

## APPENDIX A.

### COURSES OF GLACIAL STRIÆ.

The following table of glacial striæ in the region of Hudson Bay and Lake Superior and westward shows the directions of the currents of the ice-sheet within the basin of Lake Agassiz and upon the country where it lay as the barrier or dam of this lake. The notes are derived chiefly from the reports of the geological and natural history surveys of Canada and of Minnesota, and are all reduced to refer to the true or astronomic meridians. Unless they are otherwise credited, the observations in British America are by Dr. Robert Bell, and in Minnesota and North Dakota by the present writer.

The lobation of the ice-sheet in this basin, its diverse and prolonged courses of transportation of drift, which depended on the glacial currents producing the striæ, and the intersection, in some localities, of two or more sets of striation, have been considered on pages 129-131. Besides the citations on these subjects there given, reference may be made to my recent papers on remarkably deflected striation in Somerville, Mass.,<sup>1</sup> and in the vicinity of Two Harbors, Duluth, and Carlton, Minn.<sup>2</sup>

#### *Hudson Strait and Bay.*

##### Hudson Strait:

Port Burwell, 10 miles southwest from Cape Chudleigh .....	S. 85° E.
Ashes Inlet, on the north side of the strait, about.....	S. 65° E.
Cape Prince of Wales, on the south side, opposite to the last .....	E. to N. 70° E.
South part of Nottingham Island.....	S. 80° E.
Digges Island, off Cape Wolstenholme .....	N. 55°-75° E.

Ottawa Islands, in the northeast part of Hudson Bay..... N. 75° E., N. 40°-20° E., and N. 5° W.

##### East coast of Hudson Bay:

Northern part, successively, proceeding southward.....	NE., N., and NW.
From Cape Dufferin southward to Hopewell Head and the most northern of the Nas- tapoka Islands, in latitude 58° to 57° N., near the middle of the east side of Hudson Bay, numerous localities .....	S. 70°, 60°, and 35° W.

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

Thence southward to the entrance of Richmond Gulf, numerous localities, mostly between.....	S. 65°-75° W. and N. 75° W.
But in two localities, probably a later glaciation.....	S. 35°-45° W.
Cairn Mountain Island, Richmond Gulf, several localities, mostly.....	N. 60°-70° W.
But in one place varying from this to .....	S. 45° W.

<sup>1</sup> Proc. Boston Soc. Nat. Hist., Vol. XXVI, pp. 33-42, March 15, 1893.

<sup>2</sup> Geol. and Nat. Hist. Survey of Minnesota, Twenty-second Annual Report, for 1893, pp. 31-43, with map of the glacial geology (striæ, retreatal moraines, etc.) of northern Minnesota.

## East coast of Hudson Bay—Continued.

- From Richmond Gulf and Little Whale River southward to Esquimaux Harbor, many localities ..... N. 80° W. to W.
- Thence to Red Head, 57 miles northeast of Cape Jones, eight localities ..... W. to S. 75° W.
- And one locality ..... S. 55° W.
- Red Head Island ..... N. 70° W.
- Thence southward to 40 miles south of Big River, many localities ..... S. 40°-60° and 70 W.
- But on the southwest extremity of Long Island, near Cape Jones, striae bear in every direction from ..... S. 70° W., around by SW. and S., to S. 40° E.
- The two prevailing directions are about ..... S. 45° W. and S. 15° E.
- The former seems probably the older, but perhaps deflected to the south from the direction of the glacial current when the ice-sheet was thickest; and the latter, with further deflection southeastward, may belong to the closing stages of the Glacial period. An island off the southwest point of Long Island has three sets of glacial striae ..... S. 60° W., S. 40° W., and S. 20° E.
- From 40 miles south of Big River southward along the east coast of the south half of James Bay, many localities ..... S. 30°-55° W.
- But in one locality, about 3 miles northwest of the Paint Hills, three sets of glacial striae occur, bearing ..... N. 75° W., S. 55° W., and S. 30° W.
- The first probably records approximately the course of glaciation here when the ice attained its greatest area, belonging thus to a striation which was chiefly effaced by a later glacial movement to the southwest during the departure of the ice-sheet. Again, at the Paint Hills two sets of glacial striae are found, bearing .. S. 75° W. and S. 35° W.
- And on Governors Island, at the mouth of Eastmain River, the course is ..... S. 75° W.
- In the country east of Hudson Bay, extending from Richmond Gulf southward and drained by the Clearwater, Great Whale, and Big rivers, forty-nine localities (A. P. Low) ..... S. 50° W. to N. 60. W.
- Excepting two places which have intersecting striae, namely—
- For the first ..... N. 80° W. and N. 35° W.
- For the second ..... N. 68° W. and N. 50° W.
- But in a majority (thirty-six) of the localities in Mr. Low's list the bearings range between ..... S. 60° W. and W.
- Marble Island, northwest part of Hudson Bay ..... S. 15°-25° E.
- West coast of Hudson Bay:
- East side of the mouth of Churchill River ..... S. 5° E.
- Two and a half miles east from the last ..... S. 20° W.
- Five miles east from the mouth of Churchill River ..... S. 15° E.

*Region of the Churchill and Nelson rivers, Lake Winnipeg, and southwest to the Assiniboine.*

## Churchill River:

- At Fort Churchill ..... S. 30°-40° W.
- Four miles below the mouth of the Little Churchill River ..... S. 20° W. and S. 80° W.
- Six and 11 miles above the mouth of the Little Churchill River ..... S. 10°-15° W.

## Little Churchill River:

- Three localities, 4, 13, and 18 miles below Waskaiowaka Lake, respectively ..... S. 40° W., S. 80° W., and N. 85° W.
- Outlet of Lower Recluse Lake, various directions from ..... S. 15° W. to S. 50° W.
- Also ..... W.
- Eagle Rapid, 2 miles in a straight line below the last, two sets, both distinct... S. 20° W. and W.

[The courses to the west, or nearly so, probably mark the motion of this part of the ice-sheet during the time of its greatest depth and extent, while the southerly courses show its deflected motion during the final melting.]

## Along the Nelson River:

- Third Limestone Rapid, 100 miles by the course of the river above its mouth ..... S. 30°-50° E.
- Broad Rapid, 5 miles long, 11 to 16 miles above the last, mostly ..... S. 50° W.
- Also ..... S. 15° W. and S. 55°-75° W.
- Thence to Middle Gull Rapid, numerous localities ..... S. 55°-80° W.

## Along the Nelson River—Continued.

Upper Gull Rapid, and thence to the middle portion of Split Lake, numerous localities.....	N. 85°-75° W.
Southwestern part of Split Lake, two localities.....	S. 85° W.
Chain of Rocks Rapid, 3 miles above Split Lake, one set, probably the older.....	S. 85° W.
The other.....	S. 10° E.
On Grass River, tributary to the Nelson River from the west, a few miles above Split Lake, numerous localities.....	S. 85° W. to W.
But in one place, at the outlet of Witchai (Stinking) Lake.....	N. 75° W.
Between Split Lake and Sipi-wesk Lake, numerous localities, mainly.....	S. 55°-75° W.
And occasionally.....	W.
Sipi-wesk Lake, outlet and northeastern part, mostly.....	S. 70°-75° W.
Also, in numerous localities.....	S. 45°-65° W.
Sipi-wesk Lake, average course throughout the southwestern half of the lake....	S. 55°-60° W.
But in some places.....	N. 85° W.
Southwest extremity of Sipi-wesk Lake.....	S. 65° W.
From Sipi-wesk Lake to the outlet of Pipestone Lake, six localities.....	S. 55°-65° W.
Pipestone and Big Reed Lakes and vicinity, five localities.....	S. 40°-55° W.
Along the usual boat route from Hudson Bay, by Hayes and Hill rivers, to Lake Winnipeg:	
Six miles below The Rock, Hill River.....	S. 12° E.
The Rock, Hill River.....	S. 10° E.
Dr. Bell reports also at this locality another and older set of striæ.....	N. 79° W.
Borwick's Fall, and 1 mile above White Mud Fall, Hill River, both within a few miles southwest from The Rock, respectively.....	S. 18° W. and S. 28° W.
Knee Lake, numerous localities.....	S. 35°-60° W.
From Knee Lake to Pine Lake, seven localities.....	S. 45°-60° W.
From Pine Lake and Molsons Lake to Great Playgreen Lake, many localities.....	S. 35°-60° W.
Around Gods Lake, southeast of the foregoing route, 140 to 180 miles east-northeast from the north end of Lake Winnipeg, many localities (Cochrane).....	S. to S. 52° W., mostly S. 15°-40° W.
But in two localities.....	S. 80° W.
Between Jackson Bay, on Oxford Lake, and the southern part of Gods Lake, seven localities (Cochrane).....	S. 28°-40° W.
Around Island Lake, about 40 miles south of Gods Lake, many localities (Cochrane)....	S. 10°-36° W.
Between Hudson Bay and Lake Winnipeg, along the Severn, Fawn, Poplar, and Berens rivers, on almost all exposed surfaces (A. P. Low), generally.....	SW.
[The variations are only a few degrees from this on either side.]	
Mouth of Lake Winnipeg and its vicinity, several localities.....	S. 40°-45° W.
East shore of Lake Winnipeg:	
Spider Islands, on the adjacent mainland, and at the Shoal Islands, about 30 and 45 miles south from the north end of the lake.....	S. 30°-40° W.
Poplar Point, 4 miles southeast of Poplar Point, and opposite to Georges Island, a few miles farther southeast.....	S. 30°-35° W.
Four localities near the mouth of Berens River, halfway from the north to the south end of the lake.....	S. 57°-60° W.
Near the mouth of Berens River (Panton).....	SW. and SSW.
East side of Berens or Swampy Island (Panton).....	SW.
Of this island Mr. J. B. Tyrrell writes: "The general direction of striation is....."	S. 52° W.
"While another set of striæ was found to occur under a mass of pebbles and bowlders, bearing....."	S. 13° E."
Rabbit Point, near the Narrows.....	S. 48° W.
Black Bear Island, also near the Narrows (Panton).....	SSW.
Intersected by other glacial striæ, bearing.....	SSE.
[The latter, agreeing nearly in direction with striæ observed on Swampy Island, on the Winnipeg River above Lac du Bonnet, around the south end of Lake Winnipegosis, on lakes Manitoba and St. Martin, at Stonewall, Stony Mountain, and Little Stony Mountain, near Winnipeg, and on the Assiniboine River, appear to belong to the basal portion of the divergent glacial current which continued south and southeast in the Minnesota and Dakota lobes of the ice-sheet.]	

## East shore of Lake Winnipeg—Continued.

Between The Narrows and the mouth of Winnipeg River, numerous localities..... S. 40°-45° W.  
 Winnipeg River, above Lac du Bonnet to the Whitemouth River (Tyrrell), approxi-  
 mately..... SSE. and SW.

The following, to Lake St. Martin, inclusive, are from a paper by Mr. J. B. Tyrrell, of the Geological and Natural History Survey of Canada, entitled "Pleistocene of the Winnipeg basin," *Am. Geologist*, Vol. VIII, pp. 19-28, July, 1891:

## Lake Winnipeg:

Northwest shore, "from William River to the mouth of the Saskatchewan," average.... S. 2° W.  
 West shore, at mouths of St. Martin and Fisher rivers, probably about..... S.

## Cedar Lake:

East side ..... S. 18° W.  
 West side, near mouth of the Saskatchewan..... S. 39° W.

## Lake Winnipegosis:

Northeastern angle ..... S. 23° W.  
 A little farther down the east shore ..... S. 9° W.  
 Around its south end ..... S. 2°-13° E.  
 Dawson Bay ..... S. 42°-58° W.

Red Deer River..... S. 68°-78° W.

Swan Lake..... S. 48°-53° W.

## Lake Manitoba:

Northwest arm..... Southward.  
 East shore, near Steep Rock Point..... S. 8°-13° E.

Lake St. Martin, granite islands..... S. 33° E.

Stonewall, in many places (Panton, Upham)..... S. 20°-25° E.

Stony Mountain (Panton, Upham)..... S. 20°-25° E.

Little Stony Mountain (Upham)..... S. 25° E.

## Assiniboine River:

Section 36, township 8, range 11, in three places (Upham)..... S. 4°-8° W.

And in one place ..... S. 10° E.

Section 23, township 9, range 10 (Tyrrell) ..... S. 38° E.

*Athabasca River and Lake, Wollaston and Reindeer lakes, and southward to Cumberland House.*

Mountain Portage, Athabasca River, 7 miles above the mouth of Clearwater River..... S. 54° E.

Or more probably ..... N. 54° W.

Fort Chipewyan, near the mouth of Lake Athabasca, also 1 mile west and 8 miles southwest  
 of Fort Chipewyan ..... S. 78°-83° W.

The following observations, to Cumberland House, are by Mr. A. S. Cochrane, and are communicated by Dr. Robert Bell:

## North shore of Lake Athabasca:

Ten miles north from the Burntwood Islands..... S. 81° W.

Twenty miles west of Black Bay..... S. 61° W.

Halfway from the west to the east end of the lake..... S. 43° W.

Twenty miles west of the Hudson Bay Company's post at Fond du Lac ... S. 21°, 27°, and 31° W.

Hudson Bay Company's post, Fond du Lac, 50 miles west from the east end of the lake. S. 53° W.

On the western outlet of Wollaston (Hatchet) Lake, 15 miles east from its mouth at the  
 east end of Athabasca Lake ..... S. 85° W.

Junction of Porcupine River with the western outlet of Wollaston Lake, 50 miles east of  
 Athabasca Lake ..... S. 75° W.

North shore of Wollaston Lake, halfway between its western and eastern outlets..... S. 27° W.

Jackfish Lake, about halfway between Wollaston and Reindeer lakes, by way of Hatchet  
 Lake River ..... S. 17° W.

North end of Reindeer Lake:	
Average of numerous observations.....	S. 31° W.
Mouth of Hatchet Lake River.....	S. 17° W.
East shore of Reindeer Lake:	
Porcupine Point.....	S. 24° W.
Halfway from the north to the south end of the lake.....	S. 18° W.
South end of Reindeer Lake, and on its outlet.....	S. 18° W.
Churchill River:	
Near Frog Portage, 110 miles north-northwest of Cumberland House.....	S. 40° W.
At a small lake 10 miles east from the mouth of Isle à la Crosse Lake.....	S. 18° W.
On the canoe route:	
Seventy miles north of Cumberland House.....	S. 16° and 26° W.
Fifty-five miles north of Cumberland House.....	S. 26° W.

[As on the lower part of Churchill River, before noted, the more westerly courses of this list are believed to indicate the glacial motion when the ice had its maximum depth, or nearly that, continuing probably through the greater part of the period of glaciation; and the southward currents seem referable to deflection during the recession of the boundary of the ice-sheet, most of the earlier westward striae being thereby effaced.]

*From Hudson Bay to Lake Superior and the Lake of the Woods.*

On the route of Dr. Bell from James Bay to Lake Huron, commonly.....	S. 5° E. to S. 5° W.
Rarely varying to.....	S. 25° E.
Between James Bay and the east end of Lake Superior:	
From Long Portage of the Missinaibi River to Mattagami Lake, both belonging to the Moose River system, mostly.....	SSW.
Wasquagami Portage, Missinaibi River, two sets.....	S. 15° W. and S. 60° E.
[The last is doubtless a local deflection, belonging to the time when the ice-sheet was being melted away.]	
Missinaibi River, east of Brunswick Lake.....	S. 15° E.
Around Mattagami Lake.....	S. 30°-65° W.
Lake Manitowick, on Michipicoten River.....	S. 30° W.
Long Portage of the Michipicoten River, 6 miles east of its mouth.....	S. 40° W.
North shore of Lake Superior:	
Falls of St. Mary, and thence 20 miles north (Agassiz).....	SSE.
Twenty-five miles north of the Falls of St. Mary, and thence to the northeast angle of the lake, 75 miles east of St. Ignace Island, many localities (Agassiz).....	S.
Fifty miles east of St. Ignace Island (Agassiz).....	SSW.
St. Ignace Island, and the same 25 miles east (Agassiz).....	S.
Southwest side of Nipigon Bay (Agassiz).....	SSW.
Islands in Thunder Bay (Agassiz).....	SW.
Between Thunder Bay and Pigeon River (Agassiz).....	S.
Isle Royale, Lake Superior, numerous localities (Desor).....	S. 20°-75° W.
Along the Pic River, tributary to Lake Superior.....	S. 20°-30° W.
Kenogami or Long Lake, at the head of the Kenogami River, tributary to Albany River, many localities.....	S. to S. 25° W.
[“The grooving is as well marked on the tops of the highest hills as in the lake valleys.”]	
In the country northwest of Kenogami or Long Lake, several localities.....	S. 30°-40° W.
Along the Kenogami River, mostly.....	S. 30°-50° W.
But varying to.....	S. and S. 60° W.
Lake St. Joseph, mostly.....	S. 30°-45° W.
Also in two localities.....	S. 15° W. and S. 60° W.
Albany River, between Lake St. Joseph and Maminiska Lake, three localities..	S. 20°, 25°, and 40° W.
Maminiska Lake.....	S. 65° W.

Patawonga Lake.....	S. 75° W.
Eabamet Lake, two localities.....	S. 75° and 80° W.
Inlet of Sturgeon Lake, Boulder River.....	S. 70° W.
Attawapishkat River:	
Respectively 3, 13, 22, and 23 miles below the junction of the two channels from the lake of the same name.....	S. 60°, 42°, 22°, and 15° W.
Lowest exposure of Archean rocks.....	S. to S. 10° E.
On limestone about 75 miles from the southern mouth of the river.....	S. 18° W.
On limestone 9 miles below the last, two sets of striae, the older.....	S. 8°-12° W.
And the newer.....	S. 60°-70° E.
On limestone at the head of Lowasky Island, about 44 miles from the southern mouth of the river.....	S. 2° W.
Southern channel, or Lowasky River, 4 miles below the last, the older striae.....	S. 35° W.
And newer striae varying in course from the foregoing to.....	S. 80° W.
Around Lake Nipigon two sets of glacial striae are common, and are often found crossing each other on the same rock surface. The southward set, which is the older, varies from.....	S. 18° E. to S. 25° W.
And the westward and newer set varies from.....	S. 50° W. to due W.
Along and near Kaministiquia River.....	S. to SW., averaging SSW.
Dog Lake, mean of several localities (Hector).....	S. 10° W.
Lac des Mille Lacs, mean of several localities (Hector).....	S. 5° E.
Sturgeon Lake, 50 miles southeast of Lonely Lake, commonly.....	S. 20°-30° W.
But in one locality.....	S. 50° W.
Minnietakie Lake and vicinity, west of Sturgeon Lake, several localities.....	S. 20°-55° W.
Abrams Chute.....	S. 10° W.
Islands in the middle of Abrams Chute.....	S. 40° W.
Lonely Lake (Lac Seul):	
Three localities.....	S. 70° W., S. 85° W., and N. 80° W.
Three other localities, respectively 10, 13, and 16 miles east of the Hudson Bay Company's post.....	S. 60° W., S. 25° W., and S. 55° W.
East extremity of the lake.....	S. 45° W.
Root River, tributary to the east end of Lonely Lake, two localities.....	S. 50° and 45° W.
English River, below Lonely Lake, five localities.....	S. 30°-60° W.
And one locality.....	S. 80° W.
Winnipeg River, several localities (Bell).....	S. 20°-55° W.
Dr. A. C. Lawson reports the following many observations of glacial striae in the region about Rainy Lake, on canoe routes north of this lake, on the shores and islands of the lake itself, and on Rainy River:	
Kishkutena route, from Sabaskong Bay of the Lake of the Woods to the Northwest Bay of Rainy Lake, seven localities.....	S. 33°-58° W.
Pipestone Lake route, extending north from the Northwest Bay of Rainy Lake, nineteen localities.....	S. 20°-49° W.
Kiarskons route, several miles east of the last, six localities.....	S. 28°-53° W.
Manitou route, extending north from Manitou Sound, the most northern portion of Rainy Lake, twelve localities, also.....	S. 28°-53° W.
Little Canoe River route, a few miles east of the last, five localities.....	S. 26°-40° W.
Big Canoe route, a few miles farther east, five localities.....	S. 23°-43° W.
Redgut Bay of Rainy Lake, and the Turtle River route, extending thence northeastward, twenty localities.....	S. 23°-63° W.
Seine River route and Bad Vermilion Lake, fifteen localities.....	S. 36°-63° W.
Rainy Lake:	
East Arm, from its east-southeast extremity to Brûlé Narrows, twenty-four localities.....	S. 28°-73° W.
East Arm, from Brûlé Narrows and the Seine River to the mouth of the lake, forty localities.....	S. 28°-61° W.

Rainy Lake—Continued.	
North Arm, thirty-seven localities .....	S. 18°-53° W.
Northwest Bay, eleven localities.....	S. 37°-50° W.
Rainy River:	
Island 4 miles above the Manitou Rapids.....	S. 38° W.
One mile below the Long Sault, and at the first and second rapids of Pine River, three localities, alike.....	S. 24° W.
One mile above the mouth of Rapid River .....	S. 38° W.
Around the Lake of the Woods, observations in about 180 localities by Dr. A. C. Lawsor and assistants, and in about 60 localities reported by Dr. G. M. Dawson, "the great majority," i. e. 82 per cent, are.....	
But 13 per cent are.....	S. 10°-34° W.
And 5 per cent are.....	S. 56°-83° W.
Only four localities showed courses more westerly than S. 65° W.; one of these is on the southeast side of Big Island, where striae bearing.....	
Intersect others bearing.....	S. 75° W.
On the west side of Bigsby Island, which, like the preceding, lies near the middle of Sand Hill Lake (the southern and largest part of the Lake of the Woods), double sets of striae were observed in two places, respectively .....	N. 80° W. and S. 20° W.
And.....	N. 83° W. and S. 33° W.
And on a joint projecting from the south shore in the southwestern part of this Sand Hill Lake, striae bear.....	
With others.....	S. 70° and 65° W.
	S. 35° and 33° W.; also, S. 10° E.
[Probably the bearings S. 10° E. to S. 20° or 30° W. belong to the time of the maximum depth and area of the ice-sheet; the prevailing southwestern courses, to later glaciation; and the more westerly deflections, to the time of final melting of the ice.]	

*Minnesota.*

North shore of Lake Superior southwesterly from Pigeon Point, numerous localities (Norwood and Whittlesey).....	S. 25°-45° W.
Duluth (N. H. Winchell).....	WSW.
Otter Track, Sucker (or Carp), and Long lakes, in northeastern Minnesota, south of Hunters Island (Winchell) .....	SW.
Vermilion Lake, two places (Winchell), about .....	S. 20° W.
And in another place (Winchell).....	S. 40° W.
Vermilion Lake (Whittlesey) .....	S. 15° W.
Pike River, tributary to Vermilion Lake, two places (Winchell).....	S. 10° and 20° W.
In township 59, range 14, about 20 miles south-southeast of Vermilion Lake (Winchell), estimated .....	S. 30° W.

The following, to Knife Lake, inclusive, are observations by Prof. N. H. Winchell, noted in his Fifteenth Annual Report, Minnesota, for 1886, pp. 385, 386:

Vermilion Lake:	
Twenty localities .....	S. 17°-24° W.
Three other localities.....	S. 28° W., S. 10° W., and S.
Birch Lake.....	S. 12° W. and S. 22° W.
Section 30, township 63, range 8.....	S. 8° E.
Section 35, township 63, range 9.....	S. 12° W.
Section 27, township 63, range 10.....	S. 15° W.
Basswood Lake, Northeast Cape.....	S. 15° W.
Ima Lake, north shore.....	S. 36° W. and S. 23° W.
Island in Thomas Lake.....	S. 25° W.
Section 11, township 64, range 7.....	S. 30° W.
Knife Lake.....	S. 48° W.

The two following are from Prof. N. H. Winchell, in his Sixteenth Annual Report, for 1887, p. 114:

East end of Delta Lake, west of Ogishke Muncie Lake.....	S. 25° W.
Island in Pseudo-Messer Lake.....	S. 40° W.

Mr. Horace V. Winchell, in the report last cited, pp. 395-478, notes the following glacial striae, to Trout Lake, inclusive, corrected by him for magnetic variation:

Little Fork of Rainy River, five localities.....	S. 10°-42° W.
Rainy River, 3½ miles below Fort Frances.....	S. 32° W.
Rainy Lake, nine localities.....	S. 32°-64° W.
North fall on outlet from Namekan Lake to Rainy Lake.....	S. 30° W.
Bowstring River (Big Fork of Rainy River):	
Probably in township 63, range 26, intersecting striae, mainly.....	S. 10° W. and S. 30° E.
A short distance above the last, very distinct glaciation.....	S. 60° E.
Deer River, at dam about a half mile above its junction with the Big Fork, probably in township 62, range 25.....	S. 80° E. to due E.
Big Fork:	
About 3 miles above the mouth of Deer River.....	Due E.
In or near section 35, township 150, range 25.....	S. 52° E.
[The southeastward and eastward striation on the Bowstring River or Big Fork belongs to the east part of the glacial current that moved to the south and southeast from the region of Lakes Winnipeg and Manitoba, carrying plentiful bowlders and gravel of limestone from those lakes and the lower part of the Red River Valley southeast to this stream and to the mouth of Rainy Lake.]	
Lower Falls of Prairie River, section 34, township 56, range 25.....	S.
Elbow Lake, township 64, range 18, two localities.....	S. 26° W. and S. 28° W.
Pelican Lake, mostly in townships 64 and 65, range 20, four localities.....	S. 24°-36° W.
Net Lake, in the Bois Fort Indian Reservation.....	S. 20°-24° W.
Trout Lake, north of Vermilion Lake, two localities.....	S. 16° W. and S. 36° W.

In the Seventeenth Annual Report, Minnesota, for 1888, pp. 86-118, Mr. H. V. Winchell gives additional notes of glaciation as follows, to Disappointment Lake, inclusive:

Section 32, township 60, range 13, about.....	SSW.
Summit of the Giant's Range at Hinsdale.....	S. 22° W.
Section 35, township 61, range 12, south of Birch Lake, about.....	S. 12°-30° W.
Section 36, township 62, range 8, south of Lake Isabelle.....	S. 24° W.
Section 15, township 59, range 6, southwest of Crooked Lake.....	S. 6° W.
Section 10, township 64, range 8, north of Ensign Lake.....	S. 24° W.
Section 27, township 64, range 8, northeast end of Disappointment Lake.....	S. 34° W.
Sand Point Lake and Sturgeon or Namekan Lake (Whittlesey).....	SW. to S. 55° W.
Rainy Lake (Whittlesey).....	S. 46°-60° W., and WSW.
Big Fork of Rainy River, about 82 miles from its mouth (Whittlesey).....	S. 80° E.
[This seems to be near the locality noted by H. V. Winchell about 3 miles above the mouth of Deer River.]	

The Twenty-second Annual Report, Minnesota, for 1893, on pages 35-40, makes extensive additions to the foregoing lists of glacial striae in the northeastern part of that State, including very abundant and exceptionally deflected courses at Duluth and elsewhere about the west end of Lake Superior. In this report (page 42) it is suggested that some of the courses noted on the Bowstring River or Big Fork may



really have been westward, rather than eastward, due to deflection during the late stage of the glacial recession when the expanding Lake Agassiz caused the ice in northwestern Minnesota to be melted away earlier than on the land area about the sources of the Big Fork and easterly, so that the previous glacial currents of that area might become reversed from eastward to westward courses.

The following striæ are in central and southern Minnesota:

Hinekley, Pine County.....	S. and S. 5° W.
Watab, Benton County.....	S. 15° W.
Sauk Rapids, Benton County, numerous places.....	S. 45°-55° W.
But in one place.....	S. 15° W.
Sauk Center, Stearns County, 40 miles west of the last.....	S. 40° E.
Minneapolis, several places.....	S. 5°-28° E.
One to 7 miles southeast from Big Stone Lake, numerous places.....	SE.
Granite Falls, several places.....	S. 45°-50° E.
Beaver Falls.....	S. 60° E.
In the valley of the Minnesota River, 2 miles below Birch Cooley.....	S. 60° E.
One and a half miles west of Fort Ridgely.....	S. 60° E.
Redstone, near New Ulm.....	S. 25° E.
Jordan, at mill of Foss, Wells & Co.....	SE.
Posen, Yellow Medicine County.....	S. 50° E.
Echo, Yellow Medicine County.....	S. 50°-55° E.
Township 111, range 38, Redwood County.....	S. 50°-60° E.
Stately, Brown County.....	S. 50°-55° E.
Germantown, Cottonwood County.....	S. 30° E., S. 50° E., and 70° E.
Amboy, Cottonwood County, mostly.....	S. 35°-50° E.
But also rarely deflected to.....	S. 70° E.
[In one place all these courses intersect on the same surface.]	
Delton, Cottonwood County, numerous localities, mostly.....	S. 15°-40° E.
Also, in one place, all courses from.....	S. to S. 80° E.
[These intersect on the same surface.]	
Selma, Cottonwood County.....	S. 18°-22° E.
Amo, Cottonwood County.....	S. 30°-32° E.
Dale, Cottonwood County.....	S. 20°-34° E.
Adrian, Watonwan County.....	S. 20°-30° E.

The only glacial striæ recorded in North Dakota are on outcrops of a bluish-gray sandstone, occupying the place of the Fox Hills sandstone, on the Willow River, in the southwest quarter of section 35, township 161, range 73, about 6 miles south from Dunseith and the southern base of Turtle Mountain. Distinct glacial furrows and striæ, here observed in eight or ten places, bear mostly due west, but in two places S. 85° W. and S. 75° W. These striæ belong to the closing stage of glaciation here, being directed normally toward the Fergus Falls and Leaf Hills moraines and the glacial Lake Souris, whose eastern shore coincided nearly with this part of the course of Willow River. During the maximum extension of the ice-sheet its current at this locality doubtless passed nearly due south.

Almost universally throughout North Dakota, eastern Montana, and a large area stretching thence northwestward to the Athabasca and Peace rivers, the bed-rocks

are shales of the Fort Pierre and Laramie formations, so soft and easily eroded wherever exposed to weathering that glacial marks are not preserved. The sandstone of Willow River, however, outcrops also in the same district on Turkey and Ox creeks, but does not there retain striated surfaces. Farther west, apparently this stratum of sandstone occurs in the bluffs of the Souris River, near its most southern bend, and in hills within the area of the loop formed by this river, where other glacial striae may probably be found.

## APPENDIX B.

### NOTES OF ABORIGINAL EARTHWORKS WITHIN AND NEAR THE AREA OF LAKE AGASSIZ.

Archeologists will be interested in the following brief notes of the localities of mounds in this district, to which reference has been made in Chapter XI, page 612.

Many mounds, probably not less than fifty in all, varying from 2 to 15 feet in height, are situated on the bluffs of both sides of Lake Traverse, Browns Valley, and Big Stone Lake.

Three isolated mounds, each about 5 feet high, were noted on the right bank of the Red River, in Wilkin County, Minn., one being about 12 miles east of Breckenridge, another about 4 miles north of that town, and a third in McCauleyville.

Close south of the Red River, near the mouth of Ottetail Lake, is a group of sixteen mounds, varying from 1 to 10 feet in height; and others, single or in groups, are found at many places in Ottetail County.

In Clay County, Minn., a small mound was noted near Muskoda, and another near the South Branch of the Wild Rice River.

(More detailed statements concerning these and the foregoing localities are given in the *Geology of Minnesota*, Vol. I, p. 631, and Vol. II, pp. 533, 558-561, and 671.)

Mounds and artificial embankments are situated on and near the beaches of Lake Agassiz in many places. In the greater part of these instances the earthworks have been already described, or at least mentioned, in this volume (pp. 284, 313, 347, 349, 354, 390, 412, 413, 431). Among all these localities the most notable is close north of the Forest River, about 6 miles northwest of Inkster (p. 349). According to a survey of this group of mounds by Mr. T. H. Lewis, they number about forty, ranging from 1½ feet to 13 feet in height, some of them being connected by low embankments.

In the south part of Crookston an aboriginal mound about 6 feet high and 100 feet in diameter lies on the south bluff of the Red Lake River, close east of Mr. Erskine's brickyard.

On the prairie, close west of the mouth of Red Lake and north of the Red Lake River, is a large mound about 15 feet high.

Beside the Roseau Lake trail, between 2 and 4 miles eastward from its crossing of the South Branch of Two Rivers, five oblong mounds or embankments, each about 3 feet high, are reported by Mr. Charles Hallock. These are on the crest of a beach ridge, probably the Tintah beach.

Two mounds, respectively 5 and 3 feet high, are situated about half way between Fort Pembina and the town of Pembina, being some three-fourths of a mile north of the fort and an eighth of a mile west of the Red River.

In the vicinity of Devils Lake, Sweetwater Lake, and Stump Lake are many mounds, mostly 3 to 6 feet high, very rarely rising to 10 feet, occurring singly, as on the tops of the hills near Fort Totten, and in groups of several, or sometimes forty or more, as at the southeast end of Devils Lake. Other lone mounds and series of mounds are seen here and there along the bluffs of the Sheyenne and James rivers.

The largest mound known in Minnesota is 45 feet high, being the central one of a group of three (the two others only 8 or 10 feet high) on the south side of the Rainy River, close east of the mouth of the Bowstring River or Big Fork. This mound, partially excavated under the direction of Prof. George Bryce, was found to contain many skeletons, and also skulls without other parts of the skeleton, as if they had been collected on a battlefield. There were also found very interesting stone and copper implements, ornaments made from seashells and others of fresh-water shells, broken pottery, and a complete pottery cup having a diameter of 3 inches. Professor Bryce states that twenty-one mounds are discovered along the whole course of the Rainy River, one (peculiar in containing a structure of charred logs some 10 feet square and 6 to 8 feet high) being at the mouth of Rainy Lake and several at the Long Sault. On the Red River, in Manitoba, he reports one mound as formerly existing at Winnipeg, and several still to be seen near the rapids about 16 miles below that city. (Historical and Scientific Society of Manitoba, Transaction 18, 1885.)

On the Souris River and its tributaries, the North and South Antler creeks, Professor Bryce surveyed twenty-one mounds within an area of 4 miles square, ranging from 4 to 7 feet in height. One of these mounds, containing a single skeleton, had with it nearly all the types of stone implements, copper and seashell ornaments, and pottery, which had been found in the large mound on the Rainy River, about 325 miles distant to the east, besides two pipes of red pipestone; but in each case no evidence of any intercourse with Europeans was found. (Historical and Scientific Society of Manitoba, Transaction 24, 1886.)

During my survey of the shore-lines of Lake Agassiz in Manitoba and examination of the adjoining country on the southwest, I observed mounds in many localities, of which the following are the most noteworthy:

In the northwestern edge of the village of Arden the crest of the Campbell beach bears a round mound 4 feet high and 75 feet in diameter, with an embankment 2 feet high and 30 feet wide extending from it 50 feet northward. A mile south of Arden, on this broad beach, a few rods east of its crest and about 1 foot lower, is an embankment 20 to 25 feet wide, about 200 feet long from north to south, parallel with the beach crest, and  $1\frac{1}{2}$  to 2 feet high. Along its northern two-thirds this earthwork is straight, but its southern third curves somewhat eastward and this end sinks gradually to the general surface.

The formerly famous Calf Mountain, which was visited by Palliser's expedition and appeared prominent on most of the early maps of Manitoba, is an aboriginal mound,

probably built over a slight natural mound of the glacial drift. This earthwork, rising only about 15 feet above the adjoining surface, is near the north line of the northeast quarter of section 32, township 2, range 7 west. Its top is about 40 feet above Darlingford railway station and 1,600 feet above the sea. From it the land descends fast eastward to Thornhill and Morden, overlooking farther east the vast valley plain of the Red River. The earthwork consists of till, inclosing frequent boulders up to 1 foot in diameter, with a considerable admixture of gravel, which was probably brought from the shores of a beautiful lakelet a few hundred feet distant to the north. The diameter of the principal mound, which is dome-shaped, is 95 feet, with a height of 15 feet. Thence an embankment about 2 feet high extends 10 rods southwest, and its farther portion, turning with a right angle, continues about 4 rods to the southeast. Excavation in the mound has brought to light human bones and many buffalo skulls, often much decayed and fragmentary. The name Calf Mountain, probably a translation from an aboriginal name, refers to this united sepulture of the remains of man and the buffalo.

Several round mounds, 2 to 4 feet high, are situated on the bluffs of Mowbray and Snowflake creeks. Two of these, near the southeast corner of section 9, township 1, range 9 west, were found to contain in each four or five skeletons.

On the top of Star Mound (p. 99) an artificial mound, built of till, with boulders up to a foot in diameter, has a height of about 4 feet and diameter of 50 feet, with slight embankments extending beyond its circumference about 20 feet to the north and south. Similarly, the top of Pilot Mound (p. 99) has an earthwork about 2 feet high and 50 feet in diameter. The crests of a few of the Tiger Hills are also crowned with small mounds, some of which have been excavated and are found to have been built for purposes of burial.

On the southeast bluff of the Cypress River, close east of the mouth of Tiger Creek, are three mounds, of which the most northeastern and largest is 6 feet high. These are on land about 25 feet above the general level of the surrounding country and 1,260 feet above the sea.

Besides the foregoing, which I have examined, my assistant, Mr. Robert H. Young, noted a mound about 4 feet high and 60 feet in diameter on the crest of the southeastern end of a beach-like esker in the southeast quarter of section 30, township 12, range 1 east, near the Grosse Isle (p. 187).

A very large mound, said to be about 10 feet high, is reported on land of Mr. William Rhind beside the White Mud River, about a mile west from Westbourne. On its surface, or not far below it, stone pipes, pottery, and human skulls and other bones have been found; but at the time of this information no deep excavation had been made.



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