr

ligh wa Sunshine Cre high wa

Finmark.... Sunshine Cre Bada (a smi same) ... Oskondiga R Tunnel, grad

Oskondiga R Nordland.... Summit, natu

Lake Se; erior as is offices it is shown as the mean lake level, rn part of the profile, coord approximately mined by the United PHAN.

of Eagle Biver station vations thence wests e made, to agree with from Port Arthur, a ile, so that its original nerson are here copied on the east. Emerson branch dos aint Boniface to the reiber, chief engineer ways, and are on the Arthur to East Selkik, entioned. This whole approximation, as a nt Paul, Minneapolisa States Engineer Con

but are here neglects er) and thence wet, lose west of Parrywol taken into account, it it seems more probab ermined by surveys

m of levelling and the ocky Mountains. The innipeg and westward ches, which refer the ortage la Prairie. The ed; and levelling for get, instead of 75% west of the Red like here made in the start of the Red like correction, the Soci vith the Social for boundary; the soci the Emerson basel cast of the Red like

APPENDIX II.

a. Main line, from Port Arthue to Winnipeg.

percent Port Arihur and East Selkirk from profiles in the offices of P. A. Peterson, engineer, Montreal, and R. M. Pratt, engineer, Winnipeg; and between East Selkirk and Winnipeg from Collingwood Schreiber, engineer of government rallways. Ottawa.

I	Miles from Fort Arthur.	Feet above the sea.
Lake Superior, mean surface, Nov. 1, 1870, to Jan. 31		
1888, according to U.S. Engineers' gauge, Saul	lt	
Ste. Marie		601.59
Lake Superior, extreme low and high water (range	٠,	
4.9 feet), approximately		599-604
Port Arthur (a summit of grade), 993.0 miles from		
Montreal		628
McIntyre or Second River, water, 603; grade	. 6.0 .	610
Neebing or First River, water, 603; grade	. 6.2	610
Fort William	. 7.0	615
Kaministiquia River here, 11 miles above it	3	
month, bed, 586; low water (1879), 600; hig water (1859), 612.	11	
Fort William West (station disused)	. 10.0	635
Kaministiquia River here, bed, 584; low and high		
water		602-614
Murillo		947
sammit, grade (three feet above natural surface)		1050
Lofoden		1078
Pepression, tilling 7 feet ; grade		1055
samuit, cutting 2 feet ; grade		1081
Strawberry Creek, bed, 987; low and high water		110.1
990-993 ; grade	. 27.0	1002
Kaministiquia	. 27.9	1013
Kaministiquia River, bed, 973; low and high water		1015
982-996; grade		1013
Mattawan River, bed, 1078; low and high water		1010
1082-1089; grade		1099
sashine Creek, first crossing, hed, 1106; low and		1055
high water, 1109-1113; grade		1122
sushine Creek, third crossing, bed, H51; low and		1122
high water, 1158-1162; grade		11.00
Finmark		1168
		1180
Sanshino Creek, bod, 1330; water, 1334; grade		1352
Buda (a summit, natural surface and grade th		
same)		1473
Oskondiga River, bed, 1415; water, 1421; grade		1453
Tunnel, grade, 51 feet below top of rock above		1458
Oskondiga River, bed, 1426; water, 1428; grade		1411
Nordland		1543
Summit, natural surface and grade	. 57.8	1584

123 E

۸.

124 e

C

	liles from	Feet above
Southeast branch of Savanne River, bed, 1544; water,	ort Arthur.	the sea.
1545 ; grade	59.9	144.
Southeast branch of Savanne River, bed, 1537; water,	0.0.00	1554
1538 : grade	62.0	1546
Linkooping	65.2	1534
Savanne	75.8	1506
North branch of Sayanne River, bed, 1487; water,	101.0	1 - 91 (8)
1489; grade	76.4	1506
Upsala	\$6.2	1579
Carlstad	93.6	1515
Fire-steel River, bed, 1500; water, 1505; grade	98.5	1510
Beaver River, bed, 1519; water, 1525; grade	102.2	1532
Bridge River station	103.6	1543
Hawk Lake, water, 1509; grade	113.6	1518
English River, bed, 1504; water, 1510; grade	115.2	1515
English River station	116.0	1517
Scott's River, bed, 1505; water, 1511; grade	116.6	1516
Summit, cutting 11 feet ; grade	123.6	1558
Martin	124.0	1557
Depression, grade	127.4	1183
Summit, grade	131.6	1549
Bonhour	134.0	1530
Summit, grade	136.4	1554
South Lake, water, 1495; grade		1516
Depression, grade		1478
Gull River, bed, 1456; grade		1490
Falcon		1509
Abgimac River, bed, 1470 ; grade	151.3	1 (90)
Ignace	152.3	H-7
Osaquan River, bed, 1398 ; grade	158.7	1420
Butler	160.5	1423
Little Wabigoon River, bed, 1398; grade	165.7	1408
Glencoe River, bed, 1398; grade	167.0	1405
Raleigh Little Wabigoon River, bed, 1350; grade	170.4	1140
		1366
Taché Burnt Stick Creek, bed, 1314 ; grade	180.2	1366
	182.0	
Kirkpatrick Creek, bed, 1320; grade Bear Creek, bed, 1333; grade	186.6	135 <u>2</u> 1348
Brulé	190.4	1045
McHugh's Creek, bed, 1207 ; grade	190.4	1.00
Summit, grade		1255
Hughes River, bed, 1198; grade 20		12-5
Wabigoon		1211
Blackwater Creek, bed, 1200; grade		1211
Thunder Creek, bed, 1205; grade		1211
Barclay		1251
Summit, cutting 10 feet ; grade		1267
banning, calling to leet, grade	-11.0	1-11

. F-AY.]

Wabig Shosho Osdrift Beaver 44 14 Eagle I Eagle 1 Samooit Vermili Grass C Eagle L Gilbert Moskrat Sammit, Farrywo Stewart Summit, grad Outlet of Parrywo sum Ontlet of Mud Lak Feist Lal Turtle La Summit : Summit 1 Clare Lab Viaduct 1 Hawk La Outlet of . Tront Lak Beaver (d Rossland Rat Porta Winnipeg low w grade Lake of th Keewatin Winnipeg Mink Bay Winnipeg War Eagle Ostersund Summit, et

Lake Bobo

s from Arthur,

9.9

2.0

5.2

5.8

76.4

6.2

93.6

98.5

02.2

03.6

13.6

15.2

116.0116.6

123.6

124.0 127.4

131.6

134.0

136.4

138.3

139.7

148.7

144.8

151.3

152.3

158.7

160.5

165.7

167.0

170.4

180.0

180.2

182.5

183.9

186.6

190.4

198.6

202.2

202.6

204.5

206.1

209.8

211.5

0.4 - 200.8

Feet above

the sea.

1551

1546

1534

1506

1506

1579

1515

1513

1532

1543

1518

1515

1517

1516

1558

1557

1483 1549

1530

1554

1510

1178

1150

1509

1490

1457

1120

1425

1408

1405

1440

1366

1366 1347

1352

1348

1555

1235

1255

1211

1211

1211

1225

1251

1267

[F-AV-]	APPENDIX II.	125
	Miles from	Feet above
	Port Arthur.	the sea.
Wabigoon F	River, bed, 1178; grade 215.4	1219
Shoshogawa	e River, bed, 1151 ; grade 220.8	1159
		1162
	er, first crossing, bed, 1129; grade 225.8	1149
	second crossing, bed, 1125; grade 226.4	1139
11 41	third crossing, bed, 1123; grade 229.4	1153
	station 231.8	1186
	; bed, 1148; grado 232.2	1190
	tting 7 feet ; grade 234.9	1278
	Bay station 242.0	1221
	, bed, 1183; grade 242.5	1213
	, water about 1182 ; grade 246.9	1210
		1217
	ke, water, about 1174 ; grade 251.0	1206
Summit, na	tural surface and grade 255.4	1295
Farrywood		1292
	se, water, 1303 ; grade 258.3	1328
Summit, no	ear Forest Lake, natural surface and	
grade .	259.8	1382
Outlet of Sw	an Lake, bed, 1332 ; grade 260.8	1362
Parry wood	Lake, water, about 1362; grade (a	
summit	t) 262.1	1379
Outlet of U	lverston Lake, bed, 1318; grade 262.9	1364
Mud Lake.	water, 1328; grade 263.3	1355
Feist Lake,	water, 1326; grade 264.3	1347
Turtle Lake	e, water, 1366; grade 265.1	1376
Summit sta	ation, cutting near, 10 feet ; grade 265.4	1385
	ke, water, 1384; grade 265.6	1385
	water, 1284; grade 270.3	1295
	ke, water, 1246; grade 271.6	1282
	e station 272.9	1289
	arrow Lake, bed, 1220; grade 275.1	1256
	Creek, bed, 1213; grade 280.6	1248
	pression of grade near Beaver " n Lake) 284.1	1186
	288.9	1128
	297.3	1087
	River, outlet of the Lako of the Woods,	
	ner, at same level with this lake, 1057;	
		1087
	Woods, mean, 1060; low and high water. 298.1	1057-1063
		10/7-1005
	Bay, water, 1043; grade	1075
	water, 1043; grade	1070
	Bay, water 1043; grade	1070
	Rock Lake, water, 1082; grade	1121
Ostorermal	Nock Lake, water, 1082; grado	1121
	itting 35 feet; grade	1187
Lake Bobo	, water, 1138; grade 312.7	1451

125 E

d,

Miles from	Feet above
Port Arthur. Lake Deception, water, 1094; grade 313.1	the sea.
Lake Deception, water, 1094; grade 313.1 Deception	1143
Bear Lake, grade	1136
Bear Lake, grade 315.2 Summit, at west end of a cut 35 feet deep; grade 315.7	1192
, , , , , , , , , , , , , , , , , , , ,	1218
Monument Lake, grade 318.3 Red Pine Lake, grade 319.2	1218
	1226
Fellows Lake, water, 1235; grade (eleven feet lower	
than the lake) 319.7	1224
Kalmar	1217
Snmmit Lake, water, 1252; grade 322.1	1255
Kennedy Lake, water, 1245; grade (two feet lower	
than the lake) 323.1	1243
White Fish Lake, water, 1213; grade 323.8	1243
Summit, 30 rods west from the centre of a cnt 33 feet	
deep; grade	1221
lngolf	1184
Summit, cutting 30 feet; grade 328.9	0100
Cross Lake station, water, 1045; grade 334.4	1092
Depression, grade 336.2	1053
Telford	1059
Summit, grade, two feet above the natural surface 342.3	1115
For two and a half miles east and one mile	1.000
west the surface is very smooth, 1105 to 1113.	
River Brenton, water, 1041; grade 348.7	1050
Rennie	1653
Bog River, water, 996; grade 354.7	1007
" water, 993; grade 356.2	1007
Darwin	971
Westward to the Red River the country is	211
mostly swamp, bearing alders and tamaracks.	
The swamp is underlain by a bard bottom at	
depths varying commonly from 5 to 15 feet.	
Bog River, water, 927; grade 364,0	1
	9.5
	906
Whitemouth	907
Beaver Creek, water, 885; grade 369.8	904
Shelly	929
Monmouth	879
Bear Creek, water, 820; grade	831
Broken Head River, water, 784; grade 391.1	796
Beausejour	814
Tyndall 400.9	796
Devil's Creek, water, 770; grade 402.3	777
East Selkirk 408.9	743
Red River at West Solkirk, two miles west of East	
Selkirk, "ice, 1876" [probably two or three feet	
above extreme low water], 712; flood of 1876,	
723; flood of 1875, 725; extreme high water,	
flood of 1826, 732; range, 22 feet 411.0	710-732
noor or row, row, range, as reconstruction and	110-10.

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■	Junction of
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	Rosser
	Meadows
	Rosser Meadows Marquette Reaburn
	Barpierie
	neaburn
	Long Lake, c
	grade
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	Portage la 1
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	Enough Lo
	Burnside
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	Bagot
	Bagot Image Creek, Vetimoren
	Malina Creek,
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		- ,	(pere.]	APPENDIX II.		127 е
om	Feet above		-	M	iles from rt Arthur.	Feet above the sea.
hur.	the sea.	2	The	railway at East Selkirk turns southward,	IL AILUUI.	cue sea.
	1143			aving the line of its original survey, which		
	1136			rossed the Red River here.		
2	1192		Lake V	innipeg, mean, 710; low and high water,		
	1218			roximately		708-713
3	1218	-	Cook's C	'reek, water	409.1	728
2	1226			· · · · · · · · · · · · · · · · · · ·		757
				lill station		7.,9
7	1224		Winnip	eg Junction, Emerson branch	427.8	752
4	1217			ver, extreme low water, 723; highest water		
i	1255	ľ		ordinary years, 735-740; high water, 1882, ; grade, Louise bridge	429.0	752
1	1243			ng		757
8	1243		winnel		12010	
.8	1221		b	Main line; from Winnipeg to the Rocky Mounta	ins and D	onald.
.2	1184		Fr	om profile in the office of R. M. Pratt, engine	er, Winni	Deg.
.9	1150			uniform addition of twenty-four feet, as 1		
.4	1092				lites from	beet above
.2	1053				Vinnipeg. 0.0	the sea.
.5	1059	1		eg, 1422.8 miles from Montreal	1.1	757
.3	1115			n of Manitoba & Southwestern Railway	$1.1 \\ 1.2$	760
						760
				n of West Selkirk branch	1.5	759
3.7	1.050			f beginning of the original profile (at 0 of	1 0	P .14
).0	1053			ances measured thence westward)	1.8	761
1.7	1007			e Junction, of Stonewall branch	1.9	761
6.2	59596		Colony	t'reek, water, 769; grade	3.3	776
9.4	971			water, 772; grade	4.0	780
				a of V innipeg & Hudson Bay Railway	4.7	780
					7.4	784
					15.2	796
				8	22.3	793
4.0	965			tie	28.9	807
S.1	900			R transformer have and high mater "00 000.	35.2	806
S 9	907		e.	ake, ordinary low and high water, 798-803;	05 7	. 001
59.8	904			de	35.7	804
74.9	929		1	Point	40.4	815
\$4.9	879		17	Sluff	48.7	829
87.4	831			la Prairie, junction of the Manitoba & rthwestern Railway	50 0	07.4
91.1	796			-	56.0	854
94.3	814			2ek, bed, 858; grade	63.4	872
00.9	796			le	63.5	872
92.3	777			ek, water, 862 : grade	65.1	890
08.9	743			Charle watan 0201 amila	71.1	935
				Creek, water, 939; grade	75.6	953
				(or	77.6	961
				a de la bar de al las (de l'anna Canada III) a d	84.5	1005
				ntly a beach ridge (the lower Campbell beach	00.0	1001
11.0	710-732		- 01	Lake Agassiz), crest, 1066; grade	86.9	1061

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d'

	Mites from Winnipeg.	Feet abore the sea,	
Again, apparently a beach ridge (the upper Camp- bell beach, second ridge), crest, 1081; grade	87.2	1076	
Again (the apper Campbell beach, first ridge), crest, 1087; grade These beach ridges are each about 30 rods wide, with descents of 10 to 20 feet from their crests to their east bases and half as much to the west.	875	1085	I
A very nneven profile, intersected by numer- ous ravines, extends from \$9.3 to \$2.0 miles, in which distance the grade rises from \$124 to \$1232 feet.			I
Sydney	92.6	1232	
It is again very nneven from 93.7 to 95.9 miles, in which distance the grade ranges from 1234 1251 feet.			
Here and westward the profile shows frequent lakelets, but no names for them are given.			
Vollonme	98.0	1248	
Pine Creek, water, 1199; grade An uneven surface of low dunes extends from 101.1 to 102.7 miles, the grade varying from 1244 to 1257 feet.		1224	2 1 - 0 - 0 - 0
Carberry Horman beach (dd) of Lake Agassiz, erest, 1263		1258	Si B
grade	107.6	1264	P
Herman beach (d), crest, 1268; grade Each of these beach r lges is about 20 rods wide, with crest about five feet above the adjoining land; but west of the west beach (d) is a depression of 10 to 12 feet, about 50	108.9	1267	Ri Pil Gr Gr
rods wide succeeded farther west by land			Pe
slightly, only a few feet, above these beaches.			Bel
Very rough contour of dune sand reaches from 110.2 miles (grade, 1274) to 112.7 miles (grade 1249).			Pas Mo Moe
Sewell	114.2	1255	Bob
Two slight summits of grade, probably crests of the Herman beach <i>d</i> , natural surface and grade the same, 1268 feet, are crossed at 116.5 and 116.8 miles.			a Caro Mor Park Sum
Donglas	121.5	1222	Secre
Chater	127.2	1213	😤 Сьар
Assiniboiue River, water, 1161; grade	131.0	1177	Ernfe
Brandon	132.7	1194	Summ
Kemnay	140.9	1364	Morse
Alexander	148.4	1406	Herbo
Griswold	157.4	1417	Sumn

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Flat Cree Oak Lake Gopher C Virden ... Hargrave Elkhorn Fleming . Moosomin Red Jacke Wapella .. Burrows . Whitewood Percival.. Sammit, gr Broadview Oakshela . Grenfell... Summerber Wolseley ... intaluta .. Indian Hea a'Appelle McLean ummit, gra lalgonie ... flot Butte. legina, jun Railway ile of Bones rand Coulé rand Coulée ense lle Plaine. squa..... cse Jaw C ose Jaw... harm.... on..... tlach kbeg mit, grad stan (on th plin old mit, grade •••••••

ert ait, grade 9

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		(FRAW.] APPENDIX II.	129 :
rom	Feet above the sea.	Miles Winn	from Feet above ipeg. the sea.
beg.	the sea	Flat Creek, water, 1376; grade 162.	
2	1076	Oak Lake station	7 1415
-		Gopher Creek, water, 1404 ; grade 178.	
.5	1085	Virden 180.	
		flargrave 188.	
		Eikhorn 196.	
		Fleming 210.	
		Moosomin	
		Red Jacket 226.	
		Wapella	
		Burrows 242.	
		Whitewood 249	
2.6	1232	Percival	
	1	summit, grade 257.	
		Broadview 263	
		Oakshela	
		Grenfell	.9 1957
		sammerberry 287	
98.0	1248	Wolseley	
99.7	1224	sintaluta	
		Indian Head	
		McLean	
105.5	1258	Sammit, grade	
		Balgonie 341	
107.6	1264	Pilot Butte	.0 2016
108.9	1267	Regina, junction of the Regina & Long Lake	
		Railway	
		File of Bones Creek (Wascana River), grade 358	
		Grand Coulée station	
		Grand Coulée (Creek), grade 368	
		Pense	
		Belle Plaine 381	
		Pasijua	
,		Mocse Jaw Creek, grade	
		Mocse Jaw 398	
. 114.5	2 1255	Boharm 406	
8		Caron	
1			
3		Parkbeg	
		Summit, grade	
121.		Secretan (on the Missouri Cotean) 443	
127.		thaplin	
131		Emfold 461	
132	4.1.2.1	Summit, grade 464	
140		Morse	
148			
157	.4 1417	Summit, grade 485	- 2011

Mites from Winnipeg. Rush Lake station 489.3 Summit, grade...... 495.4 Waldec 496.7 Aiken's 504.8 Swift Current Creek, grade 509.7 Swift Current station 510.6 Goose Lake station 528.9 Summit, grade 532.3 Depression, grade..... 533.7 Summit, grade..... 535.5 Antelope 538.5 Gull Lake station..... 546.3 Cypress 554.8 Sidewood 565.4 Crane Lake statiou 575.5 Summit, grade..... 583.9 Colley 585.9 Summit, grade..... 589.2 Maple Creek station 596.7 Maple Creek, grade..... 597.2 Kincarth 605.9 Summit, grade 608.9 Forres 615.5 Walsh 627.9 Summit, grade 636.4 Irvine 638.3 Dunmore, junction of the Northwest Coal & Navigation Company's Railway 652.8 Medicine Hat 660.3 South Saskatchewan River, low and high water, 2137-2154; grade 660.6 Stair 667.3 Bowell 675.1 Summit, grade..... 675.7 Depression at tank, grade 682.6 Suffield 686.6 Langevin (a summit of grade)..... 695.2 Kininyie 704.1 Tilley..... 713.3 Summit, grade..... 719.3 Bantry...... 723.1 Summit, grade 764.4

Crowfoe Sammi Crowfor Clunv.. Gleicher Sammit, Namaka Sammit. Strathme Cheadle. Sammit, Langdon . Sammit, p Depression shepard .. sommit, Bow River Elbow Riv Bow River Calgary Keith.... Cochrane.. Radnor Morley.... Kananaskis Kananaskis The Gap, str Bow River h water, al Branch of Bo fannore ... Bow River, w Duthil..... Devil's Head Anthracite ... Banff (new st Forty Mile Cr Cascade Bow River, wa Castle Mounta Eldon Baker's Creek, Lion Creek, wa Lagran..... North branch d South branch o Bath Creek, wa

17-4W.

Feet above

the sea.

9301

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APPENDIX II.

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	_	ран.		191
	t above e sca.	<i>3</i> ,	liles from Winnipeg.	Feet above the sea.
	2301	Crowfoot	765.9	2698
	2420	Summit a half mile east of tank	768.4	2739
-	2357	trowfoot Croek, grade		2689
•	2401	Cluny		2850
• ·	2415	Gleichen	784.8	2952
	2423	Sammit, grado	790.0	2997
.6	2467	Namaka		2971
.9	2465	Summit, near tank	796.2	3038
.3	2586	Strathmore		3032
.7	2542	Cheadle		3189
5.5	2590	Sammit, grade		3306
3.5	2556	Langdon		3292
6.3	2562	Summit, grade		3373
4.8	2637	pepression, grade	828.2	3334
5.4	2478	shepard		0015
	2518	summit, grade		3409
5.5 3.9	2568	Bow River, grade		3377
\$5.9	2509	Elbow River, water, 3394; grade		3411
	2561	Bow River at the month of Elbow River, water		3390
89.2	2495	Calgary		3421
96.7	2497	Keith		3547
97.2	2531	Cochrane		3743
805.9 100 B	2546	Radnor		3876
508.9	2425	Morley		4061
615.5	2430	Kananaskis River, bed		4149
627.9	-1200	Kananaskis	894.1	4214
636.4	2493	The Gap, station	. 901. 9	4225
638.3	-1-5	Bow River here, at point of issue from the mountains	,	
	2405	water, about	901.9	4215
652.8	2171	Branch of Bow River, water	902.3	4220
660.3	-111	Canmore	. 907.2	4278
	2173	Bow River, water	914.5	4359
660.6	2431	Puthil	. 914.8	4380
667.3	2582	Devil's Head Creek, water	. 916.1	4436
675.1	2594	Anthracite		4484
. 675.7	2384	Bantl (new station)	921.8	4515
. 682.6	2455	Forty Mile Creek, water	. 922.0	4505
. 686.6	5420	Cascade		4531
. 695.2	2429			4586
704.1	24.0			4653
. 713.3	2402	111		4804
719.3	247			4852
723.1				4970
727.1	247	T		5029
733.1	251			5020
740.7	250	i an hi		5049
748.9) 25			5263
757.5	5 25			0200
764.4	4 27	or Kicking Horse pass		5323
		or Kicking Horse pass	. 902.2	0020

Miles from Feet above Winnipeg. Hector... 965.0 Kicking Horse Lake, water 965.0 Kicking Horse River, first crossing, water 966.2 Mount Stephen tunnel, grade 970.4 Muskeg summit, grado..... 975.7 Ottertail Creek, water, 3746; grade 978.4 Kicking Horse River, water..... 981.4 Leanchoil 986.4 Summit grade..... 988.6 Kicking Horse River, fourth crossing, water 992.7 Kicking Horse River, sixth crossing, water, 2666; Golden 1006.7 Columbia River here, at the mouth of Kicking Blueberry Creek, water.....1016.7 Columbia River, first crossing, grade 1024.4

c. Main line through British Columbia, from Donald to Vancouver.

From H. Abbott, Superintendent of the Pacific Division, Vancouver, wh figures, referred to the level of the Pacific Ocean, are given without change the first column of these elevations, showing at Donald a discrepancy of 30 above the preceding series from Winnipeg, Lake Superior, and the Atlant In the second column these figures are revised by subtraction of 39 feet fa the east end of the series for agreement at Donald; by comparison with a principal comparison with a principal comparison with a principal comparison with a principal comparison of the series of the from Donald to Sicamous, supplied by P. A. Peterson, engineer, Montreal, will indicates that this correction should be reduced to 30 feet at Glacier Houses onward, and to 20 feet at Twin Butte and onward; and by comparisonal elevations supplied by Dr. G. M. Dawson, copied from profiles in the offer Collingwood Schreiber, engineer of government railways, Ottawa, which see require the continuance of this subtraction of 20 feet west to Notch Hills Shuswap, beyond which they indicate that the elevations received from Abbott are probably correct. This line, however, needs verification by level from Donald to Lytton, about 300 miles, within which distance the discreof 39 feet at Donald can probably be eliminated. At Lytton, and through remaining distance of about 150 miles to Vancouver, these elevations agree those published by Dr. Dawson in advance sheets of the second edition Macfarlane's American Geological Railway Guide, and with the blue condensed profile prepared in the engineers' office of this railway, Montreal

Donald . Beaver .. six Mile Bear Cre Rogers 15 Sommit g Selkin Glacier II Ross Peak Illecillewa Albert Ca Twin Butt Revelstoke Colum Summit gr Gold r. Clanwillian

Griffin Lak Craigellachi Sicamons 1 Shuswa station.

almon Ari

Tappen Sidir Notch Hill s Shuswap Duck's Kamloops ... Tranquille ... Cherry Creek Savona's Penny's Ashcroft spatsum pence's Brid brynock Lytton Cisco Keefer's North Bend . . Spuzzum Yale llope..... Ruby Creek st Agassiz

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es from	Firt above
nipeg.	the sea
62.7	5313
62.7	530×
65.0	5497
65.0	5190
66.2	5151
170.4	4325
173.2	4058
075.7	4164
978.4	3856
980.2	3689
981.4	3665
986.4	3570
988.6	3669
992.7	328_{1}^{*}
994.2	3275
1003.5	2682
1006.7	2570
1006.7	2557
1008.7	253
.1013.4	2537
.1016.7	254
.1023.6	256
.1024.4	254
10.10.41.1	

ald to Vancourer.

ision, Vancouver, whe given without change 1 a discrepancy of 39 f erior, and the Atlant btraction of 39 feetfa comparison with a pronunction of the second eet at Glacier House and by comparison w n profiles in the office s, Ottawa, which seen west to Notch Hills tions received from 1 s verification by level distance the discrept Lytton, and through ese elevations agree of the second edited and with the blue is railway, Montreal

API "NDIX II.

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Miles from Winnipeg.	Feet above the sea. (Abbott.)	Feet above the sea. (Revised.)
ponald	2604	2565
Beaver 1035.6	2453	2414
six Mile Creek station	2633	2594
Bear Creek station 1050.0	3680	3641
Rogers Pass station 1055.0	4222	4183
Summit grade in Rogers Pass, crossing the		
Selkirk Monntains 1056.5	4366	4327
Glacier House station	4102	4072
Ross Peak Siding1065.5	3471	3441
Illecille waet	2740	2710
Albert Canyon station1081.0	2244	2214
Twin Butte station 1091.0	1918	1898
Revelstoke (at the second crossing of the		
Columbia River)1103.0	1515 -	1495
summit grade in Eagle Pass, crossing the		
Gold range	1848	1828
(lanwilliam	1827	1807
Griffin Lake station 1120.0	1537	1517
Craigellachie 1130.5	1259	1239
Seamous bridg, crossing narrows of Shuswap lake, 1173 (1153); Sicamous		
station1147.0	1171	1151
Salmon Arm	1175	1155
Tappen Siding1173.5	1168	1148
Notch Hill station (Shuswap summit) 1183.0	1708	1688
shuswap	1173	1153
buck's 1214.5	1150	
Kamloops1231.5	1153	
Tranquille 1239.5	1134	
Cherry Creek station 1245.5	1134	
Savona's	1158	
Penny's	1252	
Asheroft	996	
Spatsum	854	
Spence's Bridge station	768	
brypock 1309.5	752	
Lytten	687	
Cisco	558	
Keefer's	555	
North Bend	487	
Spuzzum	394	
Yale	217	
llepe	208	••••
Ruly Creek station	205	••••
Agassiz	94 52	
Agassiz	52 38	••••
Nicomen	23	••••
adoment	2.5	••••

	Miles from Winnipeg.	Feet above the sea. (Abbott.)	Feet above the sea, (Revised.)
Mission	1439.5	33	teres (1964)
Wharnoek	1449.5	14	
Hammond	1457.5	19	
Port Moody	1469.5	5	
Hastings		22	
Vancouver, 2904.8 miles from Montrea	11482.0	3	

d. Emerson Branch.

From Collingwood Schreiber, engineer of government railways, Ottawa. It agrees with the Saint Paul, Minneapolis & Manitoba Railway on the international boundary.

	files from Vinnipeg.	Feet above the sea.
Winnipeg	0.0	757
Red River, grade on Louise bridge	0.8	752
Winnipeg Junction (of this branch with the main		
line)	2.0	7.50
Saint Boniface, 429.6 miles from Port Arthur	3.0	751
River Seine, high water	10.5	760
Saint Norbert	12.0	767
Niverville	23.5	774
Rat River, low water, 752; high water	30.0	763
Otterburne	30,6	779
Dufrost,	39.0	791
Arnaud	47.0	794
Rosean Rivor, low water, 761 ; high water, 1880	54.5	779
Dominion City.	55.0	7.5
Joe River, low water, 756; extreme high water	62.6	785
Emerson, 391.1 miles from Saint Paul	65.0	790
Grade on the international boundary, connection		
with the St. P., M. & M. Railway	65.1	790

c. Southwestern Branch.

From R. M. Pratt, engineer, Winnipeg; and west of Manitou in part for profile in the office of P. A. Peterson, engineer, Montreal.

The profile requires an addition of twenty-four feet, which is made here. agrees near Gretna and at Emerson with lines of the Saint Paul, Minneapols Manitoba Railway on the international boundary, and at Thornhill w levelling from Park River, North Dakota, in the survey of the beaches of L Agassiz. Miles from

	mines trom	r eet atom
	Winnipeg.	the sea.
Winnipeg, 1422.8 miles from Montreal	0.0	757
Junction of this branch with main line	1 1	760
Saint James	3.6	764
Assiniboine River, ordinary low and high water	3.7	736-754

24416+ La Salle

wate

La Salle Seratchin wate: The ma 4, i/ Morris ... Rosenfehl On the Gretna Grade on with a Railw On th Eme Crossing th Marais Riv West Lynn Red River, Emerson.. On the Morden Thornhill ... Summit, gra Darlingford. summit, gra Manitou.... In the d Pembi 1552) t very in deep a La Riviere . Pembina Riv Ascondin is brok where The wie Pilot Monnel. ummit, grad Crystal City ...

Crystal t'reek, Summit, natur Clearwater, w 1426; grad

135 E

	appendix II.		135
ove.	м	ites from	Feet above
a.	La Salle (or Stinking) River, ordinary low and high	innipeg.	the sea.
d.)	water	18.3	737-750
	La Salle station	18.5	770
·	seratching River (R. aux Gratias), low and high		
	water	42.0	744-770
	The upper part of this stream, above the marshes in which it is lost in T. 7, Rs. 2, 3 and 4, is called Boyne River (R. aux Hes du Bois).		
	Morris	42.8	772
va.	Resenfeld, junction of lines to the south and west On the line south from Rosenfeld :	56.2	796
on the	Gretna	70.1	820
t above	Grade on the international boundary, connection with the Neche line of the St. P., M. & M.		
e sea.	Railway	70.4	* 830
757	On the line (abandoned) from Rosenfeld to		
752	Emerson :		
	Crossing the first initial meridian, grade	62.1	794
752	Marais River (R. aux Marais), bed	68.9	781
754	West Lynne	75.7	790
760	Red River, low and high water	77.0	750-787
767	Emerson	77.2	790
774	On the line west from Rosenfeld :		
763	Morden	80.6	978
779	Thornhill	87.9	1314
791	Summit, grade	94.4	1588
794	Parlingford	95.9	1560
118	summit, grado	99.4	1618
7~5	Maniton	102.4	1586
785	In the descent from the top of the bluff of the		
796	Pembina River valley at 106 miles (grade, 1552) to its bottom at 112 miles, the profile is		
790	very irregular, with frequent cuts 10 to 50 feet		
	deep and tills of 10 to 30 feet.	11.5 #	1004
	La Riviero		1304
i part fri	Pembina River, water, 1287; grade		1304
	Asconding from the remotina valley, the prome		
de here.	is broken by many ravinos to 119 miles,		
inneapola	where grade at the top of the bluff is 1547.		
ornhill w	The width of this valley is one to two miles.		
thes of L	Pilot Mound		1549
	summit, grade		1555
Feet ab			1513
the sea			1500
101			1519
760			
764	, Brenn en state en s	134.1	1498
736-75			

above	Feet abov
8 8ea.	the sea,
obolt.)	(Revised
33	
14	
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railways, Ottawa oba Railway of

iles from	Feet above
linnipeg.	the sea.
0.0	757
0.8	752
2.0	752
3.0	754
10.5	760
12.0	767
23.5	774
30.0	763
30.6	779
39.0	791
47.0	794
54.5	179
55.0	7-5
62.6	785
65.0	2743
65.1	790
Manit	on in part
or, Mon	treat.

which is mad int Paul, Min and at Thor of the beach

Feet at
the se
757
76
76
736-75

Mites from Winnipeg.	Feet above the sea.
Smoothly undulating contour reaches from 137	the sea.
to 141 miles, with grades from 1515 to 1582;	
also between 141 and 147 miles, with grades	
from 1525 to 1535 feet.	
Cartwright 144.9	1533
Badger Creek, water, 1476; grade 147.6	1509
Moderately undulating surface extends thence	
to 156 miles, the highest grades being 1535 to	
1551 feet.	
Holmfield 155.4	1551
Long River (White Mud River), water, 1541; grade 155.7	1551
Thence the line rises gradually westward to	
169.4 miles where the natural surface and	
grade are 1649 feet.	
Killarney 164.1	1625
Little Pembina station 169.7	1649
Pembina River, water, 1605 ; grade 170.3	1645
The valley here is only 40 feet deep and about	
40 rods wide.	
Lake, water, 1636; grade 171.7	1641
Lake, water, 1645 ; grade 172.2	164×
Summit, level grade 181.1-181.7	1690
Boissevain 182.7	1683
Whitewater Lake, low and high water 192.7	1632 - 1637
Deloraine	1644
The last twenty-tive miles of this line lie near	
the northern base of Turtle Monutain.	

f. Manitoba & Southwestern Railway.

[Operated by the Canadian Pacific Railway Company.]

From R. M. Pratt, engineer, Winnipeg, and west of Elm Creek in parties profile in the office of P. A. Peterson, engineer, Montreal. With uniform addition of twenty-four feet.

	Mites from Winnipeg.	Feet ab the 4
Winnipeg	0.0	10,
Junction with Canadian Pacific Railway	1.2	70
Colony Creek, bed	2.8	758
Sturgeon Creek, low water	7.5	7-6
Assiniboine River, low and high water	14.0	754-74
Headingly	14.2	776
La Salle River, low and high water		768-771
Starbuck	27.2	751
Elm Creek station, junction of Carman branch On the Carman branch :	45.0	>1 9
Maryland (on the Burnside beach of Lake Agassiz)	47.5	814
Barnsley (end of track)		854

(PHAN.] End of Soyne 1 wat 0a Burnsid The la e Slotigh, slough, 1 Slough, lloyno R Norcross The an Norcross llerman The e an Summit, an Little Bo Treberne Boyne Ri Herman I The d wes Summit, 1 the hi Holland .. Cypress R Cypress Ri Glenboro (Summit in Divide bet Lang's that fle Prairie wes

The following from Winnipeg fourfeet, like th

Souris Rive

1. les from Feet th innipeg. 144.9 147.6 155.4 155.7 164.1 169.7 170.3 . 171.7 172.2 31.1-181.7 . 182.7 . 192.7 163

. 202.7 1644 r ruy. y Company.] Eim Creek in partiru al. Miles from Feet abs Winnipez. thesa. 0.0 757

1.2 • 2.8. 7.5• 14.0 775 766-771 14.2 26.8 • 27.2751 . -19 45.0 . 814 () 47.5 854 . 51.0

APPENDIX II.

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et abore he «ea,	End of grade, one mile north of Carman	Miles from Winnipeg, 541.0	Feet above the sea, S61
	Boyne River (R. aux Hes du Bois), low and high		
	water	56.5	842-854
	On the main line west from Elm Creek junction	:	
1533	Barnside beach of Lake Agassiz, crest, 845; grade	46.1	841
1509	The descent from the crest eastward is ten feel in 25 rods, and westward seven feet in ar		
	equal distance.		
	Slough, water, 965 ; grade	57.8	947
1	slough, water, 1016; grade		1018
1551	Siough, water, 1043; grade		1045
1551	Boyne River, low water, 1034; grade		1045
	Norcross beach b of Lake Agassiz, crest, 1167; grade		1162
			1102
	The descent from the crest eastward is 15 feet		
1625	and westward 10 feet.		1 4 1
1649	Norcross beach a, crest, 1195; grade		1191
1645	Ilerman beach dd, crest, 1211 ; grade		1206
	The descent from the crest eastward is 15 feet	,	
	and westward 7 feet.		
1641	Summit, on the Herman beach d, natural surface		
1648	and grade		1217
1690	Little Boyne River, low water, 1169; grado		1209
1653	Treherne		1212
32-1637	Boyne River, low water, 1166 ; grade		1222
1644	Herman beach bb, crest, 1252; grade		1247
	The descent from the crest both to the east and	1	
	west is about ten feet.		
	Summit, natural surface and grade the same, bein		
	the highest grade on this profile		1248
	Holland		1237
]	Cypress River station	. 95.0	1232
n part fra	Cypress River, low water		1214
	Glenboro (end of track, 1886)	. 105.0	1231
1.0	Summit in sec. 4, T. 6, R. 16		1489
Feet abon	Divide between Souris River and Pelican Lake, i	n	
the sea	Lang's Valley (the channel of a glacial rive	r	
192	that flowed southeast to the Pembina River) .		1364
ទួស	Prairie west of Lang's Valley		1524
Tax.	Souris River at Souris City		1164
7.M)	" " at Milford		1114
754-764			

The following branches of the Canadian Pacific Railway, running northward from Winnipeg on the west side of the Red River, receive an addition of twenty. farfeet, like the main line from Winnipeg west :—

g. West Selkirk Branch.

From profile in the office of P. A. Peterson, engineer, Montreal.

	Miles from Winnipeg.	Feet above the sea.
Winnipeg	. 0.0	757
Junction with main line	. 1.5	759
This branch is very nearly level, ranging from	1	
760 to 750 feet, between Winnipeg and Lowe	r	
Fort Garry (also called the "Stone Fort").		
Lower Fort Garry	19.5	754
West Selkirk	23.5	736
End of the "river track"	24.1	724
Red River, ordinary stages of low and high water.	. 24.1	712-725

h. Stonewall Branch.

From R. M. Pratt, engineer, Winnipeg.

	Miles from Winnipeg.	Feet above the sea,
Winnipeg	. 0.0	757
Air Line Junction, with main line	. 1.9	761
Stony Mountain station	. 13.3	773
Stonewall	. 19.8	~1 0

WINNIPEG & HUDSON BAY RAILWAY.

From Collingwood Schreiber, engineer of government railways, Ottawa. With addition of twenty-four feet, as before explained.

	Miles from Winnipeg.	Feet above the sea.
Winnipeg	0.0	757
Junction with the Canadian Pacific Railway	4.7	780
Burnside beach of Lake gassiz about three mile		
south of Shoal Lake, crest and grade the same	. 31.0	560
Lowest natural surface crossed by the railway besid	e	
Shoal Lake, 852; grade	. 38.2	\$55
Shoal Lake, five to fifteen feet deep, surface a	t	
ordinary low stage, 850; low and high water	• ••••	849-853

MANITORA & NORTHWESTERN RAILWAY.

From protiles in the office of George II. Webster, engineer, Portage la Prairie.

These profiles are referred to the Canadian Pacific Railway station at Portage la Prairie, which is called 100 feet. The original figures accordingly receive here a uniform addition of 754 feet to refer them to mean sea level.

, INAV.] Portage stati mile Portage Rail Channel into grade Macdona Westboun White M Burnside grade Woodside White Mu summit, g Depression Gladstone grade Verge of grade Gladstone, White Mn Gopher Cre Secondary 916; g Depres begin Emerado b 929, wi the cre Depres. Third Blan This b desce from Midway ... Second Blan This de ridge wide, depre First or u nearly grade . Depression,

, Montreal. Feet above the sea. s from nipeg. 0.0 757 759 1.5 .9.5 23.5 24.1 24.1 754734 736 724 712-725

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les from	Feet above
innipeg.	the sea.
0.0	757
1.9	761
13.3	773
19.8	\$10

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railways, Ottawa xplained.

les from	Feet above
innipeg.	the sea.
0.0	757
4.7	780
31.0	SGO
38.2	\$55
	849-853

gineer, Portage

cay station at Portage s accordingly receive sea level.

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APPENDIX II.

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a. Main line.		
	files from	Feet above
	go la Prairie.	the sea.
Portage la Prairie, Canadian Pacific Railway		
station, 1478.8 miles west from Montreal, 56		
miles west from Winnipeg	0.0	854
Portage la Prairie, Manitoba & Northwestern		
Railway station	0.0	856
Channel by which the Assinibo'ne River overflowed		
into Lako Manitoba, May 3-15, 1882, bed, 850;		
grade	2.9	859
Macdonald	9.8	837
Westbourne	16.9	831
White Mud River, first crossing, bed, 812; grade	17.4	831
Burnside beach of Lake Agassiz, crost, S60-S62;		
grade at switch of spur track to gravel pit	21.8	860
Wordside	26.8	858
White Mud River, second crossing, bed, 849; grade.	27.3	859
summit, grade (one foot above natural surface)	32.2	878
pepression, filling 3 feet ; grade	34.0	876
Gladstone boach, natural surface at crest, 878;		
grade	84.3	880
Verge of plain of Gladstone, natural curface, 882;		
grade	34.5	884
Gladstone, section house and tank, grade	34.7	884
" passenger station	34.9	883
White Mud River, third crossing, bed, 871; grade	35.7	889
Gopher Creek, bed, 876; grade	36.5	888
Secondary Emerado beach, forty rods wide, crest,		
946; grade	39.1	917
Depression west of this, 914, marking the		
beginning of a more rapid ascent westward.		
Emerado beach, about thirty rods wide, crest, 927-		
929, wind-blown in hollows one to two feet below		
the crest	39.9	927 - 9
Depression west of this, 925.		
Third Blanchard beach, crest and grade alike		969
This beach ridge is thirty rocs wide, with		
descent of five feet both to the east and west		
from its crest.		
Midway	43.3	975
second Blanchard beach, crest, 979; grade43.		980
This deposit is almost flat, not having the usual		
ridged form. It is nearly a quarter of a mile		
wide, and is bordered on the west by a		
depression of two feet, to 977.		
First or upper Blanchard beach, another tract		
nearly like the last, natural surface, 994		
grade		995
Depression, natural surface, 991 ; grade	45.5	993

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N	···- 6	
• Portag	liles from ge la Prairie.	Feet above the sea
Level grade (1 to 2 feet above the natural surface).45.7-	-46.1	 the sea. 1004
Lower McCauleyville beach, crest and grade alike	46.4	1016
Depression west of this, 1014. Middle McCaulowille basen creat 1020; grade	0	
Middle McCauleyville beach, crest, 1029; grade Descent of three and five feet, respectively, to the word and east from the creat	47.0	1025
the west and east from the crest.		
Stream, bed, 1018; grade	47.1	1027
Upper McCauloyville beach, crest, 1039; grade Descent c [*] our and six feet, respectively, to the west and c. st from the crest.	47.6	1035
Lowor Campbell beach, crest, 1061; grade This beach ridge is twenty rods wide, with descont of eight feet east and tive feet west.	48.2	1056
Slight beach mark, natural surface Beginning of nearly level grade on the east margin	48.6	1070
of the Arden beach ridge (two feet above the		
natural surface)	48.7	1079
Arden	51.6	10%
Upper Campbell beach ridge, excavated for ballast,		
crest, 1089; grade	51.8	1054
Snake Creek, bed, 1051 ; grade	52.0	1079
Lower Tintah beach ridge, crest and grade alike This has a width of about thirty-five rods, with a descent of four feet to the east and three feet	55.4	1111
to the west.		
Beach ridge associated with the preceding, crest,		
1115; grade	55.7	1116
Duno crossed on steep grade, crest, 1133; grade Depression west of this, 1131.	56.9	1134
Dunes three to five feet high occur at 57.15, 57.2, and 57.3 miles, with crest and grade		
alike in each, respectively 1150, 11521, and 1154 feet.		
Level grade (0 to 7 feet above the natural sur-		11*1
face)		1151
Upper Tintah beach, crest, 1158; grade		1157
This has a descent of eleven feet in fifty rods east, and three feet in six rods west.		
Nearly level natural surface, 1174-1172; grade 58.1		174-1177
Ridge of dune sand, crest, 1177; grade	58.9	1178
This has a descent of five feet to the east and three feet to the west.		
Ridge of dune sand, crest, 1179; grade This likewise has a descent of five feet to the east and three feet to the west.	•	1180
Dunes at the level of the Lower Norcross beach occur at 60.1, 60.2, 60.25 and 60.3 miles, with their crests successively at 1192, 1192 ¹ / ₂ , 1192 ¹ / ₂ , and	•	

to w ration in loo Neepawa Upper N 1225 The on Eroded grade Herman This des froi anic of t by Herman

This in len; and Stony Cree Bridge Cro Summit gi Little Sask Minnedosa Summit, gi Depression Summit, g Basswood Outlet fron Summit, hi Newdale . Grade and Grade and

Soathelair Salt Lake, Summit, eu Shoal Lako Oak River,

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es from	Feet above
la Prairie.	the sea.
46.1	1004
46.4	1016
47.0	1025
47.1	1027
47.6	1035
48.2	1056
48.6	1070
$48.7 \\ 51.6$	1079 1086
51.8	1084
52.0	1079
55.4	1111
55.7	1116
56.9	1134
3-57.7	1154
57.8	1157
1-58.8	1174-1177
58.9	1178
59.3	1180

APPENDIX II.

	former.]	
	Miles from	
	Portage la Pra	irie. the sea.
	11934 feet. The intervening hollows are two,	
	four, and five feet deep in order from east to	
	west, i.e. at 1190, 11881, and 11871 feet. Grade	
	here	1193
	From the dunes at 58.9 miles and 59.3 miles	
	to 60.5 miles the surface is wind-blown sand	
	with hollows two to four feet deep. The	
	railway bed, formed of this sand, is somewhat	
	insecure, because of its liability to be channel-	
	led by the wind.	
	Neepawa	1206
	Upper Norcross beach, crests successively 12231,	
	1225, and 1225; grade	1227 - 1232
	The descent westward from each crest is only	
	one foot.	
	Eroled escorpment, base, 1225; crest, 1240;	
	grade	1232 - 1239
	flerman beach bb, crest, 1304; grade 64.0	1305
	This ridge has a width of forty rods, with	
	descent of soven feet both to the east and west	
	from its crest. It is found to consist of sand	
	and gravel suitable for ballast, nearly like that	
	of the Arden ridge, and has been purchased	
	by the railway company for this use.	
	Herman beach b, crest, 1523; grade 64.7	1320
	This ridge descends seven feet from crest to base	
	in tifteen rods, the amount of descent and	
	length of slope being nearly alike on the east	
	and west.	
	Stony Creek, bed, 1359; grade	1373
	Bridge Creek station 70.3	1600
	Summit grado (two feet above natural surface) 76.0	1798
	Little Saskatchowan River, bod, 1654; grade 78.4	1669
	Minnedosa, junction of Rapid City branch	1670
	Summit, grade (two feet above natural surface) 83.9	1928
4	Depression, filling eight feet ; grade	1906
7	Summit, grade (three feet above natural surface) 87.0	1956
	Basswood	1949
	Outlet from Basswood Lake, bed, 1932; grade 88.6	1950
7	Summit, highest grade on this railway 92.8	1983
8	Newdale	1975
-	Grade and natural surface	1973
	Grade and natural surface 100.0	1972
-()		1950
	Strathelair 106.1	
	Salt 1 ake, bed, 1855; water, 1860; grado 108.3	1867
	Summit, cutting four feet; grade 109.0	1879
	Sheal Lake station 114.9	1812
	Oak River, bed, 1791; water, 1794; grade 115.0	1811

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GLACIAL LAKE AGASSIZ IN MANITOBA.

M. from	Feet ah.co
Porta, a Prairie.	the sea.
Shoal Lake, about a third of a mile south; water,	
approximately 115.0	1793
Summit, cutting two feet; grade 117.0	1830
Kelloe 123.2	1814
Solsgirth 129.8	1789
Grade (eight feet above the natural surface) 132.0	1697
Ravine, bottom, 1596; grade 132.8	1648
Birdfail Creek, bed, 1538; water, 1540; grade 134.5	1558
Summit, grade (one foot above the natural surface). 137.0	1704
Birtle 137.6	1703
Summit, cutting one foot ; grade 138.0	1706
Stony Creek, bed, 1683; grade 139.0	1701
Summit, grade (one foot above the natural surface). 144.0	1747
Foxwarren 145.2	1742
Summit, grade 149.0	1772
Silver Creek, bed, 1631; water, 1632; grade 153.9	1704
Binscarth, junction of Shell River branch 154,9	1704
Two miles northwest of Binscarth, natural surface	1113
and grade 157.0	1
	1654
Three miles farther northwest, natural surface,	
1515; grade 160.0	1521
Johnson's Creek, bed, 1350; grade 161.8	1468
Old bed of the Assiniboine River, bed, 1317 ; stagnant	
water, 1319; grade 162.7	134.7
Assiniboine River, bed, 1309; water, 1314; grade 162.9	1342
One mile northwest of Assiniboine River, natural	
surface, 1405; grade 164.0	1468
Two miles farther northwest, natural surface and	
grade 166.0	1533
Harrowby 167.6	1593
Grade and natural surface 173.0	1638
Langenburg 180.1	1681

b. Rapid City Branch (Saskatchewan & Western Railway).

Ports	liles from ge la Prairie.	Feet above the sea,	. Line surveyed
Minnedosa	78.5	1670	
Little Saskatchewan River, first crossing, bed, 1643;			
water, 1645; grade	80.2	1658	summit
Riverdale	87.1	1636	Surface
Little Saskatchewan River, second crossing, bed,			Armstrong's
1569; water, 1570; grade	92.4	1579	£6
Rapid City	93.9	1579	Yorkton
A survey from Rapid City westward supplies			Mill Creek (
the following:			bed
Surface, S. E. 1 of sec. 19, T. 13, R. 20	101.5	1701	Surface
" W. 1 of sec. 16, T. 13, R. 21	105.5	1734	Summit

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Oak Riv pose Surface R. 2 Sarface,

Binscartl Four mile surfa Four mile natur

Russell... d. Line su

Red Deer Surface ... surface ... Big Cut Ar Surface Surface Crescent an

line, aj surfa .e... ·urface

surface Ravine, bot surface, one This line end

neridian, betwe he south, and a

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		(1-4V.] APPENDIX II.	143 е
-		Miles from	Feet above
l rie.	Peet abuve the sea.	Portage la Prairie. Oak River, soc. 23, T. 13, R. 22, water, 1668; pro-	the sea.
	1793	posed grade 109.2 Surface on line between sees. 28 and 33, T. 14,	1703
	1830	R. 25 132.0	1688
	1814	Surface, S. W. 1 of sec. 6, T. 15, R. 25. 135.5	1623
	1789		1020
	1697	c. Shell River Branch.	
	1648	e. sneu Kuter Branen.	
	1558	Binscarth 154.9	1713
	1704	Four miles north of Binscarth, grado and natural	
	1703	surface 158.9	1791
	1706	Four miles farther north, grade (three feet above	
	1701	natural surface) 162.9	1797
	1747	Russell	1830
	1742		
	1772	a the second of the Town and the south of the state the	11:11
	1704	d. Line surveyed west from Langenburg to the south side of the Beau	er mus.
	1713	Miles from Portage la Prairie	
	1654	Red Deer Horn Creok, bed 185.0	1721
		surface	1729
	1521	surface 195.0	1726
	1408	Big Cnt Arm Creek, bed 198.5	1651
		Surface 203.0	1720
,	134.7	Sarface	1709
,	1342	Crescent and Leech lakes, a fow miles north of this	
·		line, approximately	1679
)	1405	surfa e 220.0	1763
,	140	surface	1816
0	1533	surface	1863 .
6	1593	Ravine, bottom 236.0	1882
0	1638	surface, end of survey 237.5	1919
	1681	This line ends in the west part of T. 23, R. 7 W. from the se	econd initial
1	10-1	peridian, between the Beaver Hills on the north and the Phease is south, and about fifteen miles east of the File Hills.	ant Hills on
lwa	y).		
from Pra		, Line surreyed northwest from Langenburg, passing northeast and Beaver Hills.	north of the
.5	1670	Miles from	Feet above
		Portage la Prairie	
.2	1658	summit 194.0	1774
.1	1636	Surface 212.0	1721
		Armstrong's Coulée, first crossing, bed 213.9	1686
.4	1579	" " second crossing, bed 217.4	1652
9.9	1579	Yorkton	1633
		bed 223.3	1585
.5	1701		1620
	1734	Summit 231.0	1697
1.5 5.5		Surface	

n Prairie.
5.0
7.0
3.2
9.8
2.0
2.8
34.5
37.0
37.6
38.0
39.0
44.0
45.2
49.0
53.9
54.9

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GLACIAL LAKE AGASSIZ IN MANITOBA.

Miles from Portage la Prairie.	Feet above the sea.
Creek, bed 2003.1	1654
Big Bone Creek (or Little White Sand River), bed. 233.5	1651
Surface 238.0	1690
Owl Creek, bed 240.2	1683
Surface 240.0	1709
Clair Creek, bed 244.5	1691
Small lake 245.7	1711
Surface 252.0	1747
Chippewa Creek, bed 253.8	1736
Surface 256.5	1770
Fern Creek, bed 258_3	1747
Surface 260.0	1781
Bear Creek, bed 262.7	1762
Spring Creek, hed 265.3	1785
Surface	1820
Water-course, bed 272.5	1813
Surface 273.0	1825

Along its last forty miles this line lies from two to seven miles southwest White Sand River. It terminates near the north side of T. 30, R. 10 W. from the second initial meridian, a few miles north of the Beaver Hills and about twenty-five miles east of the Big Touchwood Hills.

REGINA & LONG LAKE RAILWAY.

From R. M. Pratt, engineer, Winnipeg.

	Miles from Regina.	Feet above the sea,
Regina, junction with the Canadian Pacific Rail-		
way, 356.6 miles from Winnipeg	0.0	1885
Qu'Appelle River, low water, 1595; grade	21.4	1605
End of track	22.2	1606
Arm of Long Lake here, in sec. 23, T. 20, R. 21,		
water	29.0	1598
[Longlaketon, at the southeast end of the main lak	e, is about	three mile
farther northwest.]		

NORTHWEST COAL & NAVIGATION COMPANY'S BAILWAY.

From Dr. George M. Dawson, of the Geological and Natural History Survey of Canada.

	Mites from Dunmore.	Fuet above the sea.	At Be
Dunmore, junction with the Canadian Pacific Rail-			W
way, 652.8 miles from Winnipeg	0.	2405	Mouth
Bull's Head Creek, grade on bridge	2.	2314	lo
Seven Persons River, grade on bridge	16.	2446	Mouth
Crossing the west line of T. 11, R. S, a summit of	•		73
grade	27.	2772	lov

Entering Depressio (rossing (Depression Crossing th summit of

PH18.

Lethbridge This elevatio stermined by Tiffeet) at th seral surface

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From levelling Saint Paul ; fi ke Agassiz.

Lakes on the Otter Tail La Red River in Mouth of Pel Mouth of th Wahpeto Mouth of the Lake Travers high wate Red River at Red River at flood, abo surface of grou Red River at and high water (ran Selmont (f water (ran th of Red ow and hi h of Peml 39; ordin ow and his

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es from	Feet above
a Prairie.	the sea.
2.1	1654
13:5	1651
18.0	1690
40.2	1683
43.0	1709
44.5	1691
45.7	1711
52.0	1747
55.8	1736
256.5	1770
258-3	1747
260.6	1781
262.7	1762
265.3	1785
270.0	1820
272.5	1513
273.0	1825

ven miles southwest f of T. 30, R. 10 W. from Seaver Hills and about

peg.

Miles from Regina.	Feet above the sea.
0.0	1885
21.4	1609
22.2	1606
22.2	1598
e, is about	three mile
e, is about	three
RAILWAY.	

atural History

Miles from Dunmore,	Feet above the sea
0.	2405
2.	2314
16.	2446
27.	2772

APPENDIX II.

			Mites from Dunmore.	Feet above the sea.
Entering th	e northeas	st corner of T. 10, R. 11	40.	2592
Depression,	grade		. 49.	2562
rossing the	e west line	e of T. 10, R. 12	. 53.	2614
16	"	T. 10, R. 14	. 65.	2609
	46	T. 9, R. 16	78.	2677
.1	4.6	T. 9, R. 17	. 84.	2707
44	46	T. 9, R. 18		2768
entession.	grade		. 91.	2751
		of T. 9, R. 19		2806
4,	44	T. 9, R. 20	. 103.	2877
mmit of	grade	· • • • • • • • • • • • • • • • • • • •	. 106.	2999
	-			2954
s elevatio	n provos	the approximate correctness on, before this railway was h	of that b	

iver T feet) at the "Coal Banks," about a mile southwest of Lethbridge. The certal surface of the country here is 250 to 300 feet above the river.

DRAINAGE SYSTEM OF THE RED RIVER OF THE NORTH.

From levelling by U.S. engineers, under the direction of Major C.J. Allen, Saint Paul; from railway surveys; and from the U.S. Geological Survey of ake Agassiz.

a. Red River.

	the sector services	
		Feet above
_		the sea.
alore	Lakes on the Otter Tail River in Becker county, Minnesota	
e sea.	otter Tail Lako	1315
	Red River in Fergus Falls, descending 80 feet, approximately	
885	Mouth of Pelican River, about	1115
605	Mouth of the Bois des Sioux River, Breekenridge and	
1606	Wahpeton	943
(10,7)	Mouth of the Bois des Sioux River, highest flood, about	958
1598	Lake Traverse, head of the Bois des Sioux River, low and	
	high water	971-976
ee mila	Red River at McCauleyville and Fort Abercrombie	910
	Red River at McCauleyville and Fort Abercrombie, highest	
	flood, about	934
	surface of ground at Fort Abercrombie	937
	Red River at Moorhead and Fargo, bed, 862; ordinary low	
y Surve	and high water, 870-885 or 890; extreme low and high	
		866-898
et above	water (range, 32 feet)	800-808
the sea.	At Belmont (formerly Frog Point), extreme low and high	
	water (range, 50 feet)	797-847
2405	Mouth of Red Lake River, Grand Forks, bed, 779; extreme	
2314	low and high water (range, 44 feet)	784-828
2446	Mouth of Pembina River, Pembina and Saint Vincent, bed,	
	739; ordinary low and high water, 753-782; extreme	
2772	low and high water (range, 40 feet)	748-788
	10	

At Emerson, on the international boundary, ordinary low

Month of Assiniboine River, Winnipeg, extreme low water, 724 : ordinary summer stage, 730 ; ordinary spring floods, 740-745; high water, 1882, 750; do., 1860, 759; do., 1852, 761; do., 1826, 763; general level of the land surface, 758; extreme low and high water (range, 39 feet)..... 724-763 At the Louise bridge, Winnipeg, extreme low water, 723; ordinary spring floods, about 740; high water, 1882, 749; do., 1826, 763; general level of the land surface, 756; extreme low and high water (range, 40 feet)..... 723-763 At Saint Andrew's church, extreme low water, 715; ordinary spring floods, about 735; high water, 1852, 745; do., 1826, 753, nearly the same as the general level of the land surface; extreme low and high water (range, 38 feet)... 715-753 At Lower Fort Garry (the "Stone Fort"), extreme low water, 711; ordinary spring floods, about 730; high water, 1852, 736; do., 1826, 746; general level of the land surface, 752; extreme low and high water (range, 35 feet)

752; extreme low and high water (range, 35 feet)	711-746
At West Selkirk, extreme low water, 710; ordinary spring	
floods, about 720; high water, 1852, 726; do., 1826, 732;	
general lovel of the land surface, 739; extreme low and	
high wator (range, 22 feet)	710-732
At Saint Peter's church, general level of the land surface,	
730; extreme low and high water (range, 15 feet)	709-7:4
Lake Winnipeg, mean, 710; extreme low and high water,	
approximately	708-713

b. Pembina River.

Whitewater Lako, low and high water	1632-1657
At bridge of the Manitoba & Southwestern Railway, near	
Little Pembina station	Te(i)
Divide between the Souris and Pembina Rivers, in Lang's	
Valley	1364
Bone Lake in Lang's Valley	1357
Grass Lake and Pelican Lake	1355
(Range of Pelican Lake from low to high water, 3 feet.)	
Lakes Lorne and Louise, about	1345
Rock Lake, about	1335
At the Marringhurst bridge, about	1330
Swan Lake, about	1310
At bridge of the Manitoba & Southwestern Railway, La	
Rivière	1287

Feet above the sea,

At the M 22, T. On the in At the " Dako about At the Wa At the Sai At Neche, Month of Month of Junction high y

At bridge 1209; 1 Mouth of t foregoi At bridge o Brande Mouth of f. At outerop about a approxi At Portage miles so the Hue At Portage 1 when th waters 1 This rise east. tlowed before Big Slough, c close so water, 84 tlood of 1 At Pratt's I. Prairie, c and high At centre of 1 of Long In lot 230, Ba At St. Franco. At crossing of

ЗΛ.

Feet above the sea, ry low

750-787 eg and northward are being in considerable ngineer in chief, 1880, here made to accord

water, ; thoods, 0., 1852, surface, 724-763 st) er, 723; er, 1882, surface, 723-763 et).... ordinary do., 1826, the land 715-75 8 feet)... ow water, ater, 1852, surface, 711-74 et)..... ry spring 1826, 732; e low and 710-73 1 surface, 709-7 et) gh water, 708-..... 1632-1 way, near in Lang's

.

er, 3 feet.)

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ilway, La

APPENDIX II.

147 E

*

At the Walhalla bridge, low and high water	feet above the sea.
 On the international boundary, about	
 On the international boundary, about	1235
about 16 At the Walhalla bridge, low and high water. 16 At the Saint Joseph bridge, seven miles east from the last 17 At Neche, bed, 810; low and high water. 16 Month of Tongne River, nbout. 17 Muth of Tongne River, nbout. 17 Muth of the Duluth & Manitoba Railroad	1125
At the Saint Joseph bridge, seven miles east from the last At Neche, bed, SIO; low and high water	050-1043
At the Saint Joseph bridge, seven miles east from the last At Neche, bed, SIO; low and high water	934-943
 At Neche, bed, \$10; low and high water	865
At bridge of the Duluth & Manitoba Railroad Junction with the Red River, Pembina, extreme low and high water	813-832
Junction with the Red River, Pembina, extreme low and high water	770
 c. Assiniboing River. At bridge of the Manitoba & Northwestern Railway, bed, 1209; water. Mouth of the Qu'Appelle River, about 17 miles south of the foregoing. At bridge of the Canadian Pacific Railway, 14 miles east of Brandon Mouth of the Souris River, approximately	757
 c. Assiniboing River. Multiply of the Manitoba & Northwestern Railway, bed, 1209; water. Mouth of the Qu'Appelle River, about 17 miles south of the foregoing. Multiply of the Canadian Pacific Railway, 14 miles east of Brandon. Mouth of the Souris River, approximately. Mouth approximately. Mouth of the Souris River, approximately. Mouth approxi	
At bridge of the Manitoba & Northwestern Railway, bed, 1209; water. Month of the Qu'Appelle River, about 17 miles south of the foregoing. At bridge of the Canadian Pacific Railway, 14 miles east of Brandon Month of the Souris River, approximately Month of Paritely Month of Lake Manitoba Month of the river overflowed here, sending part of its waters north to Lake Manitoba Month of Paritely in 1860). Mit side here to Lake Manitoba Month here to Lake Manitoba Month here to Lake Manitoba Month of Paritely to Parite, ordinary stage of water, S49; in ordinary spring floods, S50; in the grea	748-788
 1709; water	
 Month of the Qu'Appelle River, about 17 miles south of the foregoing	
 foregoing	1314
At bridge of the Canadian Pacific Railway, 13 miles east of Brandon Brandon Month of the Souris River, approximately At onterop of Niobrara limestone in see. 30, T. 8, R. 11, about 31 miles east of the month of Cypress River, approximately At Portage la Prairie, ordinary low and high water, two miles southwest from the town, near the former site of the Hudson Bay Company's fort At Portage la Prairie, extreme high water, May 3-15, 1882, when the river overflowed here, sending part of its waters north to Lake Manitoba This rise was caused by an ice jam a few miles farther east. It is said that the river had previously overflowed here to Lake Manitoba about twenty years before (probably in 1860). Big Slongh, occupying a deserted channel of the Assiniboine close south of Portage ha Prairie, ordinary spring floods, 850; in the great theod of May, 182, 854; range, 5 feet At Parti's Lauding, 21 miles southeast from Portage la Prairie, ordinary low and high water, \$40-849; lowest	10.14
 Brandon	1264
 Month of the Souris River, approximately	1101
At outcrop of Niobrara limestone in see. 36, T. 8, R. 11, about 31 miles east of the month of Cypress River, approximately	1161 1100
 about 32 miles east of the month of Cypress River, approximately	1100
 approximately	
 At Portage la Prairie, ordinary low and high water, two miles southwest from the town, near the former site of the Hudson Bay Company's fort	1000
 miles southwest from the town, near the former site of the Hudson Bay Company's fort	
 the Hudson Bay Company's fort	
 At Portage la Prairie, extreme high water, May 3-15, 1882, when the river overflowed here, sending part of its waters north to Lake Manitoba	842-850
 waters north to Lake Manitoba	
 waters north to Lake Manitoba	
 east. It is said that the river had previously over- flowed here to Lake Munitoba about twenty years hefore (probably in 1860). Big Slough, occupying a deserted channel of the Assiniboine close south of Portage ha Prairie, ordinary stage of water, 849; in ordinary spring floods, 850; in the great flood of May, 1882, 854; range, 5 feet	854
 flowed here to Lake Manitoba about twenty years before (probably in 1860). Big Slongh, occupying a deserted channel of the Assiniboine close south of Portage la Prairie, ordinary stage of water, \$49; in ordinary spring floods, \$50; in the great flood of May, 1882, \$54; range, 5 feet	
 before (probably in 1860). Big Slongh, occupying a deserted channel of the Assiniboine close south of Portage h Prairie, ordinary stage of water, \$49; in ordinary spring floods, \$50; in the great thood of May, 1882, \$54; range, 5 feet	
 Big Slough, occupying a deserted channel of the Assiniboine close south of Portage h Prairie, ordinary stage of water, 849; in ordinary spring floods, 850; in the great flood of May, 1882, 854; range, 5 feet	
 close south of Portage la Prairie, ordinary stage of water, 849; in ordinary spring floods, 850; in the great thood of May, 1882, 854; range, 5 feet	
 water, 849; in ordinary spring floods, 850; in the great thood of May, 1882, 854; range, 5 feet	
 thood of May, 1882, 854; range, 5 feet Mt Pratt's Landing, 21 miles southeast from Portage la Prairie, ordinary low and high water, \$40-849; lowest 	
1355 At Pratt's Landing, 23 miles southeast from Portage la Prairie, ordinary low and high water, \$40-\$49; lowest	0.00 054
Prairie, ordinary low and high water, \$40-\$49; lowest	849-854
1345 and highest stages	837-852
1335 At centre of lot 142, Baie St. Paul, near the southeast end	001-002
1330 of Long Lake	796
1310 In lot 230, Baie St. Paul	779
At St. Francois Xavier church	765
1287 At crossing of the Winnipeg meridian, in Headingly	757

At Hendingly, 13 miles further east, ordinary low and high	Feet above the sea,
water	754-764
Mouth of Sturgoon Creek	745
At Saint James, ordinary low and high water	786-754
728-742; extreme low and high water	721-763

d. Lakes on the Qu'Appelle River.

From H. Y. Hind; referred to sea level approximately by comparison with elevations determined by levelling.

	the sea.
Sand Hill Lake	1685
Divide in glacial water-course between the Elbow of the	
South Saskatchewan and this lake	1704
Bnffalo Lake	1635
Qn'Appelle River at bridge of the Regina & Long Lake	
Railway	1595
Long Lake, tributary to the Qu'Appelle River	1598
Fishing Lakes	1504-1500
Crooked Lako	1389
Round Lake	1364
Junction of the Qu'Appello with the Assiniboino	1264

e. Souris or Mouse River.

On the international boundary, crossing from Assiniboia	
into North Dakota, 215 miles west of the Red River,	
about	1650
At Minot, North Dakota	1535
At Towner, North Dakota	1440
Crossing the international boundary 170 miles west of the	
Rod River, about	1400
At Plum Creek, Manitoba, about	1335
At the Elbow west of Lang's Valley, 21 miles east-southeast	
from the last, about	1265
At Gregory's mill, in sec. 34, T. 6, R. 18, five miles north from	
tl e last, head 8 feet, about	1210-1202
At Souris City	1164
At Milford	1114
Junction with the Assiniboine, about	1100

ALTITUDES ON THE CANOE ROUTE FROM LAKE SUPERIOR TO LAKE WINNER, WAY OF THE KAMINISTIQUE RIVER.

Determined by levelling by S. J. Dawson in 1857 and 1858, and published Hind's Narrative of the Canadian Exploring Expeditions, London, 1860, vol. pp. 399–402; corrected approximately by comparison with the survey of Canadian Pacific Railway.

Month Sup Mountai tiqu (inc Rocky p ascer Nine 12 bel Little Dog Great Do to Gr Summit o sand llighest 1 porta "The surj leve in s Great Dog on this Mouth of 1 Cold Water l'airie port Height summit of The highest lleight of 1 route ... The pe " pass small avanne La Great Savan feet to t Thousand La on the r Thousand L high wa The Sein to Rai feet, aj "falls 3

OBA.

Feet alore the sca. 754-764 764-764 736-754 736-754 ch. water, 721-763

ely by comparison

. free rath wild
Feet above
the sea.
1685
1704
1635
1595
1598
1501-1500
1389
1364
1264
1650 1565
. 1440
9
. 1400 1335
•
at 1265
n 1210-1202
. 1164
. 1114
. 1114

ar. d 1858, and publish

us, London, 1860, vol. with the survey of

APPENDIX II.

a. From Lake Superior to the Lake of the Woods.

a.		Miles from	Feet above
4	La	ake Superior.	the sea.
	Month of the Kaministiquia River, Lake		
4	Superior	0.0	602
3	Mountain portage (Kakabeka Falls), Kaminis-		
	tiquia River, 248 rods, ascending 119 feet (including 14 feet of rapids below the alls).	29.2-30.0	681-800
	Rocky portage (or Ecarté portage), 148 rols,	20.2-00.0	031-300
	ascending 63 feet	80.2-80.7	800-863
with	Nino portages, ascending successively 63,		0.00 000
ve	121,7, 19, 10, 3, 3, 3, and 15 feet, intervene		
a. 👘	between the last and Little Dog Lake.		
55	Little Dog Lake, 1.2 miles across on this route.	52.3 - 53.5	1002
04	Great Dog portage, 1 ^a miles, ascending 348 feet,		
114	to Great Dog Lake	53.5 - 55.2	1002-1350
	Summit of this portage (a broad and massive sand ridge)	54.0	1470
395	lighest part of this sand ridge, east of the	94.0	1470
598	portage path, about	54.0	1500
500	"The great falls of Little Dog River are		1000
389	surprisingly beautiful. The difference in		
364	level between Little and Great Dog Lakes		
264	is doscended by the foaming torrent		
	in six successive leaps."		
	Great Dog Lake, 90 feet deep, crossed 10 ^a miles		
		55.2-66.0	1350
	Mouth of Prairie River, tributary to Dog River.	98.8	1378
650	(64) Water Lake, crossed 0.2 mile on this route. 10 Trairie portage, 22 miles, ascending 157 feet, to	1.9-102.1	1381
1535	Height of Land Lake	9.1-104 g	1381-1538
1440	symmit of this portage, about		1570
1400	The highest land there within view is about		1600
1:335	Height of Land Lake, crossed 0.2 mile on this		
	route	04.6 - 104.8	1538
1265	The portage from this to Savanne Lake		
	" passes over a low sandy ridge supporting		
1202	small pine."		
1164	savanne Lake, crossed 12 miles on the route10	15.4-106.9	1522
1114	Great Savanne portage, 1 ¹ / ₂ miles, descending 32	w n 100 i	1-00 1100
1100	fect to the Savanne River16 Thousand Lakes (Lac des Mille Lacs), 21 ^a miles	0.9-102.4	1522-1490
	on the route	n aliana.	1485
MPLO ₁ I	Thousand Lakes (Lac des Mille Lacs), low and	1.0-110.1	1400
	high water, approximately		1483-1488
blisheli	The Scine River, ontflowing from this lake		
it, vol	to Rainy Lake, has a total descent of 368		
ey of t	feet, approximately. Hind states that it		
	"falls 350 feet by twenty-nine steps vary-		

Mites from Lake Superior.	Feet above the sea,
ing in altitude from three to thirty-six feet."	
Baril Lake, on the head stream of Sturgeon	
River, crossed 8 miles on the route 143.d-151.d	1187
Brulé portage, 84 rods, descending 47 feet 151.6-151.9	1487-1410
Upper Brulé Lake (or Cannibals' Lake), 8 miles	
on the route	1140
Lower Brulé Lake, 41 miles on the route 159.9-164.1	1437
Great French portage, 11 miles, descending 100	
feet to French Portage Lake	1437-1837
French Portage Lake, 11 miles on the route165.9-167.4	1:137
Pickerel Lake, 13 miles on the route 169.9-182.9	1336
Pickerel portage, 104 rods, descending 7 feet to	
Doré Lake	1336-1329
Doré Lake, 11 miles on the route 183.2-185.0	1329
Deux Rivières portage, 128 rods, descending 117	
feet to Sturgeon Lake 185.0-185.4	1329-1212
Sturgeon Lake, 23] miles on the route185.4-208.6	1212
First Sturgeon rapids, descending 4 feet in 44	1010 1
rods 208.6-208.7	1212-12(8
Second Sturgeon rapids, portage 12 rods,	
descending 6 feet 209.0	1208-1202
Island portage, 12 rods, descending 10 feet 221.2	1197-1187
Nequanquon Lake (or Lac la Croix), 8 miles on	
the route	1186
Rattlesnake portage, Namekan River, 20 rods,	
descending 12 feet 235.2-235.3	1181-1172
Crow portage, 32 rods, descending 10 feet 238.6-238.7	1171-1161
Grand Falls portage, 24 rods, descending 16 feet, 245, 2-245, 3	1158-114:
Foot of Grand rapids, Namekan River	1427
Lake Namekan, 6½ miles on this route	1126
Rainy Lake, 38 miles on this route	1117
low and high water, approximately	1115-1120
Rapids, Rainy River, 1 mile, descending 3 feet 301.3-301.8	1117-1114
Chaudière Falls, close east of Fort Francis,	
portage 32 rods, descending 23 feet	1114-109
Maniton rapids, descending 21 feet in 60 rods336.2-336.4	1081-1078
Long Sanlt, descending 3 feet in 1 mile	1075~101
Lake of the Woods, crossed 72 miles on this	

The different Winnipeg de pilway surve

Lake of 1 1061 Rat Porta

Les Dalle Grand Dé Terro Jau Charetto I Terro Bla fect... Cave rapic

Month of 1 De l'Isle pe Chute à Ja descen Point des 1

Point des 1 feet... Point anx (rods, de

Roche Brul Slavo Falls, Barrier Fall Otter Falls,

Seven F 8, and Foot of the s Bonnet Lako Bonnet port Cap de Bon feet....

lig Bonnet feet....

Petit Roche White Mud I Silver Falls

1060

rods, des Pine portage, At Fort Alex Month of Riv and high

liere are thus meen the Lake

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Just.]

s from Superior. Feet above the sea 1-151.6 11 1-151.9 1487-14 9-150.0 1 9-164.1 1 1-165.8 1437-1 9-167.4 1 9-182.9 13 9-183.2 1336-4 2-185.0 .0-185.4 1329-1 .4-208.6 .6-208.7 1212-209.0 1208-221.2 1197-225-233 .2-235.3 1184 .6-238.7 1171 .2-245.3 1158 248.8 .3-257.8 .3-301.3 1117 .3-301.8 1117 .3-303.4 111 .2-336.4 108 .9-343.1 107

.1-453.1

APPENDIX 11.

b. Winnipeg River.

The difference in elevation between the Lake of the Woods and Lake $\min_{i=1}^{n} determined$ by this survey agrees exactly with that found by the place survey.

187	Miles from the take of thu	Feet above
440	Lake of the Woods, low and high water, 1057-	the sea.
		1000
1440		1060
1437		1060-1044
1 104		1043-1040
1337	Grand Décharge, descending 6 feet in 1 mile 33.55-33.8	1038 - 1032
1337	Terre Jaune portage, 20 rods, descending 22 feet. 35.7-35.8	1029-1007
1336		10061-1003
1 (1(1))	Terre Blanchø portuge, 40 rods, descending 8	
1329	feet	1002-094
	Cave rapids, descending 24 feet in 8 rods 38.0	-9931-991
1329	Month of English River, approximately 54.0	1987
1.01.0	perisle portuge, 8 rods, descending 34 feet 57.0	9861-983
-1212	(Inte à Jacques portage [Jack's Falls], 12 rods,	
1212	descending 13 feet S0.1	979-966
	Point des Bois portage, 52 rods, descending 104	
-1208	feet	9644-954
	Point aux Chénes portage [the Upper Falls], 20	
-1202	rods, descending 20 feet	954-934
-1187	Roche Brulé portage, 12 rods, desconding 8 feet. 91.1	933-925
	Slave Falls, portage 120 rods, descending 20 feet 95.5-95.9	924-904
1186	Barrier Falls, portage 8 rods, descending 5 feet. 102.0	902-897
	otter Falls, descending 3 feet in 4 rods, 107.0	\$95-\$92
1-1172	Seven portages, successively 10, 8, 51, 8, 3,	
-1161	8, and 4 ⁺ feet, follow.	
5-1142	Foot of the seventh portage	826
1127	Bonnet Lake, 41 miles across on this ronte127.6-132.1	823
1126	Bonnet portage, 4 rods, descending 7 feet 132.2	823-816
1117	Cap de Bonnet portage, 16 rods, descending 5	000 010
5-1120	fret	814-869
7-1114	Big Bonnet portage, 200 rods, descending 34	0
	feet	805-771
4-1691	Petit Roche portage, 52 rods, descending 8 feet.137.1-137.3	770-762
s1-107s	White Mud portage, 60 rods, descending 13 feet.140.7-140.9	758-745
15-1072	silver Falls [or Lower Falls], two portages, 92	100-110
	rods, descending 22 feet144.4-144.7	744-722
1069	Pine portage, 48 rols, descending 8 feet 150.25-150.4	720-712
	M Fort Alexander	720-712 710
1.1	Mouth of River, Lake Winnipeg, mean, 710; low	/10
		700 710
	and high water, approximately	708-713
	here are thus twenty-seven portages (the two décharges l	being included)

ween the Lake of the Woods and Lake Winnipeg.

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SASKATCHEWAN RIVER.

From surveys of the Canadian Pacific Railway; of the Geological and Natural llistory Survey of Canada, by Dr. G. M. Dawson, R. G. McConnell, and J. B. Tyrrell ; and of the Assiniboine and Saskatchewan Exploring Expedition by H. Y. Hind. Fout also

n, 1, mina.	Feet above	Lake Win
Bow River at the Gap, where it issues from the Rocky	the sea,	Great and
Mountains, about	4215	sea Rive
Bow River at Calgary, mouth of the Elbow River	3390	about
" at the Blackfoot Crossing, near the centre of T.	00140	Pipestone end of
21. R. 21	2595	
Belly River at the "Coal Banks," Lethbridge	2717	sipi-wesk
Confluence of the Bow and Belly Rivers, forming the South		Grand rap
Saskatchewan	2212	steep Split Lake
South Saskatchewan River at Medicine Hat, low and high		tiull Lake
water	2137-2154	Lake,
South Saskatehewan River at month of Red Deer River	1958	Twelve-fee
" in T. 22, R. 18, long. 108° 27'	1782	Lake,
at the Elbow	1619	Foot of Br
North Saskatchewan River at Rocky Mountain House and		little r
mouth of Clearwater River, about	3150	the T
North Saskatchewan River at month of Brazeau River	2637	month
" at big coal seam (27 feet thick,		Foot of Fig
but including two feet of shale), Goose Encampment,		by the
long. 114°30′	2307	about.
North Saskatchewan River at proposed crossing of the		
original line of the Canadian Pacific Railway, long. 114°	2106	ATTUTUES ON
North Saskatchewan River at Edmonton, about	2006	
Edmonton, 200 feet above high water level of the river,		From reports
about	2210	ad the U.S.
North Saskatchewan River at Victoria, near mouths of Egg		emparison with
and Smoky Creeks	1871	paparison irre
North Saskatchewan at Fort Pitt	1722	Taka Suma
Junction of the South and North Saskatchewan Rivers,		Lako Supe
estimated	1200	.approxi Mountain I
Cedar Lake	824	South Lake
Cross Lake	515	Water divi
Head and foot of Grand rapids of the Saskatchewan,		Lakes
extending from about four and a half to two miles above		North Lake
its mouth (fall stated by Hind to be 431 feet in these two		Gunflint La
and a half miles, the upper 284 feet being passed by a	P.17	Saganaga L
portage a little more than a mile long), approximately.	765-729	Otter Track
Lake Winnipeg, mean, 710; low and high water, approxi-	708 710	Knife Lake.
mately	708-713	Basswood L

The followi Robert Bell (

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Lakes.. orth Lake, unflint La aganaga La tter Track nife Lake . asswood La Lae la t'roix Namekan Le Rainy Lake

mately.

152 E

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f the Geological and , R. G. McConnell, and Exploring Expedition,

	Feet above
	the sea,
Rocky	
	4215
	3390
re of T.	
	2595
	2717
e South	
	2212
nd high	
	2137-2154
 iver	1958
271	1782
	1619
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	3150
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ong. 114	2000
he river,	
ns of Egg	
· • • • · · • • • •	1871
	1722
1 Rivers	,
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monrox	-
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APPENDIX II.

NELSON RIVER.

The following estimated elevations of points on the Nolson River are by Dr. Rent Bell (Reports of Progress, Geol. Survey of Canada, 1877-79).

		the sea.
Jake Wit	mipeg	710
Great and	Little Playgreen Lakes, also	710
sea Rive	r Falls, seventeen miles below Norway House,	
about		705-700
Pipestone	and Cross Lakes, on the Nelson River at the north	
end o	f Ross Island, about	665
sipi-wesk	Lake on Nelson River from lat. 55° to 55°20', about	565
	pid, "a descent of about fifteen feet in the form of a	
	chute," four miles south of Split Lake, about	460-445
	e, in lat. 56°15' to 56°35', about	440
	e, eighteen miles below (east-northeast of) Split	
	abont	 420
	et chute, forty-three miles below (east of) Gull	
	. about	200-188
Foot of B	road rapid, "two miles wide, and full of knobs and	
	ridges of gneiss," extending five miles next below	
	fwelve-feet chute, or 116 to 111 miles from the	
	h of Nelson River, about	125
	irst or Lowest Limestone rapid, about ninety miles	
	ie course of the river above its mouth, probably	
		50
MILITUPES C	ON THE INTERNATIONAL BOUNDARY FROM LAKE SUPER ROUKY MOUNTAINS.	NOR TO THE
END FILMP	ts of X 11 Winchell 11 X Hind G M Dawson R	G. McConnell
From repor	ts of N. II. Winchell, II. Y. Hind, G. M. Dawson, R. S. Northarn, Boundary, Commissions, referred to	G. McConnell
ad the 1'.	S. Northern Boundary Commission; referred to	G. McConnell sea lovel by
ad the 1'.	ts of N. 11, Winchell, 11, Y. Hind, G. M. Dawson, R. S. Northern Boundary Commission; referred to ith railway surveys.	G. McConnell sea lovel by Feet above
nd the 1'. Imparison w	S. Northern Boundary Commission; referred to ith railway surveys.	sea level by
nd the 1'. Imparison w Lake Suj	S. Northern Boundary Commission; referred to ith railway surveys. serior, mean, 602; extreme low and high water,	sea lovel by Feet above the sea.
nd the 1'. Imparison w Lake Sup Appre	S. Northern Boundary Commission; referred to ith railway surveys. serior, mean, 602; extreme low and high water, eximately	sea level by Feet above the sea. 599–604
ad the 1°. mparison w Lake Suj appre Mountair	S. Northern Boundary Commission; referred to ith railway surveys. serior, mean, 602; extreme low and high water, minately	sea lovel by Feet above the sea. 599–604 1652
ad the U. mparison w Lake Sup uppre Mountair south La	S. Northern Boundary Commission; referred to ith railway surveys. serior, mean, 602; extrome low and high water, oximately	sea level by Feet above the sea. 599–604
ad the U. Emparison W Lake Sup appre Mountain South La Water di	S. Northern Boundary Commission; referred to ith railway surveys. erior, mean, 602; extreme low and high water, eximately	sea lovel by Feet above the sca. 599–604 1652 1535
nd the U. Insparison w Lake Sup appre Mountain South La Water di Lake	S. Northern Boundary Commission; referred to ith railway surveys. erior, mean, 602; extreme low and high water, eximately	sea lovel by Feet above the sea. 599–604 1652
ad the I'. maparison w Lako Suj appre Mountain South La Water di Lako North La	S. Northern Boundary Commission; referred to ith railway surveys. Derior, mean, 602; extreme low and high water, eximately	sea lovel by Feet above the sca. 599–604 1652 1535
nd the I'. mparison w Lake Sup appre Mountain South La Water di Lakes North La Gundlint	S. Northern Boundary Commission; referred to ith railway surveys. Serior, mean, 602; extreme low and high water, eximately	sea level by Feet above the sea. 599–604 1652 1535 1535 1535 1535
nd the ¹ . mparison w Lake ⁵ ny appre Monntain South La Water di Lake North La Gandint Saganaga	S. Northern Boundary Commission; referred to ith railway surveys. Serior, mean, 602; extrome low and high water, eximately	sea level by Feet above the sea, 599–604 1652 1535 1573 1535
nd the İ'. mparison w Lake Sur Appre Mountair south La Water di Lake North La Gaudint Saganaga Otter Tra-	S. Northern Boundary Commission; referred to ith railway surveys. serior, mean, 602; extreme low and high water, oximately	sea lovel by Feet above the sea. 599–604 1652 1535 1535 1535 1535 1530
nd the İ'. mparison w Lake Sur Appre Mountair south La Water di Lake North La Gaudint Saganaga Otter Tra-	S. Northern Boundary Commission; referred to ith railway surveys. Serior, mean, 602; extrome low and high water, eximately	sea lovel by Feet above the sea. 599–604 1652 1535 1535 1535 1535 1530 1368
nd the I'. mparison w Lake Suppre Mountain South La Water di Lake North La Guntlint Saganaga Otter Trai Knife Lal Basswood	S. Northern Boundary Commission; referred to ith railway surveys. eerior, mean, 602; extreme low and high water, eximately h Lake, at head of Pigeon Rivor ke, at head of Arrow River vide on the boundary, between South and North s ke, at head of waters draining to Rainy Lake Lake ke. Lake Lake Lake	sea lovel by Feet above the sea. 599–604 1652 1535 1535 1535 1530 1308 1326
nd the I'. mparison w Lake Suppre Mountain South La Water di Lake North La Guntlint Saganaga Otter Trai Knife Lal Basswood	S. Northern Boundary Commission; referred to ith railway surveys. serior, mean, 602; extreme low and high water, eximately hake, at head of Pigeon Rivor ke, at head of Arrow River vide on the boundary, between South and North s ke, at head of waters draining to Rainy Lake Lake ck Lake	sea lovel by Feet above the sea. 599-604 1652 1533 1535 1533 1535 1530 1308 1326 1322
nd the 1 ² . mparison w Lake Sup appre Mountair South Lai Water di Lakes North La Gandlint Sagamaga Otter Trav Knife Lah Basswood Lae la Cr	S. Northern Boundary Commission; referred to ith railway surveys. eerior, mean, 602; extreme low and high water, eximately h Lake, at head of Pigeon Rivor ke, at head of Arrow River vide on the boundary, between South and North s ke, at head of waters draining to Rainy Lake Lake ke. Lake Lake Lake	sea lovel by Feet above the sea. 509–604 1652 1535 1535 1530 1368 1326 1322 1244
nd the ¹ . maparison w Lake Sup appro- Monntain South Lai Water di Lake North Lai Gandint Saganagra Otter Tra- Knife Lail Basswood Lae la Cr Namekan	S. Northern Boundary Commission; referred to ith railway surveys. Derior, mean, 602; extreme low and high water, eximately	sea lovel by Feet above the sea. 599–604 1652 1535 1535 1535 1530 1368 1326 1322 1244 1186
nd the ¹ . maparison w Lake Sup Appred Monntain South Lai Water di Lake North Lai Gandlint Saganaga Otter Trai Knife Lai Basswood Lae la Cir Namekan Rainy La	S. Northern Boundary Commission; referred to ith railway surveys. serior, mean, 602; extreme low and high water, scinnately	sea level by Feet above the sea. 599-604 1652 1535 1535 1535 1535 1535 1530 1368 1326 1326 1322 1244 1186 1126

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Feet above

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Woods, flowing s The following a here noted a ch of Sir John

	First above the sea.		ADDITIONA
Lake of the Woods, mean, 1060; low and high water,	the sea.		Mestly from
approximately	1057-1065	-	intart corree
Ridge twelve miles farther west, forming the divide on the boundary between the Lake of the Woods and Roseau		ľ	Pacific Railw.
Lake	1088	1	
Pine River	1047		Lake Nip
Roseau Lake, about	1040		Depressio
Ridge three miles west of Pine River	10;0		Super
Kosean River at Pointe d'Orme	976		Lonely La
Ridge twenty miles east of the Red River	1016		This
Ridge twelve miles east of the Red River	\$48		req
Emerson	790		can
Red River, ordinary stage, 752; low and high water	747-757		sho
Gretna	829		beir
Pembina Mountain, base and top	1030-1500		Lake Sain
Pembina River, approximately	1125		as ma
General level of the adjoining country, about	1540		Lake Lam
Lac des Roches in North Dakota, and divide between this			about.
lake and Badger Creek in Manitoba, about	1520	1	Lake Sain
Turtle Mountain, according to Dr. G. M. Dawson's map	2150		Lake Man
" according to profile in report of the U.S.			of Sair
Boundary Commission	2000-2534		approx
Souris River, first crossing, about	1400		Lake Wi
" second crossing, about	1650		approx
Cotean du Missouri, base and crest	1960-2140		Lake Daup
Wood Mountain, highest portion on the boundary			Swan Lake
" north of the boundary	3350		Divide bety
White Mud River	2550		Cedar Lake
Boundary Platean			Pembina M
East fork of Milk River	2790		Tiger Hills
Wild Horse Lake	2850		Big Tiger 1
Milk River, probably about	2600		Brandon H
West Butte, the highest of the Sweet Grass Hills or Three		H.	Riding Mou
Buttes	6483		Duck Monn
East Butte	6200	R	Thunder Hi
Trail from Fort Benton to Fort MacLeod	3545		Churchill R S. 33° V
North Branch of Milk River one mile north of the boundary,			
long. 113°	4173		River Was-kai-ow-
Eastern base of the Rocky Mountains, long. 113°25', about	45(81	1.6	
Waterton Lake (or Chief Mountain Lake), crossed by the			River.
boundary in long. 113°52', in the east edge of the Rocky		- 1	Churchill R:
Mountains	4245		Churchi
Rocky Mountains, summits in the vicinity of this lake, on			Frog portage
the continental water-shed	500-10.500		Woods,
			flowing s

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APPENDIX II.

ADDITIONAL ALTITUDES IN MANITOLA AND ADJOINING PORTIONS OF CANADA.

Mostly from reports of the Geological and Natural History Survey of Canada; agan corrected approximately by comparison with the Survey of the Canadian Path Railway.

Paci	it kannay.	Feet above tho sea.
	Lake Nipigon (540 feet deep near Echo Rock)	915
1	pepressions in the line of water-shed northwest of Lake	
	Superior	1500-1750
	Lonely Lake (Lae Seul)	1232
	This altitude, determined independently, probably	
	requires some subtraction, for the description of the	
	canoe route from Lonely Lake to Lake Saint Joseph	
	shows that the lattor is the higher, the difference	
Ľ	being apparently twenty feet or more.	
	Lake Saint Joseph (mean of ten barometric observations on	
	as many days)	. 1172
	Lake Lansdowne, near the head of the Attawapishkat River,	
	about	960
L	Lake Saint Martin	794
L	Lake Manitoba (determined by levelling by H. S. Treherne,	
	of Saint Paul, Minn.), mean, 809; low and high water,	
	approximately	805-813
n	Lake Winnipegosis, mean, 828; low and high water,	
	approximately	825-831
	Lake Dauphin	839?
	swan Lake, about	860?
	bivide between Lake Winnipegosis and Cedar Lake	875?
	felar Lake, on the Saskatehewan	824
	Pembina Mountain, crest of the escarpment	1400-1500
	Tizer Hills	1500-1600
	Big Tiger Hill, north of Lang's Valley, about	1640
	Brandon Hills	1550-1600
	Riding Mountain, about	2000
	Duck Mountain	
I.	Thunder Hill	1900
	Churchill River, 105 miles from its month, in the direction	
	S. 33° W. (astr.), at the mouth of the Little Churchill River	-0-
	Was-kai-ow-a-ka Lake, at the head of the Little Churchill	705
٠	Was-kar-ow-a-ka Lake, at the head of the Lattle Churchin River	000
	Churchill River, 23 miles above the mouth of the Little	936
1÷	Churchill	
	Frig portage, from the Churchill River to the Lake of the	878
	Woods, at the head of a chain of lakes and streams	
	lowing southward to the Saskatchewan, estimated	
	nowing southward to the baskatchewan, estimated	1200

the following altitudes, from 1sle à la Crosse Lako to Lake Athabasca, which there noted as determined by Sir John Richardson (Arctic Expedition in wh of Sir John Franklin), probably require an average addition of about 200

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Feet above the sea. water, 1057-1063 on the Roseau 1088 1047 1040 10,0 976 1016 \$ 18 790 747-757 829 1030-1500 1125. 1540 en this 1520. 2150map.... he U. S. 1400 1650 1900-2140 3350 25.60 3000-3250 2790 25.)(1 2600or Three 6455 6200 3545 oundary, 4173 45(81 about... 1 by the e Rocky 4245 lake, on

Feet above the sea, 1300 Gl

-

Isle à la Crosse Lake, on the Churchill River

Thence southward to Carlton House on the North Saskatchewan, and seventy miles above the junction of the South and North Saskatchewan live [estimated 1200 feet chove the sea], Richardson reports a descent of about the hundred feet, across "an undulating country, but without any mark acclivity,"

Professor Macoun states that Isle à la Crosse, Clear, and Buffalo Lakes "a on the same level," being stagnant water filled with green scum in summer.

Methy Lake or Lac la Loche	1490
" (according to Captain Lefroy,	4 1-00
cited by Richardson)	1500
Summit of Methy portage (also called Portage la Loche and	
the Long Portage), on the water-shed between the	
Churchill and Athabasca Rivers	1556
The "Cockscomb," on this portage at the crest of the bluff	
descending to the Clearwater River, tributary to the	
Athabasea	1534
Clearwater Rivor at the north end of this portage	900
Lake Athabasca	600

Altitudes determined by Dr. G. M. Dawson show the present height of glacial lake bed now drained by the Peace River, and of its probable is avenues of outflow southeast to Lake Agassiz, as follows:

Peace River at Dunvegan	1300
Top of river-bluff one mile from Dunvegan	2100
General level of the country in this vicinity	2200

Area of lacustrino silt in the basin of the Peace River...... 2000-2500 The valley of this part of the river, eight or nine hundred feet deep, is en in a vast plain, from which, according to Richardson, "the Rocky Mount are not visible, and no range of hills "neets the oye."

Water-shed between Peace River and Lesser Slave I	ake 2430
Water-shed between Tow-ti-now River, a tributary	of the
Athabasca, and the North Saskatchewan, on th	
from Athabasca Landing to Edmonton	2485

COBA. Feet above the sea. 1300 h Saskatchewan, abo th Saskatchewan Rives s a descent of about to without any marks and Buffalo Latkes "a sen scum in summer. 1490 n Lefroy, 1500 ache and ween the 1556 f the bluff ry to the 1556 f the bluff ry to the 1534 900 600 he present height of and of its probable fit 75: 1300 2000 ver. 2000–2500			
adred feet deep, is on a, "the Rocky Mount re Lake 2430 ary of the a the trail 2485			

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