ART. XLVII.—*Note on the former Southward Discharge of Lake Winnipeg*; by J. D. DANA.

THE most remarkable of the changes that are known to have occurred in the water-courses of North America is that in the discharge of Lake Winnipeg from a former southward course by the Minnesota Channel and Mississippi to its modern discharge into Hudson's Bay, first announced and sustained by General G. K. Warren, in a report of 1867 published in the Report of the U. S. Engineers for the year 1868 (pp. 307–314), after levelings along these rivers, by order of the government, in 1866 and 1867. The question was more fully illustrated by General Warren in "an Essay concerning important physical features exhibited in the Valley of the Minnesota River and upon their signification," submitted to the Chief of Engineers in 1874 and published in the Report for 1875 (pp. 385–402); and afterward, further discussed by him in his paper on the Bridging of the Upper Mississippi, in the Report for 1878 (pp. 909 to 926) with a reproduction of some of the maps of the essay of 1874. The last of the above-mentioned papers, excepting its closing details as to sections across the valleys, is reproduced in this Journal on pages 417–431, vol. xvi, 1878, along with its eight maps and plates.

In the first of his papers, that of January, 1867, General Warren, after mentioning the evidences that "Lake Winnipeg was once continuous southward over the central portion of the Red River of the North, and had its outlet down the Minnesota, and not down the Nelson to Hudson's Bay" (p. 307), considers the origin of the former hydrographical conditions. He speaks of the possibility of an ice-barrier on the north in the Glacial

era; but he sets this idea aside, and argues for an actual change of land-level, and makes the southward discharge to have ended in consequence of a depression of land to the south, accompanying (as added in his paper of 1875) a rise to the north; and instancing, as examples of a corresponding change of level, the former *southward* discharge of Michigan Lake through the Illinois River, and of Winnebago Lake through the Wisconsin River. A map of the large Winnipeg Lake—larger he observes than Lake Superior and Michigan together, and having the Saskatchewan River as the head stream—accompanied the written report sent to the Department, but it was not published. The same view is presented at more length in the paper of 1874 (Report for 1875), along with a wider discussion of the facts, and a review of the writings of previous travelers who had recognized the lake-like features of the region.

The idea of the southward discharge of Lake Winnipeg was presented again in 1875 by Mr. George M. Dawson, in his excellent Report on the Geology of the region in the vicinity of the 49th Parallel, with a recognition of General Warren's paper, but with the statement that the inference was an independent one. In explanation, he says (pp. 253, 254) that "by the flow of a large volume of water in this direction, the excavation of the basins of the Winnipeg group of lakes and the great valley of the Red River itself can be explained; the river cutting downward and westward on the sloping surface of the Laurentian rocks, at the expense of the Cretaceous strata, and later of the limestones of the Devonian and Silurian; the blocking up of the southern exit and changed direction of flow being a phenomenon only similar to that which is known to have taken place with the Great Lakes of the St. Lawrence."

The ice-barrier hypothesis has been sustained, in place of that of a change of level, by Professor N. H. Winchell in his Minnesota Report for 1877, who there observes, in his explanation, that the lake, having first appeared at the south or Minnesota end, "grew toward the north as fast as the retreating ice-sheet made way for it." In the Minnesota Report for 1879, the same view is urged, with more detail, by Mr. Warren Upham.

A decision between these two conflicting explanations is of great importance to a right understanding of Quaternary events as well as of fundamental principles in terrestrial dynamics; and I therefore review here the more prominent facts, taking them mostly from General Warren's papers and the Report of Mr. Dawson.

1. The Red River of the North, rising in Lake Traverse, flows northward along the west side of Minnesota for 225 miles, crosses then the 49th parallel, and continues on the same course

for 90 miles to Lake Winnipeg; the distance from Lake Traverse to Lake Winnipeg being 315 miles.

2. The Minnesota, rising to the westward of Lake Traverse, enters its valley within two miles of it and flows south, through Big Stone Lake, to the Mississippi at Minneapolis.

3. The valley of Red River, after narrowing much, is still 46 miles wide on the 49th parallel, and, for a long distance south of this parallel, it has an average width of 30 miles (Gen. Warren's map and G. M. Dawson's statement); toward Lake Traverse it narrows rapidly, is a mile wide along this lake, the sides rising abruptly from the borders of the lake; beyond this lake, southward, it continues on, one to two miles wide, as the valley of the Minnesota River; and, where it joins the Mississippi, the valley has four times the width of the Mississippi valley above the junction (Gen. Warren).

4. All now agree that the wide part of the valley which stretches northward from Lake Traverse is lake-bottom prairie, that it was adopted by the Red River, not made by it (Dawson); and that the part south of this lake, is, as General Warren first showed, the deserted highway of the outflowing river and lake.

5. The Red River lake-bottom valley is bordered much of the way by abrupt sides rising 100 to 200 feet to the top of a terrace-plain or plateau; and, similarly, the Minnesota channel has sides usually 100 to 150 feet in height.

6. Heights above the sea-level:

(B. C. means Boundary Commission Report.)

	1. Lake-bottom prairie.	2. Bordering plateau.
Near 45° 30' N., between Big Stone Lake and Lake Traverse (5 miles apart),	970	1,120
Near 47° N., at Fargo and Moorhead,	900	1,050 (?)
On the 49th parallel near Pembina and St. Vincent,*	784 (B.C.)	East side 989 West side 994
Toward Lake Winnipeg,	740	810
Height of Lake Winnipeg (about the mouth of Red River, a great marsh), 710 feet.		

The heights on Minnesota River are (Winchell's Report):

Surface of bordering plateau near Big Stone Lake,	1,125
At Mankato, 145 miles south,	975
At Shakopee, 50 miles northeast,	925
At junction with the Mississippi,	800 to 820

* The height of the Lake of the Woods is 1018 feet (B. C.); of the divide between it and the near-by head of Roseau River, a westward-flowing tributary of Red River along the 49th-parallel region, about 1078 feet (Dawson); edge of plateau where it looks down on the lake-bottom about Pembina, 90 feet less (B. C.), and hence about 988 feet; Pembina Mountain, on the west side, 210 feet above the lake-bottom prairie, and hence 784 + 210 = 994 feet above the sea-level. Red River as it flows in its channel is 20 to 60 feet below the surface of the lake-bottom prairie; at Pembina, about 50 feet (Warren).

7. The *slope* of the lake-bottom prairie is *northward*, toward Lake Winnipeg; and, from the 49th parallel, according to Dawson, it is nearly six inches per mile; the mean slope from Moorhead in Minnesota, 150 miles south of the 49th parallel, is little less than one foot per mile.

The slope of the bordering plateau *northward* from Lake Traverse to Lake Winnipeg, 315 miles, is about one foot per mile; for $1,125 - 810 = 315$.

The slope of the bordering plateau along the Minnesota from Big Stone Lake to Mankato (145 m.) is *southward* and about one foot per mile; for $1,125 - 975 = 150$.

8. The material of the lake-bottom, where examined by Mr. Dawson, is mostly yellowish clayey earth or loess, containing calcareous matter enough to effervesce freely with acids; the upper portion is rarely so coarse as to be called sand, though sometimes an arenaceous clayey material; that of the border is also somewhat arenaceous. The depth of this lake-bottom deposit is generally 40 feet or more over the central portions, but it thins toward the sides. This point is illustrated in the plate facing p. 248 in Dawson's Report. He represents the loess as overlying stratified drift and boulder clay. The surface of the prairie rises somewhat toward the sides; but whether the depression is more than would result from the drying (and consequent contraction) of so much wet loam after the disappearance of the lake, is not ascertained. It is rare to find anything like pebbly areas or pebbles over it.

9. The outline of the lake-bottom prairie has the appearance of being, so far as it extends, the outline of the great Winnipeg Lake, and is so recognized by Warren, Dawson and others.

10. The material of the bordering high plateau along both the Red River portion and the Minnesota is coarse gravel and sand; much of it unstratified till, much, more or less stratified; and the upper surface is often pebbly or stony, with occasional boulders.

Roseau River, for 25 miles east of the western edge of the plateau, says Dawson (p. 214), has cut deeply into the plateau formation so as to have high bluff sides; and the sections show alternating beds of clay, sand and gravel characterized by "current bedding;" one of them having stratified arenaceous clay below, then coarse gravel, then sand, and then gravel as the top beneath the soil; another "typical one" consisting of hard-compacted clay below, partly stratified, then a thin pebbly bed, then sand, then the upper gravel. These are given by Mr. Dawson as examples of the constitution of what he calls the "Drift Plateau of Eastern Manitoba and Northern Minnesota." He says of the great "High-level Plateau" that it is frequently irregular in detail, covered with banks and ridges of sand and

gravel of the nature of "kames," but, on the whole, remarkably uniform; on the 49th parallel it rises gently eastward toward the Lake of the Woods, 90 feet in the 77 miles. On the upper part of the Minnesota the deposits are largely the Glacial drift (General Warren, and Professor Winchell), with also portions that are bedded.

Conclusion.—Taking the accounts of the region from which we have cited to be correct, we have the deduction forced upon us that Winnipeg Lake did not lose its discharge into Hudson's Bay and become the great lake with southward discharge, because of a barrier of ice or of any other kind. For if so, if there had been no great change of slope over the region, the shores of the *great* lake should be approximately horizontal, to its outlet at Lake Traverse, and if horizontal, they would have a height in the vicinity of the present Winnipeg of 260 feet above the lake, supposing the waters just up to the Lake Traverse level, and 300 feet if the water at this place of discharge was merely 40 feet deep. Instead of this condition, *the observed shore line has nearly the present general slope of the surface*; and, further, *the slope of the lake-bottom prairie is not much different from that of the bordering plateau on either side.*

We have thence the conclusion, since the present outline of the lake-deposits or loess, whatever the present slope, was approximately the shore-line and once horizontal, that there has been a great change in the level of the land, as General Warren urged. The idea of a change in the position of the earth's center of gravity sufficient to change the slope of the surface a foot a mile, or half a foot, cannot be reasonably entertained.

We may infer also, from the near correspondence between the northward slope of the lake-bottom prairie and that of the bordering plateaus, that the prairie and plateaus were affected alike by the conditions as to level. And we may deduce from the regularity of the slope, that the conditions as to level affected equally the region from Lake Traverse to Lake Winnipeg, and beyond doubt also to a much greater undetermined distance northward.

This conclusion bears so profoundly on questions as to the condition of the earth's interior, and the origin of changes of level over the earth's surface, that it is greatly to be desired that further investigations should place the facts beyond all doubt.

Admitting that the facts are correctly given, they appear to point to the following succession of events:

The fact that the lake deposits are underlaid by unstratified drift, shows that before the era of the great lake the glacier

had moved southwestward over the region, and deposition of moraine material had taken place. The high-level prairie either side of the lake region and of the Minnesota valley is made largely of this unstratified drift; but the generally level surface in the part toward the lake region and valley, and the stratification in much of the material, are evidence that the flood from the melting glacier covered and levelled it, and stratified its bedded deposits; the coarseness of these deposits, and the large size of the valley of discharge, that the flood waters had great velocity; the height of the prairie, that they stood 100 to 150 feet above the present level of the region including Lake Traverse, instead of the 40 feet at the divide above supposed. This time of maximum flood and of rather violent fluvial conditions was followed by the era of the Great Lake, that is, of quiet waters and lacustrine deposits, with slow discharge over the Lake Traverse region; which may have been brought about in part by diminished supply of waters from the melting ice and precipitation, but more, with little doubt, by a diminution in the slope of the general surface, which was a part of the great change of slope that went on, as explained by General Warren, until the land was reduced to its present pitch and the streams to their modern courses.

The application of a new name, Lake Agassiz, to the flooded Lake Winnipeg, proposed by Mr. Upham because of its alleged relation to the retreating ice-sheet, tends to obscure the great historical facts in the case. All desire to honor Professor Agassiz, and no one more so than the writer; and still the name that most deserves honor in connection with the developments in Central North America is that of General G. K. Warren. But rather than use either, it is better to let the accepted name, Lake Winnipeg, be the name for past, as it is for present, time.