

CHAPTER II.

TOPOGRAPHY OF THE BASIN OF LAKE AGASSIZ.

The area that was covered by Lake Agassiz occupies the geographic center of the North American continent. Its extent is approximately from $45^{\circ} 30'$ to 55° of north latitude, and from $92^{\circ} 30'$, on the international boundary, to 106° , on the Saskatchewan River, of west longitude.

If we consider the contour of the entire continent, it is seen to include on the east and west two mountainous regions and between them a comparatively flat expanse, at the middle of which Lake Agassiz lay. The eastern mountainous tract stretches from Labrador southwestward to Alabama, culminating in the Laurentide highlands north of the River St. Lawrence, the White Mountains and the Adirondacks, the Green Mountains and the Catskills, and the parallel Appalachian ranges farther southwest. The summits of this mountain belt vary in elevation from a half mile to one mile and slightly more above the sea-level. On the west, a longer and wider region of mountains, including generally three or four lofty parallel ranges, extends from the northern and southern coasts of Alaska southeasterly and southerly through the Canadian Northwest Territory, British Columbia, the western third of the United States, Mexico, and Central America, to the Isthmus of Panama; and beyond this it continues south in the great Andes range along the entire western coast of South America to Cape Horn. In the United States this Cordilleran mountain belt includes the Rocky Mountains and the Sierra Nevada and Coast ranges, and its highest summits are nearly 3 miles above the sea.

Lake Agassiz, situated on the central expanse between these mountainous regions, was a fifth of a mile above the present sea-level. Where the slow northward ascent from the Gulf of Mexico ceases at a distance of 1,100 miles from the Gulf and an elevation of about 1,100 feet, and is succeeded farther north by a descending slope toward Hudson Bay, the

barrier of the receding ice-sheet caused this glacial lake to fill the Red River Valley and to reach northward, as the ice front retreated, over the region of Lakes Winnipeg, Manitoba, and Winnipegosis, until the continued melting of the ice at last permitted it to be drained by the natural slope of the land to the northeast, excepting its remnants, which form these lakes of Manitoba.

OUTLET, BED, AND SHORES OF LAKE AGASSIZ.**RIVER WARREN.**

The lowest point of the watershed dividing the great areas that are drained respectively to Hudson Bay and the Gulf of Mexico is between Lakes Traverse and Big Stone, on the boundary line of Minnesota and South Dakota. Its elevation above the ocean is 975 feet. Here an ancient watercourse, called Browns Valley (see the frontispiece and Pl. IV), which was occupied by the River Warren, outflowing from Lake Agassiz, is eroded in the thick sheet of glacial drift to a depth of 100 to 125 feet, with a width of about $1\frac{1}{2}$ miles. The tops of its inclosing bluffs and the general level of the adjoining country of undulating or moderately rolling till are about 1,100 feet above the sea. Portions of this channel contain the long and narrow Lakes Traverse and Big Stone, the former outflowing by the Bois des Sioux River and the Red River of the North to Lake Winnipeg and Hudson Bay, and the latter by the Minnesota River to the Mississippi. But this channel shows that subsequent to the deposition of the drift a great river has flowed here across what is now one of the principal watersheds of the continent.

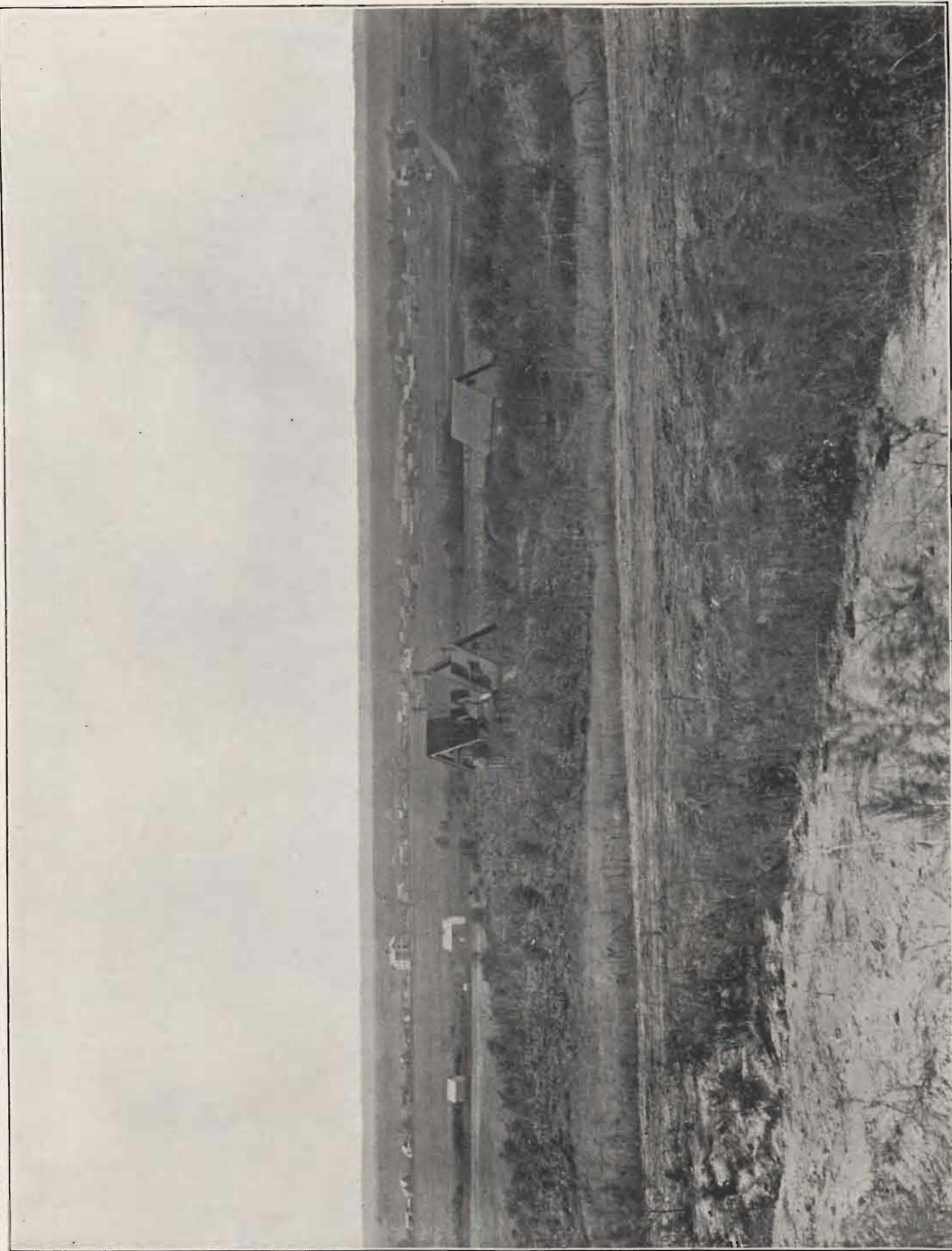
The head stream of the Minnesota¹ River, from which the State of Minnesota receives its name, after flowing eastward about 20 miles from its sources on the Coteau des Prairies, turns southerly at Browns Valley and enters the northwest end of Big Stone Lake. Here, and in its whole extent thence to its mouth, the Minnesota River occupies the channel of the glacial River Warren. This valley or channel begins at the northern

¹The aboriginal Dakota name, meaning "water nearly clear, but slightly clouded," or, poetically translated, "sky-tinted water." (A. W. Williamson, in Thirteenth Annual Report, Geol. and Nat. Hist. Survey of Minn., for 1884, p. 109. E. D. Neill, History of Minnesota, 1858, p. xlvii. Nicollet's Report, 1843, p. 69.)

part of Lake Traverse, and first extends southwest to the head of this lake, thence southeast to Mankato, and next north and northeast to the Mississippi at Fort Snelling, its length being about 250 miles. Its width varies from 1 to 4 miles, and its depth is from 100 to 225 feet. The country through which it lies, as far as Carver, about 25 miles above its junction with the Mississippi, is a nearly level expanse of till, only moderately undulating, with no prominent hills or notable depressions, excepting this deep channel and those formed by its tributary streams. Below Carver it intersects a belt of terminal moraine, composed of hilly till. Its entire course is through a region of unmodified drift, which has no exposures of solid rock upon its surface.

Bluffs in slopes from 20 to 40 degrees, and rising 100 to 200 feet to the general level of the country, form the sides of this trough-like valley. They have been produced by the washing away of their base, leaving the upper portion to fall down and thus take its steep slopes. The river in deepening its channel has been constantly changing its course, so that its current has been turned alternately against the opposite sides of its valley, at some time undermining every portion of them. In a few places this process is still going forward, but mainly the course of the Minnesota River is in the bottom-land. Comparatively little excavation has been done by the present river. As we approach its source it dwindles to a small stream flowing through long lakes, and we finally pass to Lake Traverse, which empties northward; yet along the upper Minnesota and at the divide between this and the Red River this valley or channel and its inclosing bluffs are as remarkable as along the lower part of the Minnesota River. It is thus clearly shown to have been the channel of outflow from a lake formerly extending northward from Lake Traverse.

The Minnesota Valley in many places cuts through the sheet of drift and reaches the underlying rocks, which have frequent exposures along its entire course below Big Stone Lake. This excavation shows that the thickness of the general drift sheet upon this part of Minnesota averages about 150 feet. The contour of the old rocks thus brought into view is much more uneven than that of the drift. In the hundred miles from Big Stone Lake to Fort Ridgely the strata are Archean gneisses and granites,



TOWN OF BROWNS VALLEY, MINNESOTA.
Looking west, over the channel of the river Warren, to the Coteau des Prairies, at a distance of 20 to 25 miles.

which often fill the entire valley, 1 to 2 miles wide, rising in a profusion of knolls and hills 50 to 100 feet above the river. The depth eroded has been limited here by the presence of these rocks, among which the river flows in a winding course, crossing them at many places in rapids or falls.

From New Ulm to its mouth the river is at many places bordered by Cretaceous and Lower Silurian and Cambrian rocks, which are nearly level in stratification. These vary in height from a few feet to 50 or rarely 75 or 100 feet above the river. From Mankato to Ottawa the river occupies a valley cut in Shakopee limestone underlain by Jordan sandstone, which form frequent bluffs upon both sides, 50 to 75 feet high. After excavating the overlying 125 to 150 feet of till, the river here found a former valley eroded by preglacial streams. Its bordering walls of rock, varying from one-fourth of a mile to at least 2 miles apart, are in many portions of this distance concealed by drift, which alone forms one or both sides of the valley. The next point at which the river is seen to be inclosed by rock walls is in its last 2 miles, where it flows between bluffs of Trenton limestone underlain by St. Peter sandstone, 100 feet high and about a mile apart. This also is a preglacial channel, its further continuation being occupied by the Mississippi River. The only erosion effected here by the Minnesota River has been to clear away a part of the drift with which the valley was filled. Its depth at some earlier time was much greater than now, as shown by the salt well on the bottom-land of the Minnesota at Belle Plaine, where 202 feet of stratified gravel, sand, and clay were penetrated before reaching the rock.¹ The bottom of the preglacial channel there is thus at least 165 feet lower than the mouth of the Minnesota River.

The height of Lake Traverse,² in the range between its lowest and highest stages, is 970 to 976 feet above the sea; the lowest point in Browns Valley between this and Big Stone Lake is only 3 feet above the ordinary stage of Lake Traverse; Big Stone Lake³ ranges from 962 to 967 feet

¹Geology of Min., Vol. II, p. 134.

²A translation of the Dakota name (Williamson, l. c., p. 108). "The lake has received its present appellation from the circumstance that it is in a direction nearly transverse to that of the Big Stone and Qui Parle lakes." Keating's Narrative, Vol. II, p. 2.

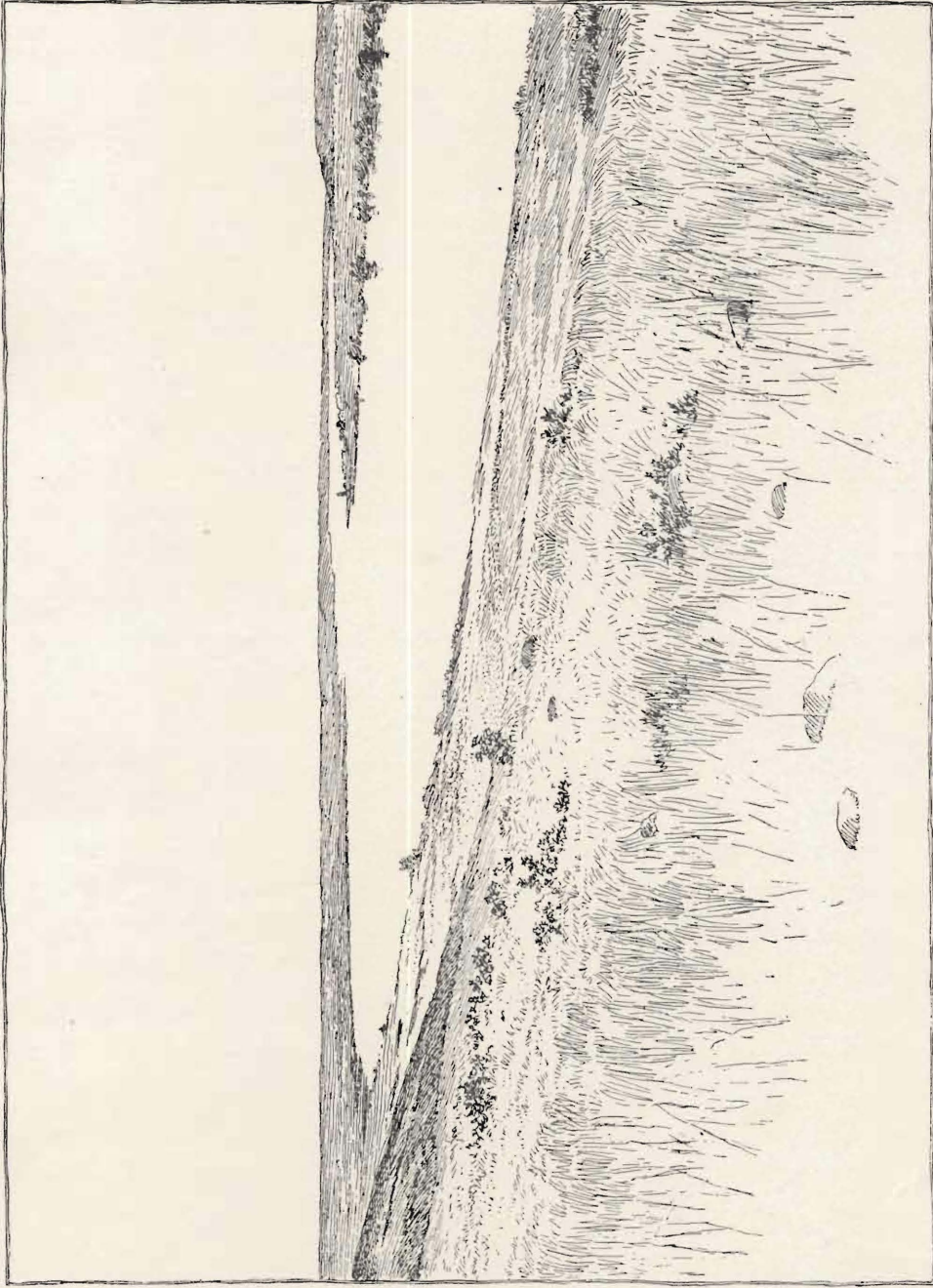
³Translated from the Dakota (Williamson, l. c., p. 105). The name probably alludes to the conspicuous outcrops of granite found in the Minnesota Valley 1 to 3 miles below the foot of the lake.

above the sea, its ordinary stage being about 8 feet below that of Lake Traverse; and the mouth of the Minnesota River at extreme low water is 688 feet above the sea, the descent from Big Stone Lake to the mouth of the river being 274 feet.

Lakes Traverse and Big Stone are from 1 to $1\frac{1}{2}$ miles wide, mainly occupying the entire area between the bases of the bluffs, which rise about 125 feet above them. Lake Traverse (Pl. V) is 15 miles long; it is mostly less than 10 feet deep, and its greatest depth probably does not reach 20 feet. Big Stone Lake is 26 miles long, and its greatest depth is reported to be from 15 to 30 feet. The portion of the channel between these lakes is widely known as Browns Valley. As we stand upon the bluffs here, looking down on these long and narrow lakes in their trough-like valley, which extends across the 5 miles between them, where the basins of Hudson Bay and the Gulf of Mexico are now divided, we have nearly the scene which was presented when the melting ice-sheet of British America was pouring its floods along this hollow. Then the entire extent of the valley was doubtless filled every summer by a river which covered all the present areas of flood plain, in many places occupying as great width as these lakes.

General Warren observed that Lake Traverse is due to partial silting up of the channel since the outflow from the Red River basin ceased, the Minnesota River at the south having brought in sufficient alluvium to form a dam; while Big Stone Lake is similarly referred to the sediment brought into the valley just below it by the Whetstone River. Fifteen miles below Big Stone Lake the Minnesota River flows through a marshy lake 4 miles long and about a mile wide. This may be due to the accumulation of alluvium brought into the valley by the Pomme de Terre River, which has its mouth about 2 miles below. Twenty-five miles from Big Stone Lake the river enters Lac qui Parle,¹ which extends 8 miles, with a width varying from one-fourth to three-fourths of a mile and a maximum depth of 12 feet. This lake, as General Warren suggested, has been formed by a barrier of stratified sand and silt which the Lac qui Parle River has

¹The French translation of the Dakota name, which is of uncertain origin (Williamson, l. c., p. 106).



LAKE TRAVERSE.

Looking northeast from the top of its western bluff about 2 miles northwest of Browns Valley.

thrown across the valley. He also showed that Lake Pepin, on the Mississippi, is dammed in the same way by the sediment of the Chippewa River; and that Lake St. Croix and the last 30 miles of the Minnesota River are similarly held as level backwater by the recent deposits of the Mississippi.

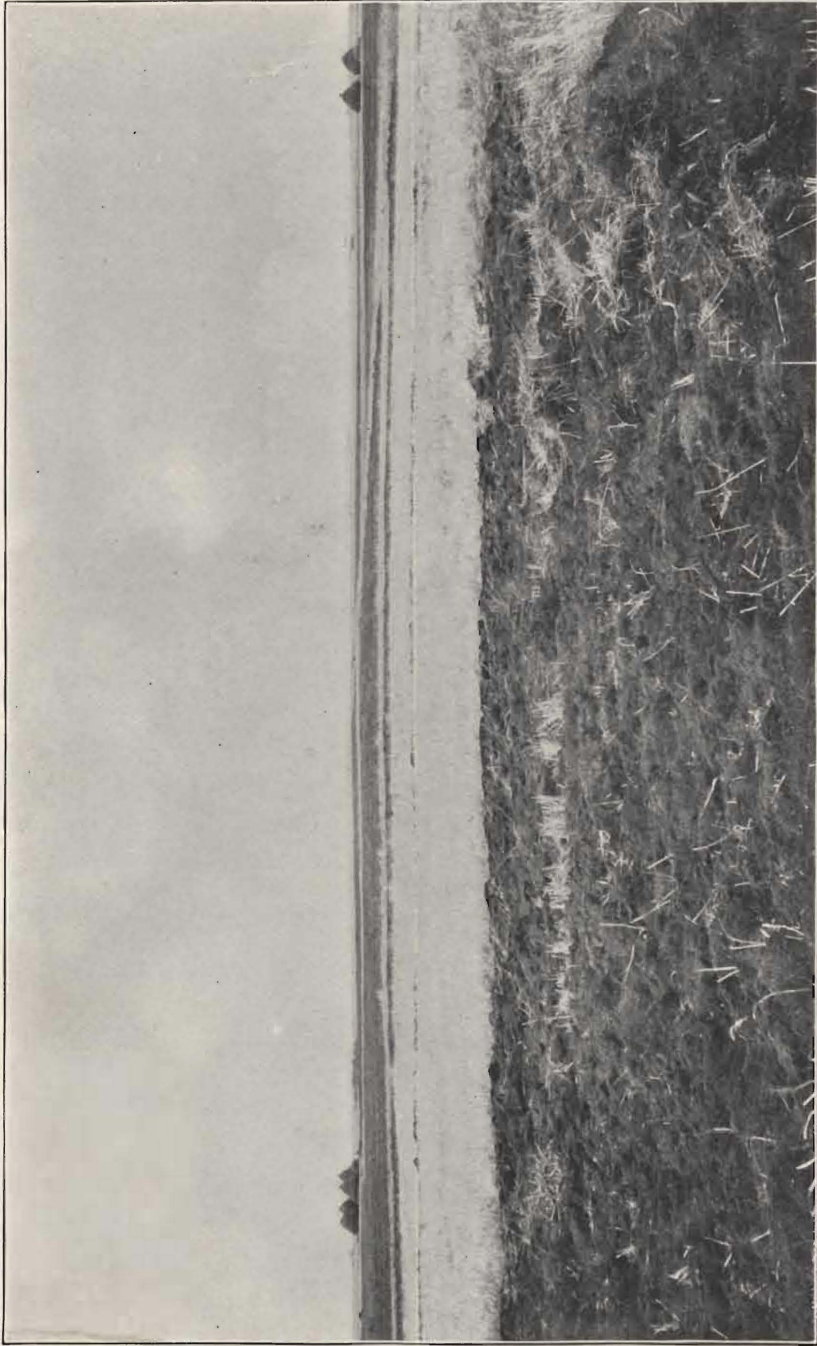
The valleys of the Pomme de Terre and Chippewa rivers, 75 to 100 feet deep along most of their course and one-fourth of a mile to 1 mile in width, were probably avenues of drainage from the melting ice fields in their northward retreat. Between these rivers, in the 22 miles from Appleton to Montevideo, the glacial floods at first flowed in several channels, which are excavated 40 to 80 feet below the general level of the drift sheet, and vary from an eighth to a half of a mile in width. One of these, starting from the bend of the Pomme de Terre River, $1\frac{1}{2}$ miles east of Appleton, extends 15 miles southeast to the Chippewa River, near the center of Tunsburg. This old channel is joined at Milan station by another, which branches off from the Minnesota Valley, running 4 miles east-southeast; it is also joined at the northwest corner of Tunsburg by a very notable channel which extends eastward from the middle of Lac qui Parle. The latter channel, and its continuation in the old Pomme de Terre Valley to the Chippewa River, are excavated nearly as deep as the channel occupied by the Minnesota River. Its west portion holds a marsh generally known as the "Big Slough." Lac qui Parle would have to be raised only a few feet to turn it through this deserted valley. The only other localities where we have proof that the floods of the River Warren at first ran in several channels are 7 and 10 miles below Big Stone Lake, where isolated remnants of the general sheet of till occur south of Odessa station and again 3 miles southeast. Each of these former islands is about a mile long, and rises 75 feet above the surrounding lowland, or nearly as high as the bluffs inclosing the valley, which here measures 4 miles across, having a greater width than at any other point.

THE RED RIVER VALLEY.

Proceeding northward to the area of Lake Agassiz, whose outflow formed this channel, the observer finds that the broad watercourse, with its bluffs and the adjoining highland on each side, ends a few miles north

of Lake Traverse. There the country sinks gradually to a level not much above the small Bois des Sioux River, which is the outlet of Lake Traverse, flowing north 35 miles and emptying into the Red River of the North at Breckenridge 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, 40 to 50 miles wide and more than 300 miles long, stretching from Lake Traverse to Lake Winnipeg. This expanse, widely famed for the large harvests and superior quality of its wheat, is commonly called the Red River Valley. It has a very uniform continuous descent northward, averaging a little less than 1 foot per mile. So slight an inclination is imperceptible to the eye, as is also the more considerable ascent, usually 2 or 3 feet per mile, for the first 10 or 15 miles to the east and west from the Red River. This river flows along the lowest portion of the plain, somewhat east of its central line, in a quite direct general course from south to north, but meanders almost everywhere with minor bends, which carry it alternately a half mile to 1 mile or more to each side of its main course. Thus its length from Breckenridge and Wahpeton to St. Vincent and Pembina, forming the boundary between Minnesota and North Dakota, is 397 miles, according to the surveys of the United States Engineer Corps, while the distance in a direct line is only 186 miles; yet the river nowhere deviates more than 5 or 6 miles from this straight line.

The Red River has cut a channel 20 to 50 feet deep. It is bordered by only few and narrow areas of bottom-land, instead of which its banks usually rise steeply on one side and by moderate slopes on the other to the lacustrine plain, which thence reaches nearly level 10 to 30 miles from the river. Its tributaries cross the plain in similar channels, which, as also the Red River, have occasional gullies connected with them, dry through the most of the year, varying from a few hundred feet to a mile or more in length. Between the drainage lines areas often 5 to 15 miles wide remain unmarked by any water courses. The highest portions of these tracts are commonly from 2 to 5 feet above the lowest. The material of the lower part of this valley plain, shown in the banks of the Red River



UPPER HERMAN BEACH OF LAKE AGASSIZ.

Looking northeastward from the south line of the SE. $\frac{1}{4}$ of sec. 35, Tilden, Minn., near Maple Lake.

and reaching several miles from it (excepting a morainic belt of till crossing the river at Goose Rapids), is fine clayey silt, horizontally stratified; but the south end and large areas of each side of the plain are mainly unstratified boulder-clay, which differs from the rolling or undulating till of the adjoining region chiefly in having its surface nearly flat. Both these formations are almost impervious to water, which therefore in the rainy season fills their shallow depressions; but these are very rarely so deep as to form permanent lakes. Even sloughs that continue marshy through the summer are infrequent, but, where they do occur, cover large tracts, usually several miles in extent.

In crossing the vast plain of the Red River Valley on clear days the higher land at its sides and the groves along its rivers are first seen in the distance as if their upper edges were raised a little above the horizon, with a very narrow strip of sky below. The first appearance of the tree tops thus somewhat resembles that of dense flocks of birds flying very low several miles away. By rising a few feet, as from the ground to a wagon, or by nearer approach, the outlines become clearly defined as a grove, with a mere line of sky beneath it. This mirage is more or less observable on the valley plain nearly every sunshiny day of the spring, summer, and autumn months, especially during the forenoon, when the lowest stratum of the air, touching the surface of the ground, becomes heated sooner than the strata above it.

A more complex and astonishing effect of mirage is often seen from the somewhat higher land that forms the slopes on either side of the plain. There, in looking across the flat valley a half hour to two hours after sunrise of a hot day following a cool night, the groves and houses, villages and grain elevators, loom up to twice or thrice their true height, and places ordinarily hidden from sight by the earth's curvature are brought into view. Occasionally, too, these objects, as trees and houses, are seen double, being repeated in an inverted position close above their real places, from which they are separated by a very narrow, fog-like belt. In its most perfect development the mirage shows the upper and topsy-turvy portion of the view quite as distinctly as the lower and true portion; and the two are separated, when seen from land about a hundred feet above the plain, by

an apparent vertical distance of 75 or 100 feet for objects at a distance of 6 or 8 miles, and 300 to 500 feet if the view is 15 to 20 miles away. Immediately above the inverted images there runs a level false horizon, which rises slightly as the view grows less distinct, until, as it fades and vanishes, the inverted groves, lone trees, church spires, elevators, and houses at last resemble rags and tatters hung along a taut line.

The traveler in the Red River Valley is reminded, in the same manner as at sea, that the earth is round. The surface of the plain is seen only for a distance of 3 or 4 miles; houses and grain stacks have their tops visible first, after which, in approaching, they gradually come into full view; and the highlands, 10 or 15 miles away, forming the side of the valley, apparently lie beyond a wide depression, like a distant high coast.

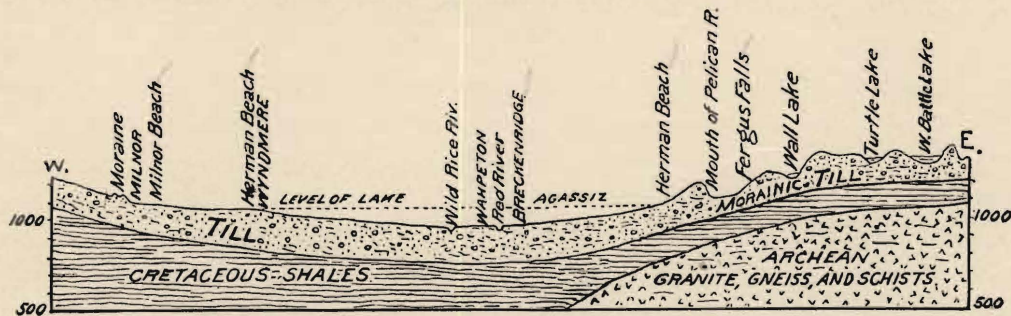


FIG. 2.—Section across the Red River Valley on the latitude of Breckenridge and Wahpeton. Horizontal scale, 20 miles to an inch; vertical scale, 1,000 feet to an inch.

At Breckenridge and Wahpeton, 35 miles north of Lake Traverse, the surface of this plain is 960 feet above the sea (fig. 2). In 17 miles east it ascends to 1,080 feet at the highest beach of Lake Agassiz; and on the west it rises in 28 miles to 1,065 feet at the corresponding beach near Wyndmere, beyond which for 8 miles farther west it maintains a level 2 to 5 feet below the crest of that beach.

At Moorhead and Fargo, 75 miles north of Lake Traverse, the surface adjoining the Red River is 900 to 905 feet above the sea (fig. 3). In the first 15 miles east it ascends about 60 feet. The highest beach of Lake Agassiz here lies at Muskoda, 17 miles east of the Red River, on the slope of a highland of till, which rises in a distance of 6 or 8 miles to an elevation of 250 feet above the flat Red River Valley, having thus an

average ascent of 30 or 40 feet per mile. On the west the plain ascends only 50 feet in the first 25 miles, beyond which it ascends within 7 miles to 1,099 feet above the sea-level at the highest beach line, $4\frac{1}{2}$ miles west of Wheatland, and a similar slope continues to a height of 1,200 feet at a distance of 4 or 5 miles farther west.

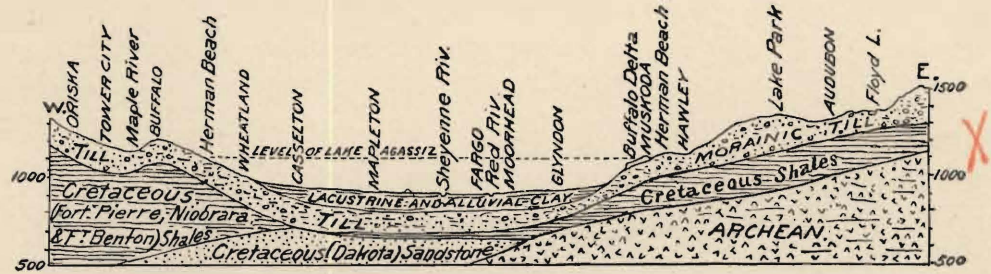


Fig. 3.—Section across the Red River Valley on the latitude of Moorhead and Fargo. Horizontal scale, 20 miles to an inch; vertical scale, 1,000 feet to an inch.

At Grand Forks, where the Red Lake River joins the Red River, 150 miles north of Lake Traverse, the surface of the plain is 830 feet above the sea (fig. 4). In the first 20 miles east the ascent is about 75 feet. Thence in 25 miles southeast there is a gradual rise of nearly 300 feet to the

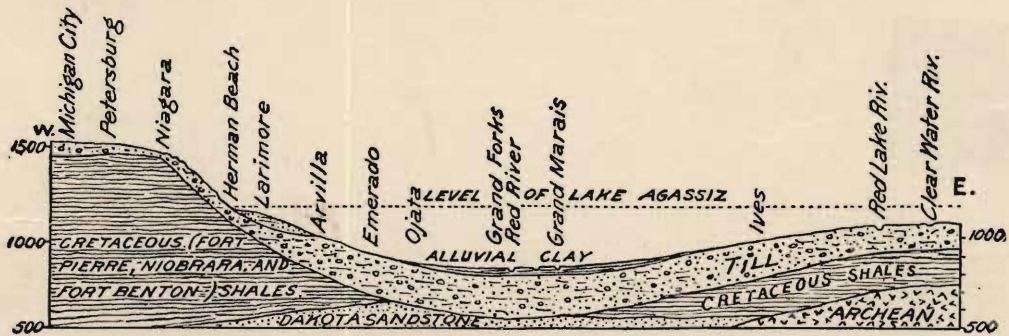


Fig. 4.—Section across the Red River Valley from Larimore and Grand Forks to Maple Lake. Horizontal scale, 20 miles to an inch; vertical scale, 1,000 feet to an inch.

highest beach of Lake Agassiz, close west and north of Maple Lake; but in a line passing due east the surface ascends only about 200 feet in an equal distance, and continues at a lower elevation than this beach to the east side of Red Lake, 100 miles from Grand Forks. On the west the surface rises only 35 feet in the first 14 miles, beyond which it rises about

300 feet in the next 19 miles to 1,162 feet above sea-level at the highest beach of Lake Agassiz, $4\frac{1}{2}$ miles west of Larimore. The westward ascent continues to 1,525 feet above the sea 12 miles west of this beach.

At St. Vincent and Pembina, near the international boundary, which is 224 miles north of Lake Traverse, the surface of the plain is 785 to 790 feet above the sea (fig. 5). Eastward on the boundary it is nearly level, rising only a few feet in the first 10 miles. Thence an ascent of about 50 feet is made in 2 miles to the crest of a slight ridge. Farther east the country is wooded, and many extensive tracts are tamarack swamps. The Lake of the Woods, about 85 miles east from the Red River, is 1,060 feet above the sea; and the highest land near the international boundary west of this lake is approximately 1,090 feet. Continuing eastward along the

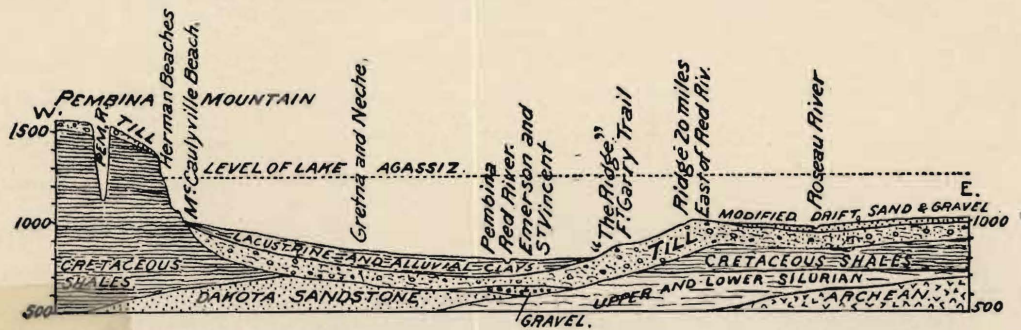


FIG. 5.—Section across the Red River Valley on the international boundary. Horizontal scale, 20 miles to an inch; vertical scale, 1,000 feet to an inch.

boundary, which here is formed by the Rainy River and Rainy Lake, the elevation of the highest beach of Lake Agassiz is reached a short distance east from the east end of Rainy Lake, more than 200 miles from the Red River. Westward the surface rises about 40 feet in 15 miles from Pembina to Neche, and 187 feet in the next 21 miles along the international boundary to the base of the great Cretaceous escarpment called Pembina Mountain, which, within 2 miles farther west, ascends nearly 400 feet to an elevation approximately 1,400 feet above the sea.

These sections give a good idea of the average width and elevation of the flat plain to which the name Red River Valley seems to be properly limited, both by topographic features and by the common usage of this term. At a distance of 35 miles north of Lake Traverse its width is about

45 miles, and its limits on each side are a slightly higher area of more rolling contour. On the latitude of Moorhead and Fargo its width is about 40 miles, and it is bordered by prominent highlands which rise 200 to 300 feet above this broad valley. On the latitude of Grand Forks its width is nearly 50 miles, and it is bordered on the east by land that rises slowly 200 to 300 feet above the plain, while on the west the surface rises by moderate slopes to a height of 600 to 700 feet. Where it is crossed by the international boundary the width of this plain is 48 miles, its limit on the east being a slightly higher and more undulating wooded region, while on the west it is a conspicuous terrace-like ascent of several hundred feet. On the average, for its extent within the United States, about one-third of the width of the Red River Valley is in Minnesota and two-thirds in North Dakota.

The northward slope of the lowest part of the Red River Valley, along the course of the Bois des Sioux and Red rivers, from Lake Traverse, 970 feet, to Lake Winnipeg, 710 feet above the sea, may thus be said to be 260 feet in a distance of 320 miles, averaging about 10 inches per mile. The valley proper, however, does not take on its distinctive character in the first 10 or 15 miles of the course of the Bois des Sioux River, but 10 miles farther east in Minnesota the same topographic features that mark the Red River Valley continue south nearly to the latitude of the southwest end of Lake Traverse. The elevation of this southern extremity of the area of Lake Agassiz is 1,050 feet above the sea, being 90 feet above the surface at Breckenridge and Wahpeton, 43 miles distant to the north, so that this part of the valley plain has a northward descent of 2 feet per mile. Thence to Moorhead and Fargo the descent is $1\frac{1}{2}$ feet per mile; next, for 75 miles to Grand Forks, it averages almost exactly 1 foot per mile; and in the 74 miles from Grand Forks to the international boundary this axial lowest portion of the valley falls about 40 feet, or a little more than 6 inches per mile. In the 60 miles thence to Winnipeg the descent is about 35 feet, or 7 inches per mile, the surface there being 45 feet above Lake Winnipeg, about 35 miles distant.

SHORE-LINES.

Considered in 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 beach deposit of gravel and sand, forming a continuous, smoothly rounded ridge, such as is found along the shores of the ocean or of our great Laurentian lakes wherever the land sinks in a gently descending slope beneath the water level. The beach ridges of Lake Agassiz (fig. 6) commonly rise 3 to 10 feet above the adjoining land



FIG. 6.—Typical section across a beach ridge of Lake Agassiz. Scale, 100 feet to an inch.

on the side that was away from the lake, and 10 to 20 feet above the adjoining land on the side where the lake lay. In breadth these ridges vary from 10 to 25 or 30 rods. In some places they have been cut through and carried away by streams, and occasionally they are interrupted for a quarter or a half mile, or even 2 or 3 miles, where the outline of the lake shore and the direction of the shore currents prevented such accumulation. Throughout almost the whole extent of Lake Agassiz examined within the United States the regular outlines of the surface, its gentle slope toward this lake, and its material, which nearly everywhere is till, were very favorable for the formation of beach deposits. Many beach ridges, record-



FIG. 7.—Eroded terrace marking the shore of Lake Agassiz. Scale, 100 feet to an inch.

ing the successive reductions in the elevation and area of this lake, have been traced in continuous, approximately parallel courses along each side of the Red River Valley. Pl. VI shows an exceptionally massive beach ridge marking the highest shore-line of Lake Agassiz close northwest of Maple Lake, about 20 miles east-southeast from Crookston, Minn.

Another type of shore-lines is presented where the lake has formed a terrace in the till (fig. 7), with no definite beach deposit, the work of the waves having been to erode and carry away rather than to accumulate. The

height of these steep, wave-cut slopes varies from 10 to 30 feet, which is indeed a very slight elevation in comparison with the cliffs of similar origin on some portions of the shores of Lake Michigan and others of the Laurentian 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 so far away as 2 or 3 miles, but nearer at hand they appear sufficiently impressive when the mind reverts to the receding ice-sheet and this great glacial lake by which they were made.

DELTAS.

Sand and gravel deltas, so extensive as to be important features in the topography, were formed in the edge of Lake Agassiz during its earliest and highest stage 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 west side by the Sheyenne, Pembina, and Assiniboine rivers. They all consist for the greater part of modified drift, derived directly from the ice-sheet in which it had been held; and another delta of this lake, extending south from the Elk Valley, in North Dakota, was deposited by a large glacial river, flowing where no river exists now.

The delta of the Buffalo River is well seen from the Northern Pacific Railroad, on which the traveler going westward enters the delta area at Muskoda and passes through it in the next $2\frac{1}{2}$ miles. Its eastern border bears a massive beach ridge, 15 feet thick, of coarse gravel and sand, which marks the highest level of the lake; but the chief mass of the delta, attaining a thickness of 25 to 75 feet, is stratified sand, with occasional layers of fine gravel, as exhibited in the railroad cuts.

The Pembina River intersects the highest part of its delta, which rises 200 to 250 feet above the stream. Its eroded eastern border, carved in a steep escarpment by the waves of Lake Agassiz while this lake fell to successive lower stages, forms the "First Pembina Mountain," passing from south to north and northwest by Walhalla as a very conspicuous wooded bluff 100 to 175 feet above the flat prairie of the Red River Valley at its base, with its crest 1,100 feet to nearly 1,200 feet above the sea.

DUNES.

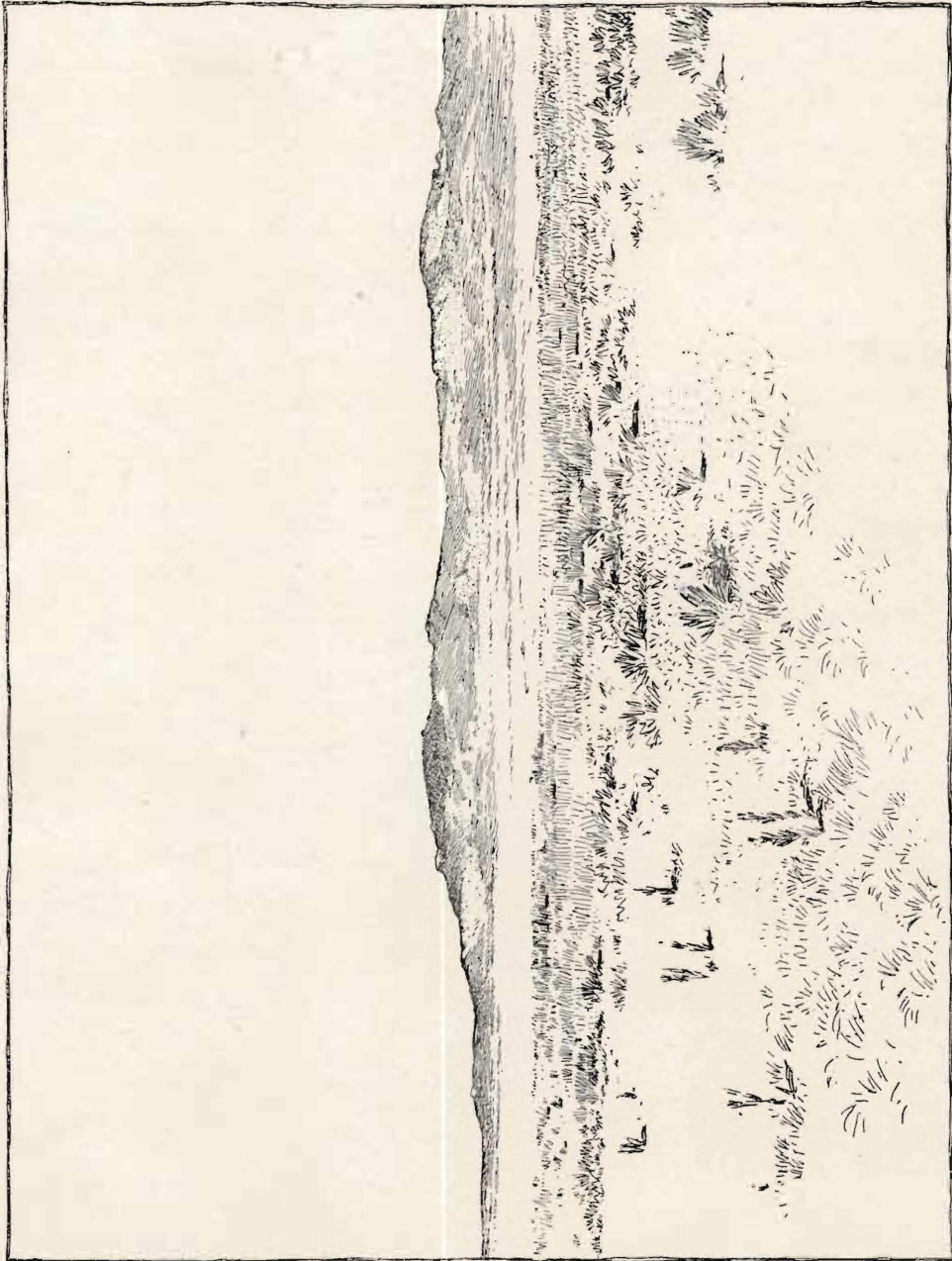
Large tracts of the deltas formed by the Sand Hill, Sheyenne, and Assiniboine rivers have been heaped up by the wind in dunes or drifting sand hills, which vary in height from 25 to 100 feet. Their extremely uneven contour, and their singular aspect, being partly covered by small trees and bushes, but 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 agriculture is also in marked contrast with the great fertility of the surrounding prairie, but they frequently include patches of good pasturage in the intervening hollows.

On the delta of the Sand Hill River, dunes 25 to 75 feet high have been formed in irregular groups and series, scattered over a tract about a mile wide and extending 3 or 4 miles south from the Sand Hill River, besides a single isolated group on its north side. Their highest points are 1,180 to 1,200 feet above the sea.

Portions of the originally flat sand and gravel beds brought into Lake Agassiz by the Sheyenne have been blown into dunes, which vary from a few feet to more than a hundred feet in height, and cover areas 5 to 15 miles long and 1 to 3 miles wide. Their summits are 1,100 to 1,150 feet above the sea. The most southeastern of these large areas of conspicuous sand hills of the Sheyenne delta lies close south of the Wild Rice River, and is continued southeastward several miles by a lower belt of such hillocks to a high isolated cluster of them called the "Lightning's Nest" (Pl. VII).

In Manitoba, wind-blown sand hills border the Assiniboine River in many places along a distance of 60 miles, from near Brandon to near Portage la Prairie, lying on the very extensive Assiniboine delta.

The time of formation of the dunes on all these deltas 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.



"THE LIGHTNINGS NEST" (DUNES OF THE SHEYENNE DELTA).
Looking east from a distance of about a half mile.

WOODED REGION OF NORTHERN MINNESOTA AND OF MANITOBA AND KEEWATIN,
PARTLY COVERED BY THIS LAKE.

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 eastern Manitoba. This is a difficult district for exploration, as the greater part of it has neither settlement nor roads, excepting those of the scanty population of Ojibway Indians, who maintain themselves chiefly by hunting and fishing and live in nearly the same manner as when Beltrami crossed this country from the Red River Valley to the Upper Mississippi River seventy years ago. Their abodes are usually on the shores of lakes and streams, which they navigate in birch-bark canoes; and this is the only practicable means of travel for geologic exploration. Considerable tracts, especially west of the Lake of the Woods and south to Red Lake, are tamarack swamps, morasses, and quaking bogs, called "muskegs," which extend many miles and can be crossed only when they are frozen in winter. Northwest of Red Lake a large area, described and named Beltrami Island in Chapter VI, rises to a maximum height of about 100 feet above the highest level of Lake Agassiz. Eastward from Beltrami Island a large tract between Red Lake and the Rainy River, reaching to the Big and Little Forks, lies 50 to 150 feet below the highest stage of Lake Agassiz; but the northeastern part of this area 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 glacial lake, where the shore in its successive stages passed from the land surface to the barrier of the receding ice-sheet, remain undetermined.

The part of Keewatin 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 toward the sea at the rate of about 2 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 consider-

able 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 30 or 40 feet above the general level.

The country adjoining the lower part of this river, according to the same explorer, has a similar contour, only moderately uneven; but the channel of the river, excepting in the 10 miles next to its mouth, is deeply eroded. Its inclosing bluffs vary in height from 100 to 200 feet between Broad Rapid, where the river is approximately 125 feet above the sea, and Gillams or Lower Seal Island, which is at the head of the tide, about 20 miles from Hudson Bay.¹

COUNTRY BORDERING LAKE AGASSIZ ON THE EAST.

Northern Minnesota, from Maple, Red, and Rainy lakes east to the high northwestern shore of Lake Superior and south to Mille Lacs and the Leaf Hills, varies in its average height from the highest level of Lake Agassiz to 600 feet above it, or from 1,200 to 1,800 feet above the sea. It is mostly a moderately rolling or hilly country, abounding with little lakes which fill its depressions. The watershed dividing the basin of Lake Agassiz from the basins of Lake Superior and the Mississippi culminates northeastward in the Giants Range and the Mesabi Range, and southwestward in the Leaf Hills. These ranges of hills rise several hundred feet above the average height of the district. Excepting its western border from near Maple Lake southward, where it is in large part prairie like the adjacent Red River Valley, this district is covered with an almost unbroken forest. Toward the east it forms a plateau, in part hilly and mountainous and in part only moderately undulating or nearly flat, everywhere well wooded and dotted with frequent small lakes, bordering the entire northern shore of Lake Superior, above which it rises 600 to 1,000 feet; and thence a downward slope, characterized by the same general features, stretches west

¹Geol. Survey of Canada, Reports of Progress for 1877 to 1879.

and north with gradually declining surface to Lake Winnipeg and Hudson Bay. The highest point of this plateau on the line of the Canadian Pacific Railway is 1,584 feet above the sea, or 982 and 874 feet, respectively, above Lakes Superior and Winnipeg.

Giants Range.—The Giants Range extends in a west-southwest course from north of Gunflint Lake, on the international boundary, to the lakes on the Embarras River, about 15 miles south of Vermilion Lake, and its mostly lower continuation, forming the northern border of the Mesabi iron-bearing belt, appears to reach to the falls of Prairie River and Pokegama Falls, on the Mississippi. Southeast and south of Vermilion Lake, where it has been called the Mesabi Range, Prof. N. H. Winchell describes it as “a distinct, narrow ridge, rising about 200 feet above the average level on either side. It is intersected at several places by streams.” Its elevation there is mainly about 1,800 feet above the sea, but eastward it rises to nearly 2,200 feet.

Mesabi Range.—Professor Winchell restricts the title “Mesabi Range” to a more prominent and persistent belt of highland 5 to 15 miles south of the foregoing, with which it is approximately parallel. The eastern and highest part of its extent is commonly known by this name. “It is, however, broad as well as high, and holds on its summit some of the largest lakes of this part of the State, Brulé Lake being one. It is characterized by bare rock, alternating with peat bogs and muskegs, with scattered and stunted spruces. * * * Its width is sometimes 15 miles, but generally from 4 to 6; and in most places, especially north from Grand Marais and south from Ogishkie Muncie Lake, its rounded low crest is distinct and narrowed to less than a mile.”¹ The summits of the Mesabi Range and of outlying hills near are 1,800 to 2,230 feet above the sea, including the highest points of land in Minnesota. The latter elevation is that of hills adjoining the south side of Winchell Lake, as determined by leveling for the Minnesota Geological Survey. Near the international boundary the Mesabi Range extends from south of Gunflint Lake eastward to South and North lakes and the south side of Mountain Lake.

¹ Geol. and Nat. Hist. Survey of Minnesota, Thirteenth Annual Report, for 1884, p. 22.

These ranges of hills cross the international boundary respectively about 90 and 120 miles east of Rainy Lake, which, as before stated, was the extreme eastern arm of the glacial Lake Agassiz at its highest stage, unless that area was still ice-covered; and their western portions are respectively 65 and 75 miles south-southeast of the east end of Rainy Lake. They coincide nearly with the line of watershed dividing the basin of Rainy Lake and River from that of Lake Superior; but this watershed takes a less direct course, winding its way circuitously over this generally uneven and hilly region. On the international boundary the belt between the Giants and Mesabi ranges is drained partly through the former to Rainy Lake and partly through the latter to Lake Superior; and the Embarras River, which sends its waters to the St. Louis River and Lake Superior, has its source north of the northern range.

About Vermilion Lake and the upper Embarras River the average height of the country is 1,500 to 1,600 feet. Thence the surface falls slowly westward to the vicinity of Pokegama Falls, Lake Winnebagoish, and Leech and Cass lakes, where the mean elevation is from 1,300 to 1,400 feet. Still farther west it rises to 1,500 and 1,600 feet about Lake Itasca and the White Earth Agency. The hills of these areas consist of morainic accumulations of glacial drift, and are not so high and massive as the Giants and Mesabi ranges, which, near the international boundary and west to the Embarras River, are mostly projecting knobs and ridges of the bed-rock.

Mesabi and Itasca moraines.—Drift hills and short ridges, having heights from 50 to 200 feet or more, extend in an approximately east to west belt, to which I have applied the name Mesabi moraine, from the lakes of the Embarras River to Deer and Bowstring lakes and the northeast side of Lake Winnebagoish. Its continuation northwestward probably passes to the prominent terminal moraine, 100 to 200 feet high, between the north and south portions of Red Lake, east of the Narrows. Eastward from the Embarras River, this morainic belt coincides in part with the Giants and Mesabi ranges for a considerable distance, so that the elevations of rock forming those heights are overspread and sometimes concealed by morainic

drift deposits; but it appears to pass finally south of those ranges and to reach the north shore of Lake Superior in the vicinity of Grand Portage.

An approximately parallel morainic belt, 12 to 25 miles distant to the south and west, lies on the south side of Pokegama and Leech lakes and reaches west to Itasca Lake, where it bends to a northerly course. Its very irregular hills and ridges rise 50 to 250 feet above the adjoining lakes and streams. This belt, especially prominent at the head of the Mississippi River, I have called the Itasca moraine.¹

Leaf Hills.—From Itasca Lake and the White Earth Agency the surface gradually falls southward to Detroit, 1,364 feet above the sea. Thence a mean elevation of 1,350 to 1,400 feet extends south through Ottertail and Douglas counties along the low plateau that forms the height of land between the Red and Mississippi rivers, east of the south part of Lake Agassiz. Upon this area, in southern Ottertail County, are the Leaf Hills, whose highest portions rise 100 to 350 feet above the general level, or 1,500 to 1,750 feet above the sea, being the most prominent morainic accumulations found within the State of Minnesota. They reach in a semicircle from Fergus Falls southeast to the south line of the county, and thence east and northeast to East Leaf Lake, a total distance of 50 miles. In the first 20 miles, or from Fergus Falls to the north side of Lake Christina, at the northwest corner of Douglas County, these morainic deposits are divided into two or three belts of roughly hilly land, with intervening areas of smoother contour. For the next 20 miles to the east and northeast they form a range 5 to 3 miles wide, composed of very irregular, roughly outlined hills, 100 to more than 300 feet high, widely known by the name Leaf Mountains. Northeast of East Leaf Lake, where this moraine is crossed by the road from Wadena to Ottertail Lake, its elevations rise only about 100 feet and are named Leaf Hills, which seems a more appropriate title and should include the highest part of the range. The common name has currency because they are the only hills in this part of Minnesota that are conspicuously seen at any great distance.

¹Detailed descriptions of these and other moraines crossing the basin of Lake Agassiz are given in Chapter IV.

The Leaf Hills are crossed northwest of Parkers Prairie by a road that winds 3 or 4 miles among their knolls, hills, and short ridges, rising about 100 feet above the land on each side. Again, the road from Alexandria to Clitherall crosses this range in the township of Leaf Mountain, the summit of the road being near the south line of this township, about 1,525 feet above the sea. The top of a hill a quarter of a mile east of the road here, and about 125 feet higher, affords a fine view of these "mountains" (Pl. VIII), which westward and northeastward rise in most tumultuous confusion 150 to 250 feet or more above the intervening depressions. They are massive, though very irregular in contour, with steep slopes. No prevailing trend is noticeable. Between them are inclosed frequent lakes, which vary from a few rods to a mile in length, and one of the largest lies at the northeast foot of this hill. The material is chiefly unmodified drift, nearly like that which forms very extensive, gently undulating tracts elsewhere. The principal difference is that rock fragments, large and small, are generally much more numerous upon these hills, and occasionally they occur in great abundance.

South of the Leaf Hills the country adjoining Lake Agassiz is an expanse of smoothly undulating or rolling till, 1,200 to 1,075 feet above the sea. So slight are its elevations and depressions, usually differing from each other by 10 to 25 feet, that in an extensive prospect these inequalities are lost sight of, and the land seems bounded by a level line at the horizon. This contour extends south through Grant and Stevens counties, and thence more than 100 miles southeast, descending on the average about a foot per mile along the wide, slightly undulating basin of the Minnesota River, which seems to be a continuation of the same topographic belt that forms the Red River Valley.

COUNTRY WEST OF LAKE AGASSIZ.

Along the west side of the basins of the Minnesota River, of the Red River Valley, and of Lakes Manitoba and Winnipegosis, the surface rises from 200 or 300 to 1,000 feet above their slightly undulating or quite flat belt of lowland. No other feature in the contour of the northwestern States and adjoining British territory is more noteworthy, extended, and



THE LEAF HILLS.

View looking northeast from a hill in the east part of section 33, Leaf Mountain township.

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 Lakes Winnipeg, Manitoba, and others, and by the Red and Minnesota rivers, 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 the sea-level at the foot of the Rocky Mountains, on the international boundary. Most of this elevation is attained by a gradual slope, averaging 4 or 5 feet per mile throughout the distance of 730 miles from the Red River to the mountains; but at two lines, extending from south to north or northwest, 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. Its lower continuation from the head of the Coteau des Prairies, west of Lake Traverse, for the next 175 miles northward, bears no name, and is scarcely more conspicuous, or in some parts even less so, than the moderate ascent that forms the opposite border of the Red River Valley in Minnesota. Farther north this line of higher land rises abruptly 300 to 500 feet in Pembina Mountain, and from 500 to 1,000 feet or more in Riding and Duck mountains and the Porcupine and Pasquia hills. All of these are successive parts of a very remarkable terrace-like escarpment, called by Mr. J. B. Tyrrell the Manitoba escarpment,¹ stretching from North Dakota by the west side of Lakes Manitoba and Winnipegosis to the Saskatchewan River. Its portions thus differently named are divided by deep and broad valleys eroded by intersecting streams.

This whole belt of highland, reaching in a nearly direct north-northwest course about 800 miles, may thus be considered in three parts. At the south a quarter of its length is the great plateau-like ridge of the

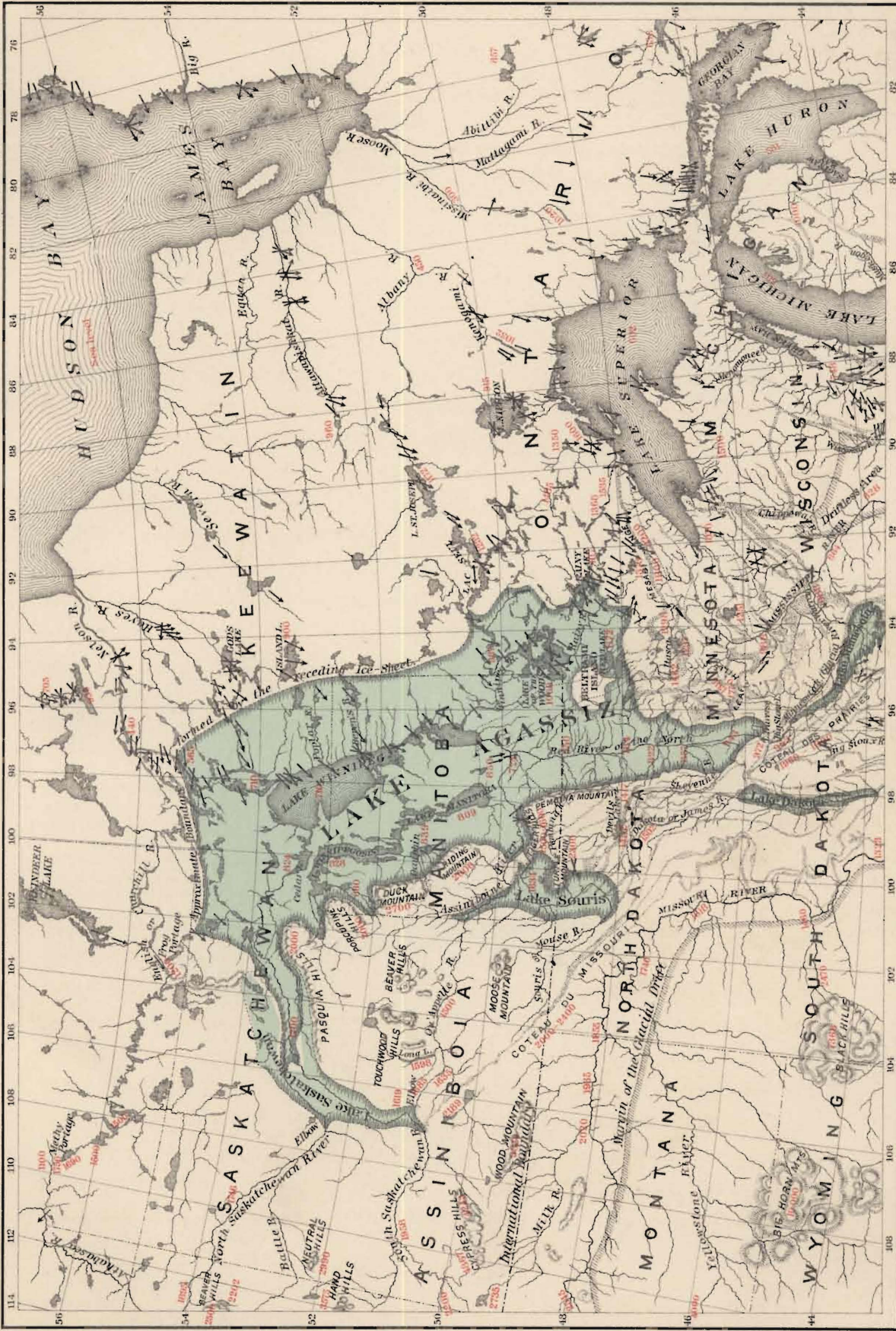
¹ *Am. Geologist*, Vol. VIII, pp. 19-28, July, 1891.

Coteau des Prairies. Next, a nearly equal extent, is the less elevated highland that gradually rises west of the Red River Valley, between it and the Sheyenne River and Devils Lake. The northern half is a somewhat interrupted, mountain-like escarpment, lying mainly in Manitoba, whose top, like the highland just mentioned, is the verge of plains that extend thence westward, generally with a nearly level but slowly ascending surface, excepting where they are channeled and irregularly sculptured by stream erosion. Occasional groups of hills also rise above the average height of these plains, as Turtle Mountain and others farther northwest. Beneath their thin covering of drift these hilly tracts contain remnants of older formations, of which the portions formerly continuous between these elevations and on each side have been eroded and carried away.

The accompanying maps, which form Pls. IX and X, giving altitudes as determined chiefly by railway surveys upon the area of Lake Agassiz and the adjoining country, show the extent and height of the Manitoba escarpment, of portions of the Coteau des Prairies and the Coteau du Missouri, and of the region extending eastward from Lake Agassiz to Hudson and James bays and the great Laurentian lakes.

THE COTEAU DES PRAIRIES.

A large area extending from south-southeast to north-northwest in southwestern Minnesota and the northeast part of South Dakota, and terminating on the west side of the south end of Lake Agassiz, has an elevation from 500 to 1,000 feet above the Minnesota River, and from 1,300 to 2,000 feet above the sea. Upon this highland district are the sources of the Lac qui Parle, Yellow. Medicine, Redwood, and Cottonwood rivers, tributary to the Minnesota; of the Des Moines River; and of the Little Sioux and Big Sioux rivers, tributary to the Missouri. The outermost of the series of terminal moraines of the waning ice-sheet, denominated the Altamont moraine, generally lies on the highest portion of this area, which extends in Minnesota from southeastern Nobles County in a nearly north-northwest course, passing west of Worthington, through southwestern Murray County, the northeastern township of Pipestone County, and southwestern Lincoln County, by the west ends of Lakes Benton, Shaokatan, and Hen-



MAP WITH ALTITUDES OF LAKE AGASSIZ AND ADJOINING COUNTRY.

Scale, about 165 miles to an inch.

Late Agassiz and associated Glacial Lakes

Altitudes in feet above the sea

710

dricks into South Dakota, where it continues in the same course through Deuel and Grant counties and the Sisseton and Wahpeton Indian Reservation. It thus reaches past the sources of the Big Sioux River, and farther northward becomes the divide between the head streams of the Minnesota and Wild Rice rivers on the east and the James River on the west. This elevated tract, extending 200 miles, was called by the earliest French explorers the Coteau des Prairies, meaning the Highland of the Prairies. This name, according to Nicollet, alludes to its conspicuous appearance, "looming as it were a distant shore," when viewed from the valleys of the Minnesota and James rivers, as is very noticeable from the vicinity of Lakes Traverse and Big Stone and from the highest points near the Minnesota River for perhaps 20 miles below Big Stone Lake. Farther southeast this title was applied to the first prominent ascent above the broad, gently undulating expanse that reaches everywhere 20 or 30 miles from the Minnesota River.

In crossing the Coteau des Prairies from northeast to southwest there is generally a very gradual, smooth slope, rising 100 to 300 feet in 5 to 15 miles. Then comes a steeper ascent, which amounts to 300 feet or more within a width of 2 or 3 miles, coinciding through the greater part of its extent with the tract of knolly and hilly drift that forms the second or Gary moraine. The average height beyond, sometimes after a slight descent, continues to rise, but only slowly, amounting to 100 or 150 feet in crossing the smoother, undulating or rolling area, 5 to 15 miles wide, between this and the outer morainic range, which next rises 100 to 200 or 300 feet within 2 or 3 miles and forms the crest of the highland along nearly its whole extent. West of this moraine in Minnesota the surface soon drops 50 to 100 feet, this descent being greatest at the south and diminishing northward, and thence a smooth slope of till falls southwesterly some 200 feet within 10 miles. Farther to the north, from Lake Hendricks nearly to Goodwin, S. Dak., a gently undulating expanse of till, slightly lower than this western belt of drift hills, extends from them westward, approximately level, for a width of several miles, beyond which a similar slope falls to the southwest.

On the Minnesota division of the Chicago and Northwestern Railway the traveler going west enters the inner moraine belt of the Coteau at the west edge of Minnesota, a little east of Gary, about 1,450 feet above the sea (fig. 8). The line crosses this belt obliquely, occupying about 4 miles, and ascending some 200 feet. Then 6 miles are moderately rolling, mainly in smooth swells; and the next 6 miles, lying partly on each side of Altamont, are among the knolls and small hills of the outer moraine, 1,750 to 1,950 feet above the sea; succeeded by a smooth, slightly undulating area of till, which rises to the summit of this line near Goodwin, 2,000 feet above the sea, extends thence nearly level to Kranzburg, and then descends 250 feet by a very gradual slope to Watertown.

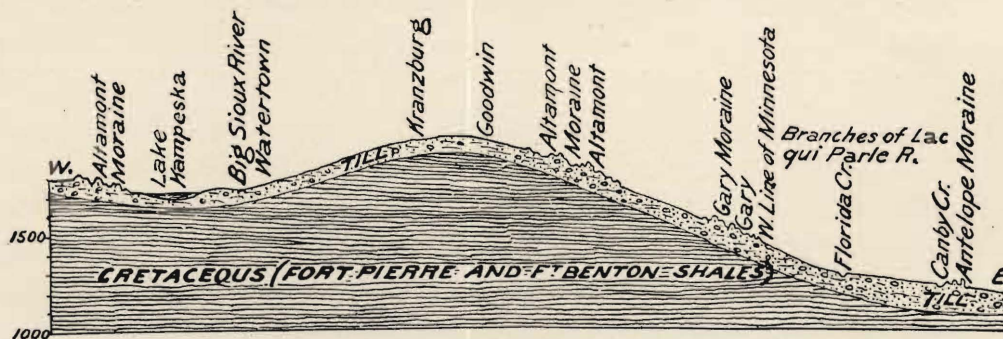


FIG. 8.—Section across the Coteau des Prairies in Yellow Medicine County, Minn., and Deuel and Codington counties, S. Dak. Horizontal scale, 12 miles to an inch; vertical scale, 1,000 feet to an inch.

The altitude of the Coteau des Prairies is due to the Upper Cretaceous formations, here spared and left by preglacial erosion as a broad and high ridge, upon which the drift deposits lie, rather than to extraordinary thickness of the drift beyond that which it commonly has on the lowlands at each side. The knolls and hillocks of the morainic belts rise 20 to 50 and rarely 75 or 100 feet above the intervening hollows, and the thickness which they add to the drift sheet of the Coteau des Prairies appears to be from 50 to 150 feet. That the prominence of this highland is not due to these morainic accumulations is shown in South Dakota at Goodwin and farther north by the greater elevation that is reached within a distance of 2 to 5 miles by the smooth sheet of till at their west side, which there forms the watershed and beyond descends to the Big Sioux River.

Nearly a constant elevation, varying between 1,950 and 2,050 feet above the sea, is maintained along the entire northern half of the Coteau

des Prairies, lying in South Dakota. The north end of this highland, called the Head of the Coteau des Prairies, is about 35 miles west-northwest of Lake Traverse and the south end of Lake Agassiz. Within 5 or 6 miles farther north there is a descent of nearly 800 feet to a level only about 1,200 feet above the sea. Along the continuation of this line northward, instead of such a prominent massive ridge, bordered by much lower land on each side, there is a more gradual ascent, attaining a third or half as great elevation above the valley on the east, with only slight descent or none thence westward to the Sheyenne and James rivers.

ASCENT FROM THE RED RIVER VALLEY IN NORTH DAKOTA.

From the Head of the Coteau des Prairies for 140 miles north to the latitude of Larimore and Devils Lake the highland bordering the west side of the Red River Valley rises by such gentle slopes that it is not generally seen conspicuously from the flat plain of this valley. Standing on the upper beach of Lake Agassiz, the observer sees a smoothed surface descending very slowly eastward within the area of this lake, and a moderately undulating or rolling surface rising slowly toward the west. Along most of this distance, however, the slope both to the east and west is so slight that the view in each direction reaches only a few miles.

On the line of the Fargo and Southwestern Railroad the highest land crossed between the west shore of Lake Agassiz and the Sheyenne River is 1,190 feet above the sea; and between the Sheyenne and James rivers it is about 1,400 feet above sea-level, or 500 feet above the central part of the Red River Valley at Fargo.

The Northern Pacific Railroad attains a height of 1,440 feet between the area of Lake Agassiz and the Sheyenne River, and the highest land between that stream and the James River is approximately 1,500 feet, being thus 600 feet above Fargo. By each of these lines the descent to the James River is only about 100 feet.

Between Larimore and Devils Lake, at the northern end of this extent, where the highland west of the Red River Valley rises less prominently than in the Coteau des Prairies on the south or in Pembina Mountain on the north, there is a slightly greater ascent than on the two preceding railroads which cross its southern half. At Larimore, near the highest western

shore of Lake Agassiz, the elevation of the Great Northern Railway is 1,134 feet, or about 300 feet above the plain of the Red River Valley at Grand Forks. Thence the surface in the next 17 miles westward rises to 1,525 feet, and this elevation is maintained somewhat uniformly, nowhere exceeding 1,535 feet nor falling below 1,450 feet, to the city of Devils Lake, 1,464 feet above the sea, 60 miles west of Larimore.

THE MANITOBA ESCARPMENT.

A very remarkable series of highlands, forming the eastern limit of the elevated plains of the northern part of North Dakota and of western Manitoba and the Saskatchewan region, extends in a north-northwest course 400 miles, from the Pembina Mountain to the Pasquia Hills. Along much of this distance a steep, mountain-like escarpment, which was the west shore of Lake Agassiz, rises 500 to 1,000 feet above the bed of that lake, now the low plain bordering the Red River and the great lakes of Manitoba. Topographically, this line of conspicuous highlands is allied with the Coteau des Prairies by their together forming the western ascent from the broad, continuous valley plain, which in its southeast part passes from the Red River Valley to the lowland of the basin of the Minnesota River. Both the Coteau des Prairies and the Manitoba escarpment consist, beneath their drift covering, of nearly horizontal Cretaceous shales, whose continuation has been removed by erosion on both sides of the Coteau, but only east of the escarpment.

Pembina Mountain.—The southern end of the Pembina Mountain, where it is reduced to rounded hills, about 100 feet above the lowland at their east base and 1,300 feet above the sea, is in section 30, township 158 north, range 56 west, between the south and middle branches of Park River. Thence for the next 5 miles northward this ascent is merely a slope that rises 50 or 60 feet, or in some portions only 30 or 40 feet, within a quarter or half mile from east to west, succeeded beyond by a moderately rolling surface with slower ascent westward. Along the west line of townships 159 and 160 of range 56 this highland rises gradually in its course from south to north, attaining an elevation about 1,500 feet above the sea; and it holds this height quite uniformly northward to the Pembina River, in the south part of township 163, range 57, about 5 miles south of

the international boundary. It is a prominent wooded bluff, some 300 feet high, extending in a very direct course from south to north or a few degrees west of north. From its southern end to the Pembina River the base of this escarpment is 1,200 to 1,225 feet above the sea. The width occupied by its slope varies from a half mile to 2 or 3 miles, and from its crest a treeless plateau, having a moderately rolling surface, stretches with slow ascent westward. North of the Pembina River its crest sinks to about 1,400 feet, and its base to about 1,025 feet, at the international boundary.

Where the Pembina River cuts through this escarpment, entering the area of Lake Agassiz, the eroded eastern front of its delta deposit forms another conspicuous bluff, about 200 feet high, falling in a steep, wooded slope from 1,175 to 975 feet, approximately, above the sea-level. The delta bluff, called the "First Pembina Mountain," is composed of sand and gravel, and lies about 5 miles east of this more prolonged line of highland, which is denominated in that vicinity the "Second Pembina Mountain." The latter, throughout its entire extent both in North Dakota and Manitoba, is caused by the outcrop of a continuous belt of almost level Cretaceous strata, mostly overspread by glacial drift.

The ascent of this highland on the international boundary, where it occupies a width of about $1\frac{1}{2}$ miles, is described by Dr. G. M. Dawson as follows:

The eastern front of Pembina escarpment is very distinctly terraced, and the summit of the plateau, even at its eastern edge, thickly covered with drift. The first or lowest terrace, which is about one-third from the prairie level toward the top of the escarpment, does not seem to preserve exactly the same altitude. On the boundary line its height above the general prairie level was found to be about 90 feet, a second terrace 260 feet, and that of the third level, or summit of the plateau, about 360 feet. The surface of the first terrace, which is here wide, is strewn with boulders, as is also that of the second terrace and plateau above. These are chiefly of Laurentian gneiss and granite, but a few smaller ones of limestone occur. The banks of ravines cutting the top of the plateau and draining westward into the Pembina River show in some places a great thickness of light-colored, yellowish, marly drift, with few boulders embedded in it.¹

¹ Report on the Geology and Resources of the Forty-ninth Parallel, from the Lake of the Woods to the Rocky Mountains, 1875, p. 219.

In Manitoba this escarpment extends with a north-northwest course by Mountain City and Thornhill to 6 miles east-southeast of Treherne, a distance of about 50 miles. With its extent in North Dakota, the whole length of Pembina Mountain is approximately 80 miles. Its crest north of the international boundary averages about 400 feet above its base, or 1,400 feet above 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 Mountain forms the eastern edge is interrupted across a distance of 65 miles to Riding Mountain. This broad depression is occupied by the Assiniboine River 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 the country farther north and west, because it has been eroded to the depth of several hundred feet on the greater part of the Assiniboine basin.

Tiger Hills.—The border of the plateau south of the Assiniboine, reaching from close south of Treherne westerly 50 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 morainic accumulations. For a distance of 40 miles west from the Pembina Mountain this belt occupies a width of 5 to 8 miles, upon which the surface falls from south to north 300 to 400 feet. The country on the south has an average elevation nearly the same as the summits of the hills, which yet rise very prominently as seen from the lower region on the north. The western part of the Tiger Hills, extending 10 or 12 miles east and an equal distance west from the gorge that is cut through the range by the Souris, rises 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 than 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 Souris to this belt, but that name is not used by the people of the district.

Riding and Duck mountains.—North of the Assiniboine River the eastern outline of the continuation of this plateau is preserved in the prominent

¹From the aboriginal name, which doubtless refers to the cougar or American panther (*Felis concolor* L.).

elevations of Riding and Duck mountains, two remarkable wooded highlands, much alike in their general features and extent. The steep eastern escarpment of each is about 50 miles long, that of Riding Mountain trending from southeast to northwest and that of Duck Mountain having a course a few degrees west of north. These elevations rise above the country adjoining the Assiniboine by a somewhat gradual slope, but they are abruptly cut off on their northeast side by a precipitous descent. This takes place on a line approximately parallel with Lakes Manitoba and Winnipegosis, the former of these lakes being about 40 miles east of Riding Mountain, while the south end of the latter is 25 miles east of Duck Mountain. The crests of these highlands, according to Mr. J. B. Tyrrell's measurements, are respectively about 2,000 and 2,300 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 400 to 700 feet above the lakes on the east, whose height slightly exceeds 800 feet.

The reader is referred to Mr. Tyrrell's map and descriptions of the district of Riding and Duck mountains for details of its topography and geology, and of the shore-lines of Lake Agassiz north of the limit of my exploration.¹

Porcupine and Pasquia hills.—Beyond Duck Mountain, after an interruption of about 30 miles across the basins of Swan and Woody rivers, this line of highlands is continued in the Porcupine Mountain or hills, which reach about 25 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 20 miles wide, is occupied by the Red Deer and Overflowing rivers.

Next are the Pasquia Hills, whose eastern end is in line with Pembina, Riding, and Duck mountains and the Porcupine Hills, being about 100 miles west from the mouth of the Saskatchewan. The Pasquia Hills extend thence 150 miles westward, where they formed the southern shore of the northwestern arm of Lake Agassiz, lying about 25 miles south of the

¹Geol. and Nat. Hist. Survey of Canada, Annual Report, new series, Vol. III, for 1887-88, pp. 1-16 E, with a preliminary contour map. Bulletin, G. S. A., Vol. I, 1890, pp. 395-410. Am. Geologist, Vol. VIII, pp. 19-28, July, 1891.

Saskatchewan River and parallel with it to the Birch Hills and the South Saskatchewan. They are the northern escarpment limiting the irregularly eroded country, which is here considered as an extension of the great plateau of North Dakota and southern Manitoba and Assiniboia, thus holding the same relation to the valley of the Saskatchewan that the Tiger Hills sustain to the Assiniboine Valley.

Great Bear Hills.—On the north side of the Saskatchewan the Great Bear Sand Hills, extending in a north-northwest course to the east end of Lac la Rouge and to the Churchill River, are geographically a continuation of the line of highlands thus described from the Coteau des Prairies and Pembina Mountain to the Pasquia Hills, and they will probably be found also to belong to the same geologic age. If this be true, they differ from this great Cretaceous escarpment south of the Saskatchewan by being outlying remnants, separated from the broad Cretaceous area on the west by a belt of Devonian limestones where these overlying beds have been eroded. The amount of erosion west of the middle portion of this escarpment, through North Dakota and in southern Manitoba, since the cycle of base-leveling which spared the Turtle Mountain area, has been inconsiderable, so that in general the surface is a great plain with a gradual ascent westward. On the south the Cretaceous strata are deeply eroded west of the Coteau des Prairies, exposing the underlying red quartzite, probably of Keweenaw age, at the celebrated Pipestone quarry in southwestern Minnesota and at many localities thence westerly to the James River. Again, in western Manitoba and northwestward, between the Assiniboine and Saskatchewan rivers, the Cretaceous strata are much denuded, though not worn through, west of the highlands that form their eastern escarpment. Still farther north, between the Saskatchewan and Churchill rivers, the denudation appears to have cut through the Cretaceous beds and to have left remnants of their eastern portion.

FOREST AND PRAIRIE.

The area of Lake Agassiz is crossed by the southwestern boundary of the forest that overspreads the greater part of British America and nearly all of the eastern half of the United States. This boundary between forest

and prairie (see Pl. XXXVIII, Chapter XI), having an almost wholly timbered region on its northeast side, and a region on its southwest side that is chiefly grass land, without trees or shrubs, excepting in narrow belts along the streams and occasional groves beside lakes, runs as follows: From near the junction of the South and North Saskatchewan rivers it passes southeasterly by the sources of the Red Deer and Assiniboine rivers and over the southwestern slopes of Duck and Riding mountains to the south end of Lakes Manitoba and Winnipeg. Thence it turns southward and holds this course along the east side of the Red River and approximately parallel with it, at a distance increasing from 15 to 50 miles from the river for about 300 miles to the upper part of this stream, where it flows from east to west. It enters the United States about 15 miles east of Emerson and St. Vincent and extends south-southeastward to the mouth of Thief River, the sources of Poplar and Sand Hill rivers, and the White Earth Agency, being at the last-named locality some 50 miles distant from the Red River. Its course continues to the south by Detroit and Pelican Rapids to Fergus Falls, where it crosses the Red River, and thence it runs south east and east through the central part of the south half of Minnesota.

Groves border the greater part of Lakes Big Stone and Traverse, and cover the islands of Big Stone Lake. But considerable portions of the shores and bluffs of these lakes and the islands of Lake Traverse are destitute of timber, or bear only bushes and small trees. The Bois des Sioux River has no timber along the upper two-thirds of its course, but below is fringed here and there by woods, from which it derives its name. The Mustinka River, flowing into the north end of Lake Traverse; Rabbit River, tributary to the Bois des Sioux; and the upper part of Wild Rice River, in North Dakota, and of Elm River, tributaries of the Red River, are also unwooded.

The Red River has no timber, or very little, for 20 miles east from its bend at Breckenridge and Wahpeton. In the next 10 miles downstream it has scattered groves of bur oak, ash, box elder, elm, and basswood, occupying perhaps one-fourth of this distance, while small poplars and willows occasionally appear in the spaces between the groves. Thence to the north this river is continuously fringed with timber, and its larger tributaries

have their course marked in the same way. The growth of wood is here confined chiefly to the banks of the streams, which have cut hollows 20 to 40 feet deep in the broad lacustrine plain.

About a sixth part of the area of Lake Agassiz, and a larger proportion (nearly the whole) of the adjoining country on the south and west, are prairie, this term being commonly used to embrace all tracts destitute of trees and shrubs, but well covered with grass. Groves of a few acres, or sometimes a hundred acres or more, occur here and there upon this prairie region beside lakes, and a narrow line of timber usually borders streams, as just described along the Red River; but many lakes and creeks, and even portions of the course of large streams, have neither bush nor tree in sight, and occasionally none is visible in a view which ranges from 5 to 10 miles in all directions. The contour of the prairie is as varied as that of the wooded region. Within the area of Lake Agassiz the surface is almost absolutely level, but the adjoining prairie country is undulating, rolling, and hilly, having in some tracts a very rough surface of knolls, hills, and ridges of morainic drift that rise steeply 25 to 100 feet or more above the intervening hollows. The material of the greater part of all these areas, whether forest or prairie, is closely alike, being till or unmodified glacial drift, showing no important differences such as might cause the growth of forest in one region and of only grass and herbage in another. Chapter XI will include a discussion of the climatic conditions, as abundance or lack of rainfall, and auxiliary causes, as prairie fires, by which the limits of these diverse phases of vegetation have been determined.

EXISTING LAKES WITHIN THE AREA OF LAKE AGASSIZ.

The glacial Lake Agassiz was gradually reduced in size, first by the lowering of its southward outlet, and afterwards by finding successively lower outlets to the northeast, until, with the complete departure of the ice-sheet, it shrank to its present representatives, the great lakes of Manitoba. These are three in number, Lakes Winnipeg, Manitoba, and Winnipegosis. With them are associated several others, comparatively small, as Cedar Lake, through which the Saskatchewan flows near its mouth; Lake

Dauphin, south of Lake Winnipegosis and tributary to it; and Lake St. Martin, on the Fairford or Little Saskatchewan River, the outlet of Lakes Manitoba and Winnipegosis.

Many other lakes of still smaller size, but ranging up to several miles in extent, are scattered here and there on all this northern part of the bed of Lake Agassiz. Such small lakes are also frequent on its southeastern part, in northern Minnesota, eastward from Roseau, Thief, Mud, and Maple lakes, besides the three large lakes of that district, Rainy Lake, the Lake of the Woods, and Red Lake.

Lake Winnipeg.—The length of Lake Winnipeg is about 250 miles, trending from south-southeast to north-northwest, while the maximum width of its southern part is about 25 miles, and of its northern part 60 miles. Its area is approximately 8,500 square miles, being intermediate in extent between Lakes Ontario and Erie. Eighty-five miles from its south end, Lake Winnipeg is reduced to a strait 2 to 4 miles wide, which extends northwesterly 12 miles, terminating at the cape called Dog Head. The narrowest part of the strait, scarcely exceeding 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 survey for the Canadian Pacific Railway, is 710 feet above the sea. Its depth, according to Mr. J. Hoyes Panton, nowhere exceeds 65 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 disastrous waterway to the freighting boats of bygone days. As you sit upon the deck of the steamer, threading its way among the islands, you are surprised at the tortuous course made, when water seems on every side and no shore near. So shallow is the lake that many places miles from land are not covered with more than 6 or 7 feet of water. It is only safe to experienced captains, thoroughly acquainted with the concealed channels that afford a safe course at a distance from the shore."¹ On account of this slight depth, the water of most parts of the lake is com-

¹"Notes on the geology of some islands in Lake Winnipeg." Transactions of the Historical and Scientific Society of Manitoba, January 28, 1886.

mionly turbid with mud, stirred up by the waves from its shores and bed.¹ Low land borders this lake along nearly its whole extent, and the highest points on the shore or visible from it rarely attain an elevation of 50 feet.

Lakes Manitoba and Winnipegosis.—Lake Manitoba² lies about 40 miles west of the south half of Lake Winnipeg; and Lake Winnipegosis,³ separated only about 2 miles from the north end of Lake Manitoba, lies mostly 40 to 50 miles west of the north half of Lake Winnipeg, but its most northeast part is only 20 miles southwest from that lake. The length of each of these lakes, measured in a straight line, is about 120 miles, trending in parallelism with Lake Winnipeg, from south-southeast to north-northwest; 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.

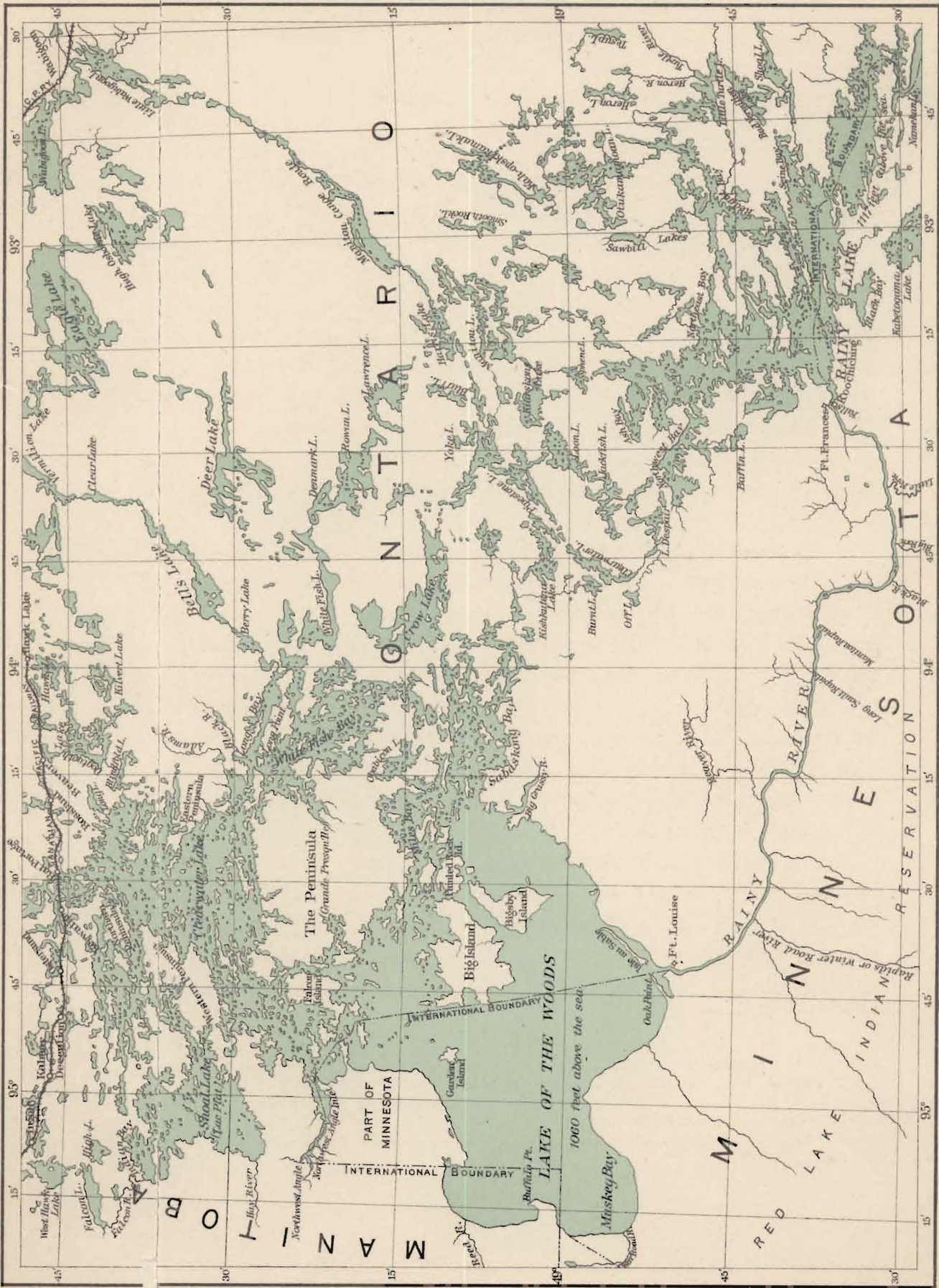
The maximum width of Lake Manitoba, about 28 miles, is at its south end. Near its middle it is narrowed to a strait about a half mile wide and 2 miles long. Its northern part is of quite irregular form, and is nearly intersected from the north by a long peninsula. This lake, according to leveling by Mr. H. S. Treherne, is 809 feet above the sea, being thus almost exactly 100 feet higher than Lake Winnipeg, to which it is tributary by the Little Saskatchewan. 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 5 to 15 miles. Its northern portion is bent to the west and south, terminating in Dawson Bay, so that its length, following this course, is nearly 150 miles. Its outlines, moreover, are very irregular, presenting a constantly varying

¹“Lake Winnipeg receives its name from the muddy or sallow appearance of its waters; *We* signifies muddy, and *Nepe* water, in Chippewa.”—Keating’s Narrative of Long’s Expedition, Vol. II, p. 77.

²Meaning the “Narrows or Strait of the Manitou or Great Spirit,” as I am informed by letters from Prof. George Bryce and Mr. J. B. Tyrrell. This name was originally pronounced by white inhabitants nearly as by the Indians, with accents on the initial and final syllables; but during the past ten years or more its almost universal pronunciation in English has been with only one accent, which is laid on the next to the last syllable.

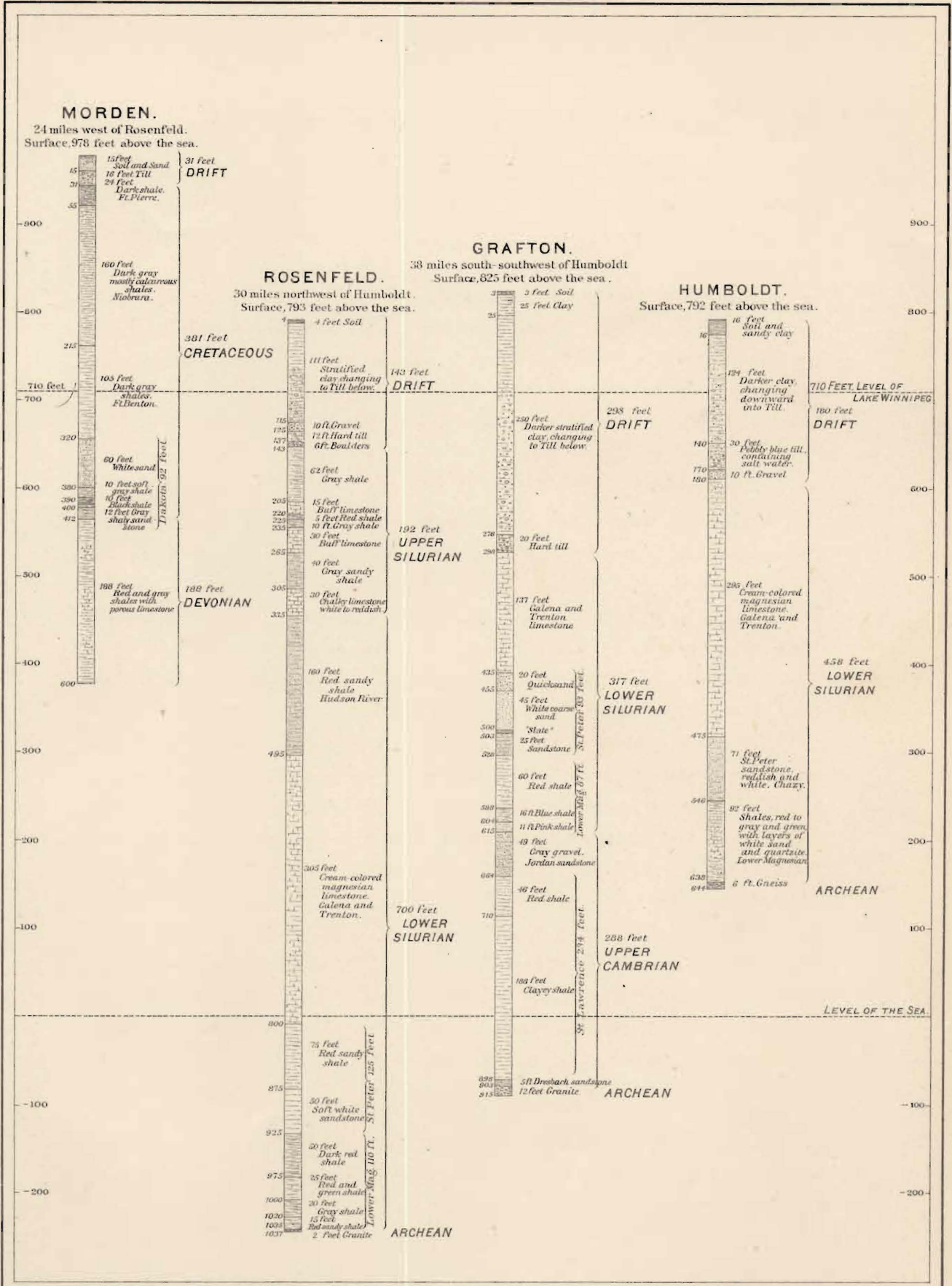
³Meaning “Little Winnipeg.”—Hind’s Narrative of the Canadian Exploring Expeditions, Vol. II, p. 42.



MAP OF RAINY LAKE AND THE LAKE OF THE WOODS.

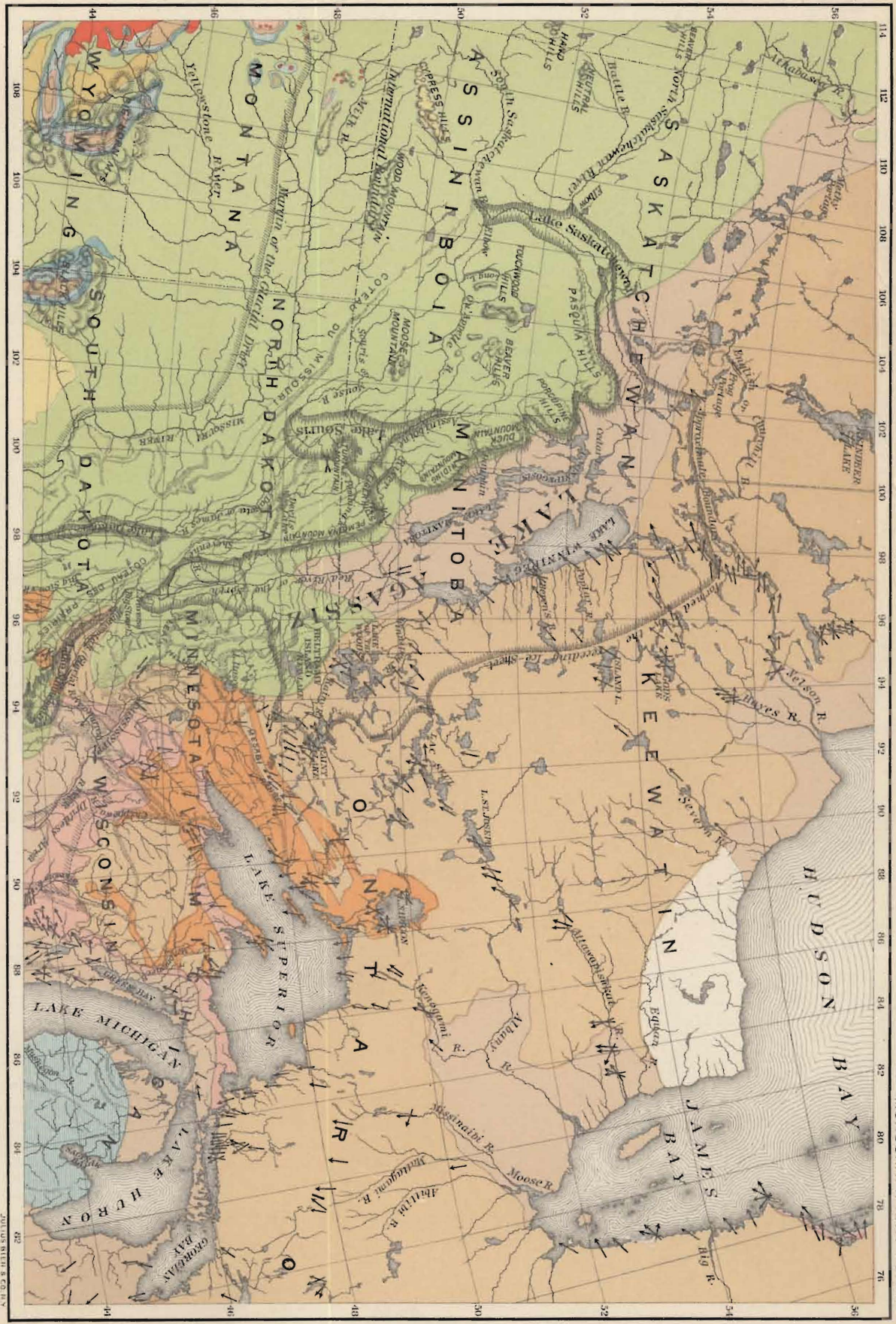
Scale, about 14 miles to an inch.

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SECTIONS OF WELLS AT HUMBOLDT, MINN; GRAFTON, N.D; AND ROSENFELD AND MORDEN, MANITOBA.

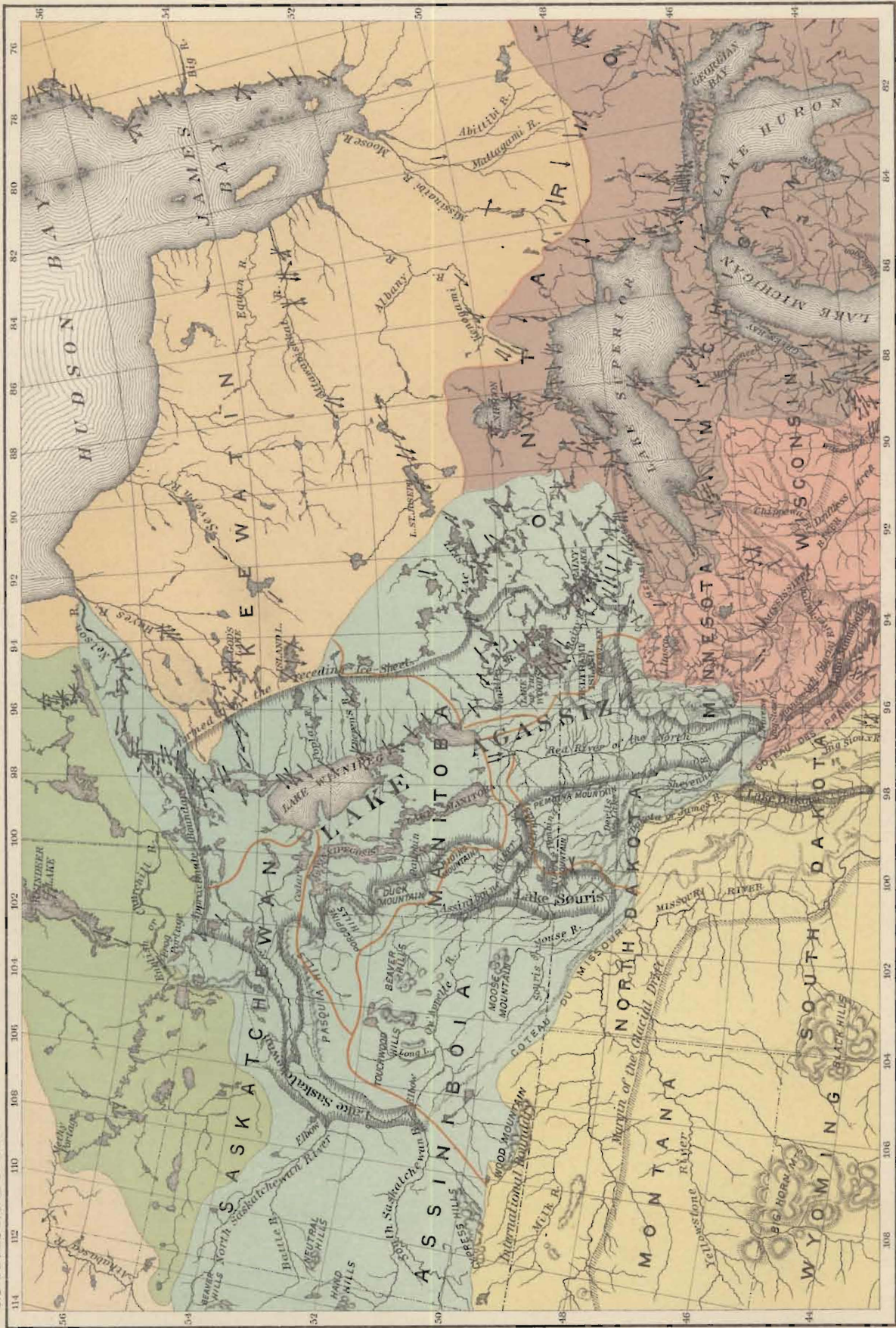
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MAP OF THE ROCK FORMATIONS UNDERLYING THE DRIFT ON THE AREA OF LAKE AGASSIZ AND ADJOINING COUNTRY.

Scale, about 165 miles to an inch.

- Archean
 - Cretaceous
 - Algonkian
 - Eocene
 - Cambrian
 - Silurian and Devonian
 - Neocene
 - Volcanic
 - Carboniferous
 - Triassic and Jurassic
 - Unexplored
- Chiefly from maps by Prof. C. H. Hitchcock and of the Geological Surveys of the United States and of Canada.

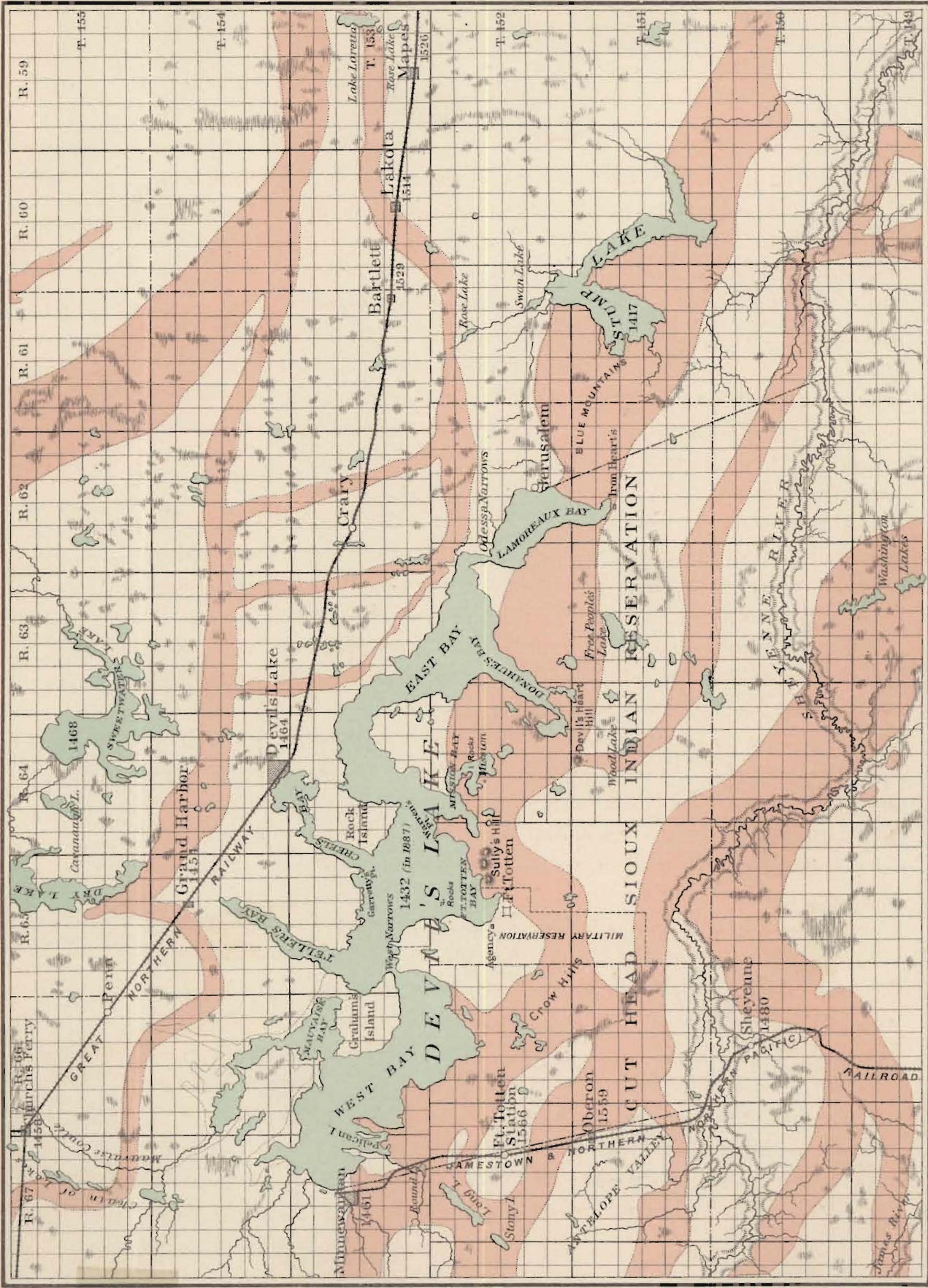


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MAP OF DRAINAGE SYSTEMS ON THE AREA OF LAKE AGASSIZ AND ADJOINING COUNTRY.

Scale about 165 miles to an inch.

- Nelson
 - Churchill
 - Other Tributaries of Hudson and James Bays
 - Mackenzie
 - Missouri
 - Upper Mississippi
 - St. Lawrence
- The chief divisions of the Nelson drainage area are designated by red lines.



JULIUS BETH & CO. N.Y.

MAP OF DEVILS AND STUMP LAKES.

Scale, 6 miles to an inch.

Moraines

Altitudes of Railway stations and of lakes are noted in feet above the sea.

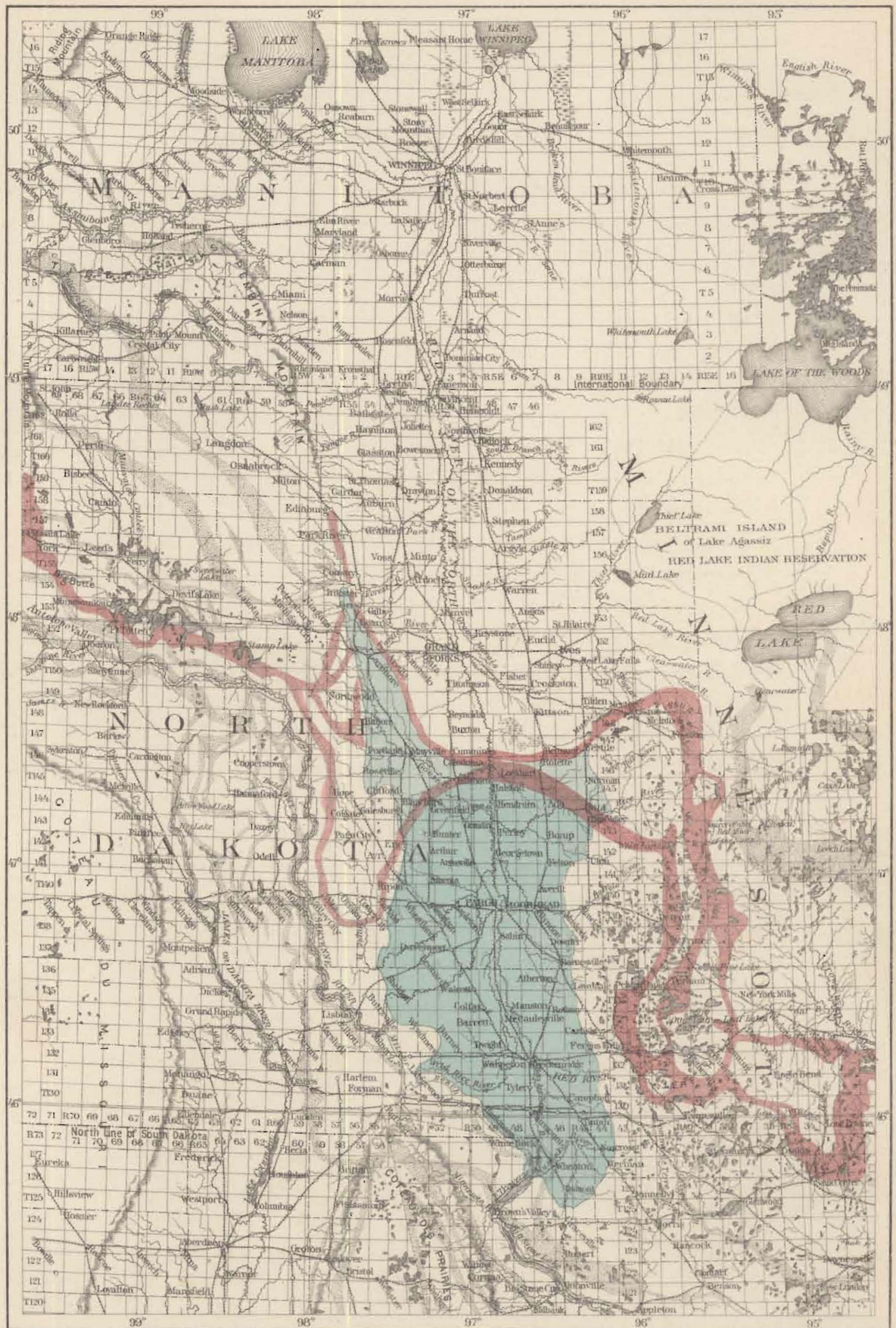


MAP OF THE GLACIATED AREA OF NORTH AMERICA.

Scale, about 550 miles to an inch.

- Areas covered by Land-ice during the Quaternary Era Quaternary Lakes Bonneville and Lahontan and the Glacial Lake Agassiz
- Glacial Currents known by Striae Glacial Currents known by Drift Transportation or otherwise inferred

Note.—The dotted southern part of the drift area in the Mississippi and Missouri river basins represents the drift of the early Kansan and East Iowan stages of glaciation. The northern boundary of this drift notes the extent of the ice-sheet at the time of beginning of its moraine-forming or East Wisconsin stage.



JULIUS BIEN & CO. N.Y.

MAP SHOWING THE EXTENT OF LAKE AGASSIZ AT THE TIMES OF FORMATION OF THE FERGUS FALLS AND LEAF HILLS MORAINES.

Scale, about 42 miles to an inch.

Area of Lake Agassiz contemporaneous with the Fergus Falls Moraine Area added at the time of the Leaf Hills Moraine
 Fergus Falls (eighth) and Leaf Hills (ninth) Moraines

succession of bays, capes, and islands. This lake outflows by Water Hen Lake and River to Lake Manitoba, and has an elevation of 19 feet above the latter, as determined by surveys for the Canadian Pacific Railway, or 828 feet above the sea.

Rainy Lake.—Two bodies of water of considerable size, namely, Rainy Lake and the Lake of the Woods (Pl. XI), lie on the northern boundary of Minnesota, within the eastern part of the area of Lake Agassiz. The length of Rainy Lake is slightly more than 50 miles, trending from east-southeast to west-northwest, and its average width is about 5 miles, giving it an area of 250 square miles, approximately. It is extremely diversified by projecting points, numerous bays 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 110 feet.

Lake of the Woods.—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 it adjoins Minnesota. Measured from north to south or from east to west, its maximum extent in either direction is 60 miles approximately, and its area is about 1,500 square miles. Its elevation, determined by the Canadian Pacific Railway survey, is 1,060 feet above the sea, and the maximum depth of its northern part, called Clear Water Lake, is stated by Dr. G. M. Dawson to be 84 feet.

Red Lake.—The largest lake lying wholly in Minnesota is Red Lake (Pl. XII), situated in the southeast edge of the area of Lake Agassiz, at a distance of about 50 miles south from the Lake of the Woods. Its elevation, as determined by the Duluth and Winnipeg Railroad survey, is 1,172 feet above the sea, being about 40 feet below the adjacent portion of the highest shore-line of the glacial lake. A strait about three-fourths of a mile wide divides Red Lake into two nearly equal parts, which trend from east to west. The length of each part is somewhat more than 20 miles, and of both together about 30 miles, while the maximum width of each is about 10 miles. Its area is approximately 440 square miles. This lake

differs remarkably from all the preceding in its regular outlines, broken by no capes nor bays, and in the complete absence of islands. The map plate shows the various drift deposits adjoining Red Lake, as observed in a canoe trip along its entire shore-line in September, 1885.

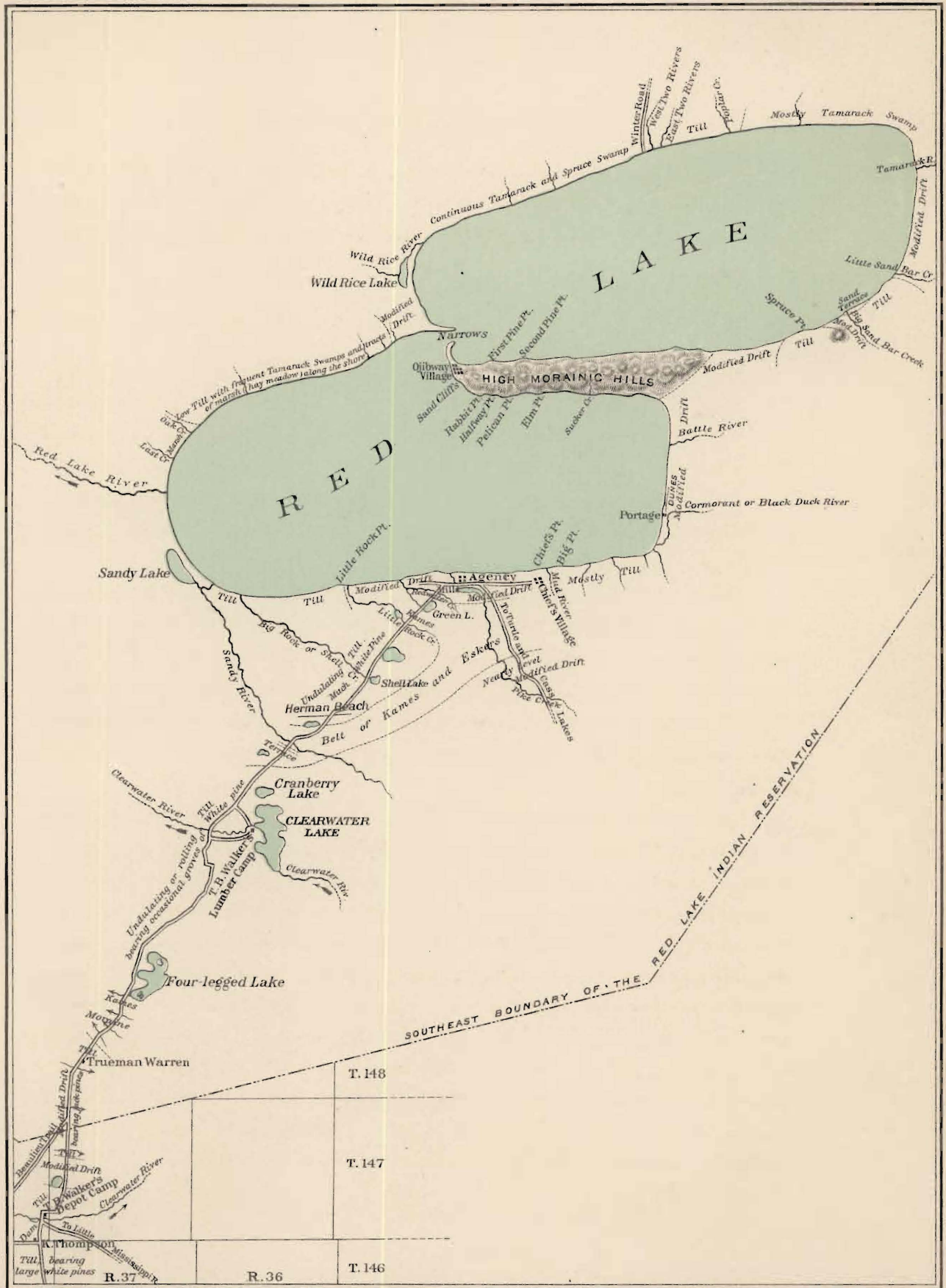
RIVERS TRIBUTARY TO LAKE AGASSIZ AND DRAINING ITS AREA.

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. Pl. XIII is colored to show the several drainage areas of the Lake Agassiz basin and adjoining country.

Rainy and Winnipeg rivers.—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.

Rainy River, about 80 miles long, connecting Rainy 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 general in a somewhat direct west-northwest course. At the mouth of Rainy Lake it has rapids that fall about 3 feet. Its principal falls are between Koochiching and Fort Frances, situated opposite to each other on the south and north banks of the river, a little more than 2 miles from Rainy Lake, where it descends 23 feet in about a tenth of a mile. Manitou Rapids, about 35 miles from Rainy Lake, are a short descent of about 2 feet, with outcropping 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 10 feet;"¹ but subsequent leveling by S. J. Dawson shows that it probably

¹Keating's Narrative of Long's Expedition, Vol. II, p. 230.



MAP OF RED LAKE AND ITS VICINITY.

Scale, 6 miles to an inch.

does not exceed two-thirds this amount. Excepting these rapids, Rainy River has an average descent of only about 3 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 thence to Rainy Lake it is navigated by a tug or propeller, towing Mackinaw boats. The banks of the river are only 10 to 20 feet high, and are fertile and heavily wooded, having commonly a clayey soil. The most important tributaries of Rainy River are on its south side, and include the Little Fork and the Big Fork or Bowstring River (whose mouths are respectively about 15 and 21 miles from Rainy Lake), Black River (4 miles below the Big Fork), and the Rapids or Winter Road River (about 12 miles from the Lake of the Woods).

Winnipeg River, the outlet of the Lake of the Woods, has a length of about 160 miles, flowing in a winding course to the northwest. Its total descent is 350 feet, four-fifths of this being in the many falls and rapids which occur along nearly its entire extent. 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 perceptible. At Rat Portage the Winnipeg flows out from the Lake of the Woods by two channels, which are divided by Tunnel Island. Each channel descends about 16 feet, the eastern one being called Hebes Falls, and the western one the Witches Caldron, which opens into Winnipeg or Darlington Bay. After flowing about 8 miles through this and other bays or lakes, the river enters the Dalles, passing with a very swift current between perpendicular walls of granite. Beyond the Dalles its banks and abundant islands along a distance of about 15 miles, as described by Keating, are clay slate, occasionally varying to mica-schist. "The river expands considerably, being in some places several miles wide. * * * Its current is swift, especially near the islands, but it is free from ripples; we observed none of the foaming rapids which characterize the lower part of the stream. The islands, which in some places are countless, are generally small and of a form nearly square; from the vertical stratification of the rock their banks are perpendicular; they generally rise from 10 to 20 feet above the level of the water." Below this belt of slate the river flows through a very picturesque region of granite,

gneiss, and schists, over many falls, cascades, and rapids, and through numerous lakes. In descending order these include Jacks Falls, the Upper Falls, "which for beauty are second only to the Lower Falls;" Slave Falls, "computed at 20 feet;" Lac du Bonnet, "about 15 miles long and from 600 yards to 4 miles in breadth," and the Lower Falls.¹

On each side the country rises to a moderate elevation in low hills and ridges, with frequent outcrops of the bed-rocks. The highest land crossed by the Canadian Pacific Railway south of the Winnipeg River, from 18 to 28 miles west of Rat Portage, is about 200 feet above the Lake of the Woods and about 550 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 River, draining a considerable area 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.

Red Lake River.—Originally the name Red River was applied by the Indians to the outlet of Red Lake, flowing westerly to Grand Forks and thence northerly to Lake Winnipeg, and the stream now called Red River was known to them as the Ottetail River from Ottetail Lake to its junction with the Red Lake River. Beltrami affirms, with poetic license, that the aboriginal names of Red Lake and of its outflowing river, the latter translated by him Bloody River, refer to the "blood of the slain" in the wars between the Ojibways and Dakotas.² This stream is the largest trib-

¹ Keating's Narrative of Long's Expedition, Vol. II, pp. 82-102.

² A Pilgrimage in Europe and America, leading to the discovery of the sources of the Mississippi and Bloody River, Vol. II, pp. 335-340. Also see Keating's Narrative of Long's Expedition, Vol. II, p. 34.

Rev. J. A. Gilfillan, however, states that the Ojibway name of Red Lake perhaps alludes to "reddish, fine gravel or sand along the shore in places, which in storms gets wrought into the water near the edges," or to the reddish color of streams flowing into the lake from bogs on its north side. (Fifteenth Annual Report, Geol. and Nat. Hist. Survey of Minnesota, for 1886, p. 460.)

D. D. Owen, in the description of his canoe journey down the Red River, writes of its junction with the Red Lake River at Grand Forks: "The Red Fork of Red River, which flows from Red Lake, * * * is the stream to which the name of Red River properly belongs. The stream which we navigated is known to the Indians by the name of Ottetail River. The color of the waters of Red River proper also shows the origin of the name. They are of a reddish brown cast, and contrast strongly with the whitish, milky appearance of the stream coming from Ottetail Lake, and which henceforth assumes a darker hue."—Report of a Geological Survey of Wisconsin, Iowa, and Minnesota, 1852, pp. 176, 177.

utary of the Red River from its east side. From Red Lake to the mouth of Thief River it flows west-northwest about 40 miles, measured in a direct line; next it flows south 16 miles to a point about 3 miles east of Red Lake Falls; thence west-southwest 21 miles to Crookston, and finally west and northwest 23 miles to Grand Forks. Its entire length, not measuring minor bends, is thus approximately 100 miles, but if the course of the river were followed in all its meanderings this distance would be nearly doubled. Its width varies mostly from 6 to 10 rods. At its mouth it has only about half as great width as the Red River above their junction, but probably carries an equal volume of water, as it flows with a much stronger current, estimated between 2 and 3 miles per hour at the stage of ordinary low water.

The Grand Marais, extending 22 miles from the Red Lake River near Fisher to a point on the Red River 12 miles below Grand Forks, is a former channel of the Red Lake River, now occupied by marshes, pools, and lakelets. The width of this deserted channel or valley, measured between the crests of its bluffs, varies commonly from 15 to 30 rods, rarely expanding to a quarter or third of a mile, and its depth below the general level of the valley plain is mostly about 20 feet. It is only half as deep, and averages probably not more than a fifth as wide, as the present river valley. During times of abundant rains, and especially when the snow melts in the spring a stream occupies the Grand Marais, but through the greater part of the year it has no running water. In a similar manner the Wild Rice River of Minnesota, along its lower portion, at first flowed in the present channel or valley of the Marsh River, from which it has turned away about 2 miles southeast of Ada to a more southerly course. Doubtless in each case a smaller stream had previously begun the erosion of the channel into which the river was diverted.

The fall of Red Lake River between Red Lake and Thief River is 73 feet, from 1,172 to 1,099 feet above the sea. Thence to its mouth it descends 315 feet, averaging more than 5 feet per mile in its direct course. Its banks and bed consist of glacial drift, excepting where this formation is covered by alluvial deposits, and consequently the stream has acquired a somewhat regular slope, broken, indeed, by frequent rapids where it runs

over cobbles and boulders, but having no abrupt falls. The height of the banks and of the adjoining country, which has a flat or slightly undulating contour, is generally 30 to 40 feet above the river; but in the vicinity of Red Lake Falls this stream and the Clear Water River, an important tributary to it from the southeast, have eroded their channels to the depth of nearly 100 feet. The range of these rivers from low to high water at Red Lake Falls is only 5 feet, and the descent of each is about 40 feet within 2 miles.

Red River.—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 1,550 feet above the sea, 13 miles west of Lake Itasca. It first flows south about 60 miles, measured in a direct line, passing in succession through Elbow, Many Point, Round, Height of Land, Little Pine, Pine, and Rush lakes to Ottetail Lake, this portion being commonly called Ottetail River. In this distance it descends to 1,315 feet above the sea. The contour of the adjoining country is rolling or hilly northward and undulating or flat southward.

Below Ottetail 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 Ottetail River to its junction with the Bois des Sioux River at Breckenridge and Wahpeton, 42 miles west of Ottetail Lake.¹ The descent in this distance is 372 feet, or about 5 feet per mile, following the course of the stream. It is most rapid in the vicinity of Fergus Falls, amounting to 80 feet in 3 miles, from 1,210 to 1,130 feet above the sea. Because of the numerous large lakes on the upper part of the stream, its volume along this descent to Breckenridge is not greatly affected by either heavy rains and snow melting or dry seasons. At Fergus Falls the range from its lowest to its highest stage is only 2 or 3 feet. Its banks and bed are the hard, stony clay of the glacial drift, affording a good foundation for dams and canals. From Ottetail Lake to the border of Lake Agassiz, 9 miles southwest from Fergus Falls, the

¹The Ojibways, according to Rev. J. A. Gilfillan (l. c., p. 463), thus apply the name Ottetail River as far as to the Bois des Sioux; and the Red River thence northward is called by them Kitchizibi (Great River).

country is rolling and hilly, rising 50 to 100 feet above the river. Farther west the flat or slightly undulating surface of the lacustrine area soon sinks, so that the average height varies from 5 to 15 feet above the river in its ordinary low stage, yet its banks are seldom or never overflowed. The only noteworthy tributary to the Red River between Ottertail Lake and Breckenridge is the Pelican River, which joins it from the north 3 miles west of Fergus Falls. This stream, nearly 50 miles long in a straight line, flows through a rolling and hilly region, receiving the waters of many lakes, of which the largest are Detroit, Cormorant, Pelican, Lizzie, and Lida.

From its bend at Breckenridge and Wahpeton the Red River flows north 285 miles, measured in a direct line, to Lake Winnipeg. Its course through this distance has been already described in an earlier portion of this chapter, treating of the Red River Valley. The entire length of the Red River, measured thus in straight lines successively to the south, west, and north, is about 390 miles; but in its meanderings, nowhere diverging far from these lines, it flows nearly 700 miles. Its descent below Breckenridge is 233 feet, and in total from its source to its mouth approximately 840 feet. All the way below McCauleyville and Fort Abercrombie, 15 miles north of Breckenridge, it is navigated by steamboats, barges, and flatboats, but along the Goose Rapids, extending about 12 miles next below the mouth of Goose River as measured in the meandering course of the stream, the channel is obstructed by bowlders which forbid navigation during low stages of water. A broad belt of till, formed by the united Fergus Falls and Leaf Hills moraines, as described in Chapter IV, causes these rapids. The width of this river in the United States varies from 6 to 20 rods, being in some places less than the length of the steamboats; but north of the international boundary it is commonly 20 rods wide.

The range between the lowest and highest stages of the Red River increases rapidly north of Breckenridge, becoming 32 feet at Moorhead and Fargo, and attaining its maximum of 50 feet at Belmont. It continues nearly at 40 feet from Grand Forks to the international boundary and to Winnipeg. At Lower Fort Garry, 16 miles north of Winnipeg and about 20 miles from the mouth of the river, it is 35 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, which is usually broken up along the southern upper portion of the river earlier than along its lower course. 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 2 to 4 or 5 miles from it is covered with water 1 to 5 feet or more in depth.

The noteworthy tributaries of the Red River on its east side, in their order from south to north, are the Buffalo, Wild Rice, Marsh, Sand Hill, Red Lake, Snake, and Tamarack rivers, the stream named Two Rivers for its two branches which unite 3 miles above its mouth, and Joe, Roseau, and Rat rivers; and on the west, the Bois des Sioux, Wild Rice, Sheyenne, Elm, Goose, Turtle, Forest, Park, Pembina, Marais, Scratching or Boyne, La Salle, and Assiniboine rivers. Excepting the Red Lake River, already described, and the Sheyenne, Pembina, and Assiniboine rivers, all these are small, the farthest portions of their areas of drainage being 40 to 75 miles from the Red River. 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 the channel.

Sheyenne River.—The Sheyenne, having its sources near the great southeastern bend of the Souris or Mouse River, in North Dakota, first flows to the east nearly 100 miles, passing 10 miles south of Devils Lake; next it flows south about 100 miles, to where it enters the area of Lake Agassiz; and thence its course is eastward and northward, uniting with the Red River 10 miles north of Fargo and Moorhead. Where it is crossed by the Jamestown and Northern Railroad, south of the west end of Devils Lake, its elevation is 1,410 feet above the sea. Thence it falls to 1,064 feet at Lisbon, and 857 feet at its mouth. Along its eastward and southward course it flows through an undulating or rolling and occasionally hilly region, in which its valley is eroded 100 to 200 feet deep. Within the area of Lake Agassiz it has cut 50 to 75 feet into its delta, and beyond occupies

a channel 20 to 30 feet below the flat lacustrine plain. This lower portion of the river is mostly from 50 to 75 feet wide and 1 to 3 feet deep. The Maple River, flowing south and then northeast, parallel with the Sheyenne, joins this river about 8 miles from its mouth. The large valley of the upper part of the Sheyenne River, and its extensive delta deposited in Lake Agassiz, are attributable to a stream which was doubtless much larger than the present Sheyenne, formed by drainage from the ice-sheet when it terminated near Devils Lake. At that time, also, a glacial lake in the basin of the Souris outflowed southeastward to the Sheyenne and James rivers.

Langs Valley.—During a later stage in the recession of the ice-sheet the glacial Lake Souris was extended west and north of Turtle Mountain and finally found a lower outlet in southern Manitoba. Its outflowing river ran southeasterly from the elbow of the Souris, 18 miles southwest of its mouth, to the Pembina River. Pelican Lake, 11 miles long from northwest to southeast and about a mile wide, occupies a part of the channel of this stream; and a distinct water course of similar width, called Langs Valley,¹ eroded 110 to 150 feet below the general level, extends 11 miles between this lake and the Souris. The highest portion of Langs Valley is 1,364 feet above the sea, and about 100 feet above the Souris at its elbow, and is inclosed by bluffs 110 feet high. It is a channel similar to that of Lakes Traverse and Big Stone and Browns Valley, eroded by the River Warren, outflowing from Lake Agassiz.

Pembina River.—The Pembina River² flows from the northern part of Turtle Mountain in a rather crooked easterly course through southern Manitoba and the edge of North Dakota about 130 miles, measured in a direct line, to its mouth at Pembina and St. 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. Rock Lake and Swan Lake, on this part of the river, each several miles long and from a half mile to 1 mile wide, are due to deposits brought into this valley by tributaries after it ceased to be the avenue of drainage from the Souris

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

²This name is stated by Keating to be from the Ojibway word "anepeminan, which name has been shortened and corrupted into Pembina," meaning the fruit of the bush cranberry (*Viburnum opulus*, L.).—Narrative of Long's Expedition, Vol. II, p. 38.

basin. In crossing the Red River Valley the Pembina runs in a channel only 20 to 40 feet deep. Its descent from the northern base of Turtle Mountain to Wallhalla is about 700 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, Clear Water or Cypress River, and Tongue River are its chief tributaries, all from the south side.

Assiniboine River.—The largest tributary of the Red River is the Assiniboine, which drains a basin in Assiniboia, Manitoba, and North Dakota, 300 miles wide from south to north and 400 miles long from west to east. From its source in the south edge of Saskatchewan, 50 miles southwest of the Porcupine Hills, the Assiniboine flows south-southeasterly 200 miles, to a point about 50 miles below the mouth of the Qu'Appelle and 40 miles west of Brandon; thence it flows easterly about 150 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 1,075 feet; at Portage la Prairie, 842 feet, and at its junction with the Red River in Winnipeg, 724 feet. During its high stages of water the Assiniboine has been navigated by steamboats to Fort Pelly, about 90 miles above the mouth of the Qu'Appelle. Along this portion it varies from 10 to 25 rods in width.

The highest floods of the Assiniboine at Portage la Prairie and along a considerable distance eastward rise only 12 to 15 feet above its lowest stage, but they then attain a height only a few feet below the highest portions of the adjoining country, much of which is submerged. At this extreme height, which the river reached and maintained from the 3d 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, 2 miles southwest of Portage la Prairie, and a portion of its flood passed north in shallow, winding watercourses to Lake Manitoba, making a descent of about 40 feet in the distance of 15 miles between the river and the lake. Near the same time Lake Manitoba also reached its highest stage, about 8 feet above its lowest level, rising until it overflowed southward across the east part of township 13, range 6, and thence eastward through the southern row of sections in township 13, range 5, falling

10 feet in 15 miles to Long Lake, through which old channel of the Assiniboine its waters were discharged into this river 20 miles east of Portage la Prairie.¹

The excavation of the Assiniboine basin, before mentioned in connection with the description of Pembina, Riding, and Duck mountains, depressing much of its area hundreds of feet below the great plains farther south, was effected by preglacial rivers. Over the irregular surface thus sculptured a thick covering of glacial drift is spread somewhat uniformly, so that the preglacial contour is preserved in the broader outlines of the country; but the smaller inequalities of the surface and the present watercourses have been formed during Glacial and Recent time.

While Lake Agassiz held nearly its highest level, the Assiniboine brought into its west side a vast delta of gravel and sand, which extends from Brandon 75 miles east to Portage la Prairie, and from Treherne, Glenboro, and Milford 40 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.

Qu'Appelle and Souris rivers.—The Qu'Appelle or Calling River and the Souris or Mouse River are 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 eroded by the outlet of a glacial lake in the basin of the South Saskatchewan River. The description, map, and sections given by Hind² show that this valley is quite uniformly about 1 mile wide, and is eroded from 110 to 350 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 Assiniboine is about 270 miles, the general course being a little to the south of east. Of this extent the west end of the valley for about 12 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

¹ Compare H. S. Treherne's description of this vicinity, "An ancient outlet of Lake Manitoba," Ninth Annual Report of the Geol. and Nat. Hist. Survey of Minnesota, for 1880, pp. 388-392.

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

between these rivers being 85 feet above the South Saskatchewan, 440 feet above the mouth of the Qu'Appelle, and 1,700 feet above the sea. The inclosing bluffs are composed mainly of glacial drift, with only a few exposures of the underlying Cretaceous rocks. The alluvial bottom land of the Qu'Appelle is generally from a half mile to 1 mile wide, and through it the river flows in a winding course, here and there passing through long 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 glacial lake, fed by the melting ice fields of an immense area reaching west to the Rocky Mountains, took its course east by this trough-like channel or valley, entering the Assiniboine at Fort Ellice and reaching the border of Lake Agassiz at Brandon.

Long or Last Mountain Lake, about 50 miles long from south to north and 1 to 2 miles wide, lying north of the upper part of the Qu'Appelle and tributary to it, occupies a similar glacial watercourse. The elevation of Long Lake is 1,598 feet, being about 100 feet lower than the divide in the channel from the elbow of the South Saskatchewan to the Qu'Appelle. It seems probable that when the ice-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 of this lake, forsaking its former outlet.¹ Owing to the changes in relative elevation which have taken place in the region of Lake Agassiz since that time, this new outlet, or the earliest and highest one of several successive outlets, across the watershed between the Saskatchewan basin and Long Lake, may now be found 50 or perhaps even 100 feet higher than the old channel to the head of the Qu'Appelle—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.

Souris River, flowing circuitously southwestward from Assiniboia into North Dakota and thence northeastward into Manitoba, became tributary to the Assiniboine after the waters of the glacial lake in its own basin, at

¹ Report of the Assiniboine and Saskatchewan Exploring Expedition, 1859, pp. 28, 35, 118.

first flowing to the James and Sheyenne, had been wholly drained away by its outlet through Langs Valley and the Pembina River. The length of the Souris is nearly 400 miles, but it is only 5 to 10 rods wide along its lower portion. In North Dakota its descent is approximately from 1,650 to 1,400 feet above the sea, and thence to its mouth it falls about 325 feet.

Little Saskatchewan or Fairford River.—An area that extends more than 200 miles west from Lake Winnipeg and includes an equal distance in latitude, from the most northern part of Lake Winnipegosis to the south end of Lake Manitoba, is drained by the Little Saskatchewan or Fairford River.¹ Several small streams flow into the south end of Lake Manitoba, and the Water Hen River, the outlet of Lake Winnipegosis, flows into its north end. Four considerable streams are tributary to Lake Winnipegosis, namely; Mossy River, the outlet of Lake Dauphin, flowing into its south end, and the Swan, Red Deer, and Overflowing rivers at its northwest end. Riding and Duck mountains form the southwestern boundary of this basin, but the Porcupine Hills are entirely inclosed between the Swan and Red Deer rivers, and the latter drains much of the plateau bordered by the Pasquia Hills.

Saskatchewan River.—The lower part of the basin of the Saskatchewan, next to its mouth, was latest occupied by the ice-sheet; but that area was evidently relinquished by it, allowing this great river to take its present course, before Lake Agassiz began to be drained northeastward. From the most western sources of the Saskatchewan in the Rocky Mountains to its mouth is a distance of more than 700 miles, and the maximum width of its basin is about 350 miles. Its two branches, of nearly equal size, the North and South Saskatchewan rivers, unite 230 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, about 1,200 feet. Cedar and Cross lakes, through which the Saskatchewan flows

¹The portion of this river extending 10 miles, with a descent of about 15 feet, from Lake Manitoba to Lake St. Martin, is commonly called the Fairford River, and the lower portion, extending 31 miles and falling 85 feet to Lake Winnipeg, is known as the Little Saskatchewan.—J. B. Tyrrell, Geol. and Nat. Hist. Survey of Canada, Annual Report, new series, Vol. IV, for 1888-89, pp. 19-21A.

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 43 feet in $2\frac{1}{2}$ miles.¹ Its average descent per mile from Medicine Hat eastward is about 2 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 in width, and during favorable stages of water are navigated by steamboats from Cedar Lake to Edmonton, on the North Saskatchewan, about 2,000 feet above the sea, and beyond the confluence of the Bow and Belly rivers, which form the South Saskatchewan, 50 miles west of Medicine Hat, at an elevation exceeding 2,200 feet. The chief hindrances to their navigation in low stages are shifting sand bars, over which they expand in some places to widths of a half mile to 1 mile, being very shallow and divided by low sandy islands. The adjoining country rises within a few miles from these rivers, or at the farthest 10 or 20 miles, to an elevation 300 to 600 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 50 to 100 feet above the river, and its shores are generally low and in many portions swampy.

The smaller tributaries of Lake Winnipeg.—Besides the great affluents of Lake Winnipeg, namely, the Winnipeg, Red, Little Saskatchewan, and Saskatchewan rivers, about a dozen streams, varying in length from 10 to 40 miles, enter its west side, and twenty or more of similar or somewhat greater length enter its east side. Of the latter the largest are Berens and Poplar rivers, each about 100 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 east, before its melting finally permitted the waters of the Glacial Lake Agassiz to be drained to the level of this lake.

Nelson River.—The outlet of Lake Winnipeg, as before noted, is bordered by no areas of highland along its course of about 400 miles to

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

Hudson Bay. The upper half of the Nelson flows in a general direction only a few degrees east of north, passing through Great and Little Playgreen, Pipestone, Cross, and Sipi-wesk lakes, to Split Lake; thence it turns to the east for about 100 miles, passing through Gull Lake, and finally takes a northeastward course along its lower 100 miles. According to Dr. Bell's observation, Sipi-wesk Lake is approximately 570 feet above the sea, or 140 feet below Lake Winnipeg; Split and Gull lakes are respectively about 440 and 420 feet above the sea; and the descent in the next 48 miles, to the foot of Broad Rapid, is nearly 300 feet. The Nelson is navigable from the sea about 90 miles to the First Limestone Rapid, where the elevation is probably about 50 feet above the sea-level.

About four-fifths of the region drained by the Nelson, including the basins of the Red River of the North, the Little Saskatchewan, and the Saskatchewan, and the greater part or possibly all of the basin of the Rainy and Winnipeg river system, were uncovered from the ice-sheet and were tributary to Lake Agassiz as early as the middle portion of the time while it had its southward outlet. The waters of a large part of British America were thus carried along the course of the Minnesota and the Mississippi to the Gulf of Mexico. The basin of Lake Agassiz then included approximately 350,000 square miles, of which nearly a third was covered by the lake itself.

**EXTENSION OF THE BASIN OF LAKE AGASSIZ BY GLACIAL LAKES
OUTFLOWING TO IT FROM THE REGION OF THE PEACE AND
ATHABASCA RIVERS.**

Furthermore, within the time after the ice-sheet had retreated beyond the valley of the lower Saskatchewan, and before its melting upon Hudson Bay and the adjoining country permitted Lake Agassiz to gain an outlet to the northeast, it seems certain that the ice must have been melted upon a large region north of the Saskatchewan basin, where drainage now passes east by the Churchill and north by the Mackenzie, but was then pent up in lakes by the ice barrier and caused to flow to the south. Lake Agassiz thus received the waters of the upper Churchill, and of the basins of the Athabasca and Peace rivers, the great head streams of the Mackenzie;

and the Churchill, and probably also the upper Mackenzie basin, continued to be tributary to this lake through all its lower stages of outflow to Hudson Bay. With this addition, the area of the glacial lake basin was not less than 500,000 square miles.

Extensive areas bordering the Peacè River are described by Dr. G. M. Dawson as "covered superficially by fine, silty deposits, resembling those of the Red River Valley, and doubtless indicating a former great lake or extension of the sea in the time immediately succeeding the Glacial period." The exploration of ancient shore-lines is very difficult in that generally forest-covered region, and it must be many years before the boundaries and outlets of former bodies of water in the basins of the Peace and Athabasca rivers can be mapped; but it may be predicted with reasonable confidence that these basins, now drained to the Mackenzie and the Arctic Ocean, will some time be found to have contained glacial lakes outflowing southeastward to Lake Agassiz. Probably the earliest outlet from the glacial lake of the Peace River was across the watersheds to Lesser Slave Lake and to the North Saskatchewan at its eastward bend, about 50 miles below Edmonton; and the latest outflow from the Athabasca glacial lake appears to have formed a channel across the Mackenzie and Churchill divide near the famous Methy Portage.

¹Descriptive Sketch of the Physical Geography and Geology of the Dominion of Canada, 1884, p. 32.