

the use of many who are not specialists in the sciences to which the essays especially relate. The maps are very valuable, but the volume is otherwise but slightly illustrated.

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POST-GLACIAL SUBMERGENCE IN THE REGION OF THE
GREAT LAKES.

- Raised Beaches of Lake Michigan.* FRANK LEVERETT. (1889)
Wisconsin Academy of Science, Vol. VII., 83-87.
- Abandoned Shore-lines of Green Bay.* By F. B. TAYLOR. American Geologist, Vol. XIII., May, 1894.
- Abandoned Shore-lines of the South Coast of Lake Superior.* By F. B. TAYLOR. American Geologist, Vol. XIII., June, 1894.
- Coastal Topography of the North Side of Lake Superior.* By A. C. LAWSON. (1893) Twentieth Annual Report of the Geological and Natural History Survey of Minnesota for 1891, pp. 181-289.
- Ancient Strait at Nipissing.* By F. B. TAYLOR. Bulletin Geological Society of America, Vol. V., 1893.
- Limit of Post-Glacial Submergence in the Highlands East of Georgian Bay.* By F. B. TAYLOR. American Geologist, Vol. XIV., November, 1894.
- The Duration of Niagara Falls.* By J. W. SPENCER. American Journal of Science, 3d Ser., Vol. 48, p. 455, December, 1894.

The investigations by various observers within the last five or six years have added greatly to our knowledge of the Pleistocene history of the Great Lake region. Following is a brief summary of the results of these observations.¹ Mr. Leverett's paper deals with the raised beaches and sea cliffs around the head of Lake Michigan. Three distinct beaches are recognized which are continuous and traceable for a long distance. These are designated the Upper, Middle and Lower raised beaches. Between Waukegan and Winnetka, Illinois, the lake is farther west than when the beaches were formed and is gradually encroaching upon the till-covered country beyond. At Winnetka the base of a sea cliff twenty feet high lies sixty feet above the level of Lake Michigan (641). Southward the cliff becomes continuous with the

¹For convenience the elevations referring to sea level are placed in parenthesis.

upper beach of gravel and sand which maintains an altitude of sixty feet to within a short distance of the Chicago River where it decreases to a height of forty feet (621). At La Grange there is another sea cliff with its base forty-six feet above the lake. At the time this beach was formed, the lake had an outlet down the Des Plaines valley at Summit, and another entered the same valley from the east at The Sag, about three miles below. The depth of water passing through this outlet at the time this higher beach was formed was forty or fifty feet. East from Summit, the beach ridge stands at sixty-five feet near Homewood (646), fifty-five feet near Glenwood, and eastward to Dyer, in Indiana (636).

The middle beach is about twenty-five feet below the upper, and the lower beach ten feet below this.

Beginning at Sheboygan, Wisconsin, Mr. Taylor's observations extend northward along the western shore of Lake Michigan. The greatest submergence noted is not considered by this author to be represented by any of the terraces described by Mr. Leverett. Evidence of submergence was found at Kewaunee in a low terrace fifteen to twenty feet above the lake (601). Northward the corresponding beach lines rise gradually, and at Menominee on the west coast of Green Bay, there is a well marked beach ridge fifty feet above the lake (631). On the north shore of Green Bay several beaches are distinguished, the highest being 135 feet above the lake (716). Northward from Brampton the general appearance of submergence seemed to extend some distance north of Lothrop, which is 460 feet above the lake (1041), but no shore line was seen. At Marquette a strongly developed shore was found at 590 feet above Lake Superior or 1191 feet above sea level. There is thus seen to be a depression in the beach lines in the vicinity of Kewaunee, north of which the rise is about eight inches per mile for seventy-three miles, while the succeeding sixty-three miles have a rise of from two feet two inches to two feet four inches per mile. Compared with the eastern shore of the lake, the beach on the west appears to be about twenty to thirty feet lower in the same latitude.

Along the south shore of Lake Superior the line of submergence ranges from 572 feet above Lake Superior at Duluth (1173) to 630 feet at Marquette (1231), decreasing from this point eastward to 452 feet at Sault Ste. Marie (1053) (Lawson). The suggestion is made that during the great submergence the Superior basin connected with Hudson Bay by one or more straits.

According to Lawson a very evident relationship exists between the topography of the north side of Lake Superior and the geological structure of the region. From Duluth eastward the Keweenaw, Animikie and Archean constitute successive geological provinces marked by characteristic topography. The Potsdam is represented to a limited extent in the vicinity of Sault Ste. Marie, and is of especial interest as forming the dam in St. Mary's River which holds the waters of the lake at their present level. The beaches, bars, spits, deltas and wave-built terraces are described in detail. The highest mark of submergence was found at Mt. Josephine at a height of 607 feet above the lake (1208), while the number of strands recognized in at least two localities was thirty-one, ranging up to a height of 534 feet (1135). This was the level of the highest strand noted at Duluth, while at Sault Ste. Marie the highest was 413 feet (1014). It is evident, however, that owing to the difficulties attending observation the record of the higher strands is very incomplete. On the supposition of the lowering of a lake barrier to the southeast it is evident that the outlet of the vast sheet of water represented by these strands shifted from time to time in consequence of continental warping. The evidence of an outlet into Hudson Bay referred to by Taylor is given and others noted.

Observations at Mackinaw Island had shown the existence of a shore line 205 feet above the lake (786) which was correlated with the Algonquin beach of Spencer, and the belief was entertained that an old outlet of Lake Warren would be found at Nipissing. Later investigation, the details of which are given in the fifth paper, corroborated this conclusion. This ancient strait, as defined by the two highest shore lines, was about thirty-two miles wide where observed, narrowing eastward to about twenty-five miles. Its depth over the low pass between Lake Nipissing and Trout Lake must have been nearly 500 feet.

The last paper by Mr. Taylor records the results of observations between Lakes Simcoe and Nipissing, where the altitudes of the highest beaches observed range from 780 feet above sea level at Barrie to 1140 at North Bay on the east shore of the latter lake. The identity of the upper beach of the Nipissing region with the Iroquois or Algonquin beach of the Ontario basin is reaffirmed.

The eastward rise of the Algonquin beach noted by Dr. Spencer in the region west of Lake Simcoe was corroborated. Great silt-beds were found showing singular alternations of clay and silt in laminæ often not more than one-half inch in thickness. The evidence is con-

sidered strongly against the theory of glacial dams, and favors the inference that the submergence was an invasion of the sea through a strait over Lake Nipissing.

Previous estimates of the age of Niagara Falls are given in the paper by Dr. Spencer, and attention is called to the error introduced into the later computations by neglecting to take into account the changing episodes of the river. It is noted that previous writers have overlooked the presence of an ancient drainage of Lake Erie about forty miles west of the Niagara. Moreover, the assumption often made that the old course of this river passed through the whirlpool ravine is shown to be erroneous.

There was no preglacial Niagara River, and the present channel has been cut almost entirely in limestone. The Horseshoe falls during forty-eight years has shown a mean rate of recession of 4.175 feet per year. The American falls, however, has retreated but 0.64 feet per year during this period. Four different episodes are recognized. The first represents the recession of the falls from the escarpment to the level of the Iroquois beach, which is computed to have occupied 17,200 years. The second stage began with the lowering of the water at the end of the first and the recession of the falls to the vicinity of the whirlpool—a period of about 10,000 years it is thought. The third stage was the time passed at the whirlpool rapids—computed to be 800 years. The fourth episode is characterized by the rising of the waters in the Ontario basin. In the first part of this episode the river cut its way through a ridge (Johnson's) of limestones, following which comes the modern stage of the falls. The duration of this epoch is placed at 3000 years, making a total of 31,000 years, or, allowing 1000 years for the time before the advent of the falls, the age of the river is 32,000 years.

In the deformatory elevation of the district, Johnson's ridge was raised twenty-four feet above the Chicago divide, causing an overflow in this direction which threatened to end the falls when the cut through the ridge was effected. On this basis the drainage of Lake Michigan by way of the Des Plaines ended about 1500 years ago. At the present rate of terrestrial deformation, the falls will come to an end in about 5000 years, by the turning of the waters into the Mississippi. The conclusions of the paper are based on a long series of observations which have been given in detail in a number of papers, a list of which accompanies the present article.

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