

1886

Description of Maps Showing the Climate, Geography and Geology of Minnesota

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Recommended Citation

Upham, W. (1886). Description of Maps Showing the Climate, Geography and Geology of Minnesota. *Journal of the Minnesota Academy of Science, Vol. 3 No. 1*, 151-155.
Retrieved from <https://digitalcommons.morris.umn.edu/jmas/vol3/iss1/22>

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thermal springs of the interior basins, show that the underground forces of the globe, so largely instrumental in elevating and shaping the continents, are by no means wanting here. If it is the case that the western side of the continent is continually rising then the climate of the plains to the east will continue to grow drier until it becomes too arid to support any form of vegetable life. Our records do not cover sufficient time to say if the mean annual rainfall is diminished. It is a noticeable fact, however, that there is a gradual drying up of many marshes and small streams throughout Minnesota and North Dakota. It is usually supposed to be due to the breaking up of the sod, causing the rain and melting snows to sink into the ground instead of collecting in ponds. But it is plainly to be seen that there has been a gradual loss of water long before any ground was broken. The river channels are more contracted, the lakes show that they formerly stood at a much higher level, and narrow arms or inlets of lakes, together with numerous small ponds, have become shallow marshes and peat bogs. These results should in the main, I think, be ascribed to a continuous slow elevation of the country, causing more or less disarrangement of the subterranean water courses, as shown in the drying up of springs, in furnishing a more rapid drainage and in decreasing the mean annual rainfall and temperature.

May 4, 1886.

[*Paper V.*]

DESCRIPTION OF MAPS SHOWING THE CLIMATE, GEOGRAPHY AND GEOLOGY OF MINNESOTA.—*By Warren Upham.*

The exhibit in the New Orleans exposition, 1884-'85, by the geological and natural history survey of Minnesota, included twenty maps showing the climate, geography and geology of the state, prepared by the writer under the direction of Prof. N. H. Winchell, the state geologist.

Four of these maps show the climatology.

1. Mean annual rainfall: 34 inches in the southeast corner of the state; 28 to 32 about lake Superior and Rainy lake; thence diminishing westward to 22 at Moorhead and Fargo and at lakes Traverse and Big Stone on the west boundary of the state. It is

about 28 inches at St. Paul and Minneapolis, and 23 inches (mean for eleven years) at Winnipeg, in Manitoba.

2. Mean temperature for the year: 46 degrees in the southeast corner of the state; 44 degrees at St. Paul and Minneapolis; 36 degrees to 34 degrees in northern Minnesota; and 33 at Winnipeg.

3. Mean temperature for January: 14 degrees in the southeast corner of the state; about 12 degrees at St. Paul and Minneapolis and at Duluth; thence diminishing northwestward to zero at the Lake of the Woods,—2 degrees at Saint Vincent and Pembina, and—4 degrees at Winnipeg.

4. Mean temperature for July: 76 degrees in the southeast and southwest corners of the state; 74 degrees at Saint Paul and Minneapolis; about 72 degrees at Moorhead and Fargo; 68 degrees at Saint Vincent; 67 degrees at Winnipeg; and 64 degrees to 62 degrees in northeastern Minnesota, north of Lake Superior.

Thirteen maps show geographic features.

5. River systems: Red River of the North, draining about 15,100 square miles in Minnesota, and Rainy river, about 10,300, making 25,400 square miles tributary to Hudson bay, the total area of the state being 84,286 square miles; basin of lake Superior and the Saint Louis river tributary to the Saint Lawrence, about 8,500 square miles; the Mississippi river, about 48,700 square miles; and the Missouri river, whose basin includes about 1,700 square miles in this state.

6. Distribution of lakes: showing areas of abundant lakes, others having comparatively few lakes, and others having no lakes. The last named areas are the southeast and southwest corners of the state, which lie beyond the limit of the drift of the last glacial epoch, and also the flat land of the Red river valley. It is estimated that this state contains 10,000 lakes; and the portion of its area covered by water is approximately 5,600 square miles.

7. Areas of forest and prairie, and approximate limits of some of the principal trees and shrubs: forest covers the northeastern two-thirds of the state; while the other third, lying at the south and southwest, and reaching in the Red river valley to the international boundary, as also the part of this valley farthe north to lake Winnipeg, is prairie.

8. Chief topographic features: the Red river flats, 800 to 950 feet above the sea; the basin of the Minnesota river, a slightly undulating expanse, 900 to 1,100 feet above the sea; the Coteau des Prairies in southwestern Minnesota, 1,800 to 1,950 feet above the sea; the Leaf hills, 100 to 300 feet high, being 1,000 to 1,750 feet above the sea; the Giant's range and the Mesabi range, near the international boundary north of lake Superior, each 1,800 to 2,200 feet above the sea, being the highest land in the state; the Sawteeth mountains, near the shore of lake Superior in Minnesota, 1,500 to 1,800 feet above the sea, or 900 to 1,200 feet above the lake; and the valley of the Mississippi river, from lake Pepin southward, several miles wide, and inclosed by bluffs 200 to 600 feet high.

9 to 16. Contour-lines for each 100 feet above the sea level: shown in successive pairs on seven maps with areas colored, and finally all presented on a single map, delineating only the course of the lines. To the elevations already stated, the following may be added: lake Superior, 602; Rainy lake, about 1,175; the Lake of the Woods, 1,062; the Red river at the northwest corner of the state, 758; lake Itasca, about 1,500; the Mississippi river at Minneapolis above the falls of Saint Anthony, 800; in lake Pepin 661, and at the southeast corner of the state, 620; Red lake, about 1,160; Mille Lacs, 1,246; lake Traverse, 970; Big Stone lake, 962; and the southwest corner of the state, about 1,400. Professor Winchell estimates the average elevation of the entire state to be approximately 1,275 feet above the sea.

17. Historical chart showing the geographical names and their dates prior to Nicollet's map: already published in *Geology of Minnesota*, vol. I, the first in the series of final reports of this survey.

Three maps show geological structure, glacial drift and the subsoils.

18. The geological systems below the drift and Cretaceous: Devonian limestones and shales, belonging to the Hamilton and Marcellus epochs, in Fillmore and Mower counties, and extending into Iowa; Silurian limestone and shales, belonging to the Hudson river and Trenton epochs, reaching from Saint Paul and Minneapolis south and southeast to Fillmore county and north-eastern Iowa; Cambrian sandstones and limestones, including the Saint Peter sandstone, Shakopee limestone, Jordan sandston

Saint Lawrence limestone and Saint Croix sandstone, together regarded as the equivalent of the Chazy and Calciferous formations in the northeastern states and Canada, extending in southeastern Minnesota from the Kettle river and Taylor's Falls, southeast to the lower portions of the Minnesota and Blue Earth rivers, and occupying a considerable belt along the Saint Croix and Mississippi rivers to the southeast corner of the state; the Potsdam or Cupriferos formation, of lower Cambrian age, consisting of red sandstone, conglomerate and trappean rocks, on the shore of lake Superior, and in Pine, Chisago and Kanabec counties, but in southwestern Minnesota being mainly red quartzite, exposed near New Ulm, and thence westward to Pipestone and Rock counties, in the southwest corner of the state; and the Archæan system, divided into three parts, namely, Upper Gneisses, Taconic and Laurentian, together covering more than half of the state, reaching on the international boundary from the Lake of the Woods east to lake Superior, and extending thence southwest to the Minnesota river between Big Stone lake and New Ulm, but terminating twenty or thirty miles southwest of this river.

19. The glacial geology: showing post-glacial alluvium, to which is referred the stratified clay bordering the Red River of the North, apparently deposited after lake Agassiz was drained to Hudson bay; modified drift or stratified gravel, sand and clay, washed from the ice-sheet and assorted and deposited by the streams produced in its melting; loess, belonging to the modified drift, extending from the Missouri river over western Iowa and into Rock county in the southwest corner of Minnesota; till, or boulder clay, covering the greater part of the state, mostly having a moderately undulating surface; terminal moraines, belts of hilly and knolly till, with associated deposits of modified drift, accumulated along the margin of the ice-sheet of the last glacial epoch, including, besides the moraine found at the extreme limit reached by that ice-sheet ten others indicating successive stages in its recession; glacial striæ, having a southwest course from lake Superior to the Mississippi river, over which region is spread a red till with no limestone, but in the west part of the state running to the south and southeast, the till there being gray or blue with much limestone; changes in the currents of the ice-sheet during its recession, shown by the course of the successive morainic belts, the most notable change being the extension of the western ice-

current from Wright county east, northeast to the edge of Wisconsin, proved by the presence of the gray or blue till with limestone boulders overlying the red till; the driftless area, extending into the southeast part of the state to include Houston and Winona counties and the eastern portions of Fillmore, Olmsted, Wabasha and Goodhue counties; the surface of this area being residual clay from eroded strata, partially modified by the water of a lake confined there by the ice-sheet confluent farther south; the beaches of the glacial lake Agassiz, held by the retreating ice-sheet in the basin of the Red and Rainy rivers, the outlines of a similar glacial lake which existed earlier in the basin of the Blue Earth and Minnesota rivers, and the former shore of lake Superior, which in like manner was held 500 feet higher than now, having its outlet southwestward to the St. Croix and Mississippi rivers; and the thickness of the drift as shown by deep wells, being found to average 100 to 200 feet upon the western two-thirds of the state, where it conceals the older rocks over large districts, including all of the basin of the Red River of the North in Minnesota.

20. The subsoils: clay and loam in the Red river valley, in the southwest corner of the state, and on the driftless area; sand and gravel covering considerable tracts from Dakota county, Saint Paul and Minneapolis northwestward to the Crow Wing river and the sources of the Mississippi; gray or blue till, occupying the greater part of the state; red till, reaching from lake Superior southwest to Brainerd and south to Saint Paul; and a track bordering the international boundary eastward from Rainy and Vermilion lakes, where only scanty patches of soil are found, the surface being mostly bare rock with many little lakes.

May 4, 1886.

[Paper W.]

AN ACCOUNT OF THE TORNADO WHICH VISITED SAINT CLOUD, MINNESOTA, APRIL 14, 1886.—C. W. Hall.

At seven o'clock on the morning of April 11th, last, an area of low barometric pressure was detected by the U. S. Signal officers centering a few miles north of San Francisco, Cal. This