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THE FORMATION AND DEFORMATION OF MINNESOTA LAKES.

BY C. W. HALL, MINNEAPOLIS, MINNESOTA.

IN respect to inland waters Minnesota shows conditions which are exceptional in North America. Exclusive of that portion of Lake Superior within her boundary, the State has 5,700 square miles of lakes varying from a few acres to the size of Red Lake, which has 340,000 acres in its area. These lakes are conveniently divided into three classes.

First, rock-bound lakes. These bodies of water occur chiefly in the northeastern portion of the State. They occupy the troughs in the crustal folds that have contorted the surface, or the depressions where excessive faults have broken and considerably tilted the strata. These, as a rule, are long, narrow, and deep. The water is clear and sparkling, abounding in fish, and remarkably free from the various forms of plant growth peculiar to shallow waters.

Second, silted-river lakes. These lakes occur in rivers where rapid streams have brought down a deposit into the channels of the more sluggish ones, the silting debris being so course that the slower current fails to transport it. Thus slower streams are choked up and the water set back for miles. Such lakes are Lake Pepin, formed where the sluggish Mississippi is dammed by the debris brought into its channel by the more rapid Chippewa River, Lake Saint Croix, Lake Lac qui Parle, and many others.

Third, glacial lakes. If this group could be minutely subdivided, there would be seen several types of lake formation. Those of the Lake Agassiz type, where one portion of the shore consisted of a wall of ice, have long since disappeared and left scattered pools of varying sizes, occupying the depressions in the generally level surface of the old lake bottom. Going outside of the State for an illustration, we may name Lake Winnipeg as the largest pool now remaining in the bottom of glacial Lake Agassiz. Many other lakes are scattered over the level portions of the State, occupying the depressions in the drift-sheet where this was laid down evenly through the steady and uniform movement of the ice, or through the silting effect of waters due to the melting of the ice border.

But by far the greatest number of lakes in Minnesota are those occupying the depressions in the unevenly distributed morainic matter deposited during glacial times. Portions of the State are thickly studded with these beautiful sheets of clear water. The region between Minneapolis and the Red River valley is appropriately called the Lake Park Region, as lakes occur here in vast numbers. Wright County, nearest to Minneapolis, contains 259 lakes, Kandiyohi County contains 286, and Ottertail County, well up towards the borders of glacial Lake Agassiz, holds the banner over 430 lakes. Passing northeastward from the Lake Park Region towards Ontario, past the head-waters of the Mississippi, and across the upper streams of the St. Lawrence River basin, we pass gradually from the region of moraines to the region of thin glacial deposits and constant and tumultuous rock-exposures, carrying large numbers of lakes of the first type.

It has been frequently estimated that Minnesota contains 10,000 lakes. To one passing over the State through the region named this does not seem an exageration. There must be several thousand lakes from one mile in length upwards to the very largest.

While glacial lakes show many varieties of form due to the position of tongues, branches, and subdivisions of the moraines, they are generally circular in outline. The deepest portion is at the centre. Their shores show but few successive beaches to indicate erosion at their outlets and consequent drainage, or great variation in the amount of rainfall during the last few thousand years. They were all evidently formed in the same general manner, by the washing down of fine silt from the high land into the bottom, thus gradually filling the interstices in the gravels and sands beneath them, making water-tight bottoms to hold the water. Probably the lakes were small at first, and enlarged gradually as this deposition of fine silt extended their borders until the lowest point in the margin was reached and an outlet drained away the excess of water. When this outlet was reached the conditions of formation ceased, and the conditions of deformation became manifest. Material was constantly washing in from the high lands around through the melting snow of successive springs and the heavy showers and rain-storms of the summer months; it was also brought by streams flowing into the lakes from every direction, and formed *in situ* by the vigorous growth of aquatic vegetation. In the shallower lakes this last cause of deformation works with great rapidity. After the ice disappears in the spring under the warm sun of this latitude the water very rapidly rises in temperature to 70° or 75°, a favorable temperature for vigorous vegetable growth, and thus plant-forms which can get foothold upon the lake bottom will develop a vast amount of plant debris. Already hundreds of the shallow, small lakes of the State have disappeared, and rich, productive hay-meadows have taken their place. This will be the fate of thousands more within the coming century. On every hand we hear old settlers speak of large lakes once affording superb hunting ground for wild geese, ducks, and other water fowl and excellent fishing, as now either hay-meadows or extensive marshes soon to be fitted for hay production by a further lifting of the surface above the level of the outlet through this rapid accumulation of the vegetable mold.

The lakes of Minnesota afford some of the most attractive summer resorts to be found in our northern States; as already famous can be mentioned Minnetonka, White Bear, the Chisago Lakes, and Waconia. The list can be indefinitely extended. Their climatic influence is very marked. The amount of heat stored up during the summer, if calculated by its mechanical equivalent, is enormous. With 43° as the average increment in temperature, 10 feet as an average depth of 5,700 square miles of water surface, we have nearly 11 cubic miles of water. Since each cubic foot of this water receives 1,250,000 foot pounds of heat, which must be given off during the autumn months as these lakes gradually settle down to the freezing-point of winter, the amount of heat thus made available for our autumn weather reaches quintillions of foot pounds. This warmth is a break against early autumn frosts. The south side of Lake Minnetonka has most productive vineyards and fruit gardens, while the northern side is liable to early frosts.

Other writers have called attention to the distribution of fresh-water lakes. They are almost wholly confined to the glacial regions of our globe. Northern Europe and northern central North America, with other isolated portions of the globe, are the only places where many bodies of fresh water are found. It remains to be noted that within these glaciated regions the oldest portions are already comparatively free from lakes. The southern border of the glacial area of the United States is almost wholly devoid of them. The vast prairies of Ohio, Indiana, and Illinois have but few, yet there are vast agricultural tracts within these States which show deep and rich accumulations of vegetable mould, evidence of former aquatic plants. Doubtless there were once thousands of lakes within these States, but the silting-in of