movement ripened into the organization of an association to promote legislation for preserving the scenery of the Falls of Niagara, Mr. Howard Potter of New York being president, and Hon. J. Hampden Robb, chairman of the executive committee.

Through the efforts of this Niagara-Falls association, an act was passed, in 1883, providing for a commission entitled 'The commissioners of the state reservation at Niagara,' and giving them power to proceed through the courts to condemn the lands needed. Ex-Lieut.-Gov. William Dorsheimer is the president of this board; and the other members are President Anderson of Rochester university, Hon. J. Hampden Robb, Hon. Sherman S. Rogers, and Andrew H. Green. With some modifications made necessary by changed conditions, they adopted the plan proposed by the state survey. The lands selected were then surveyed, and their value appraised by a commission of very high character, appointed by the court, the total valuation of the lands being $1,433,429.50. The report of the commissioners of the reservation was made to the present legislature, and a bill to appropriate this sum was introduced. The Niagara-Falls association worked in every part of the state to arouse public opinion to the importance of making this appropriation, and the commissioners labored most earnestly among the legislators and the people. The battle was a hard one against ignorance and narrow-minded selfishness; but the victory is complete. The legislature, by more than a two-thirds majority, has appropriated the $1,433,429.50, and the governor has approved the act.

After six years of almost continuous effort on the part of the active friends of this enlightened project, it is secured by a law which declares that the lands are purchased by the state in order that they may be 'restored to, and preserved in, a *state of nature*,' and that every part of them shall be forever free of access to all mankind.

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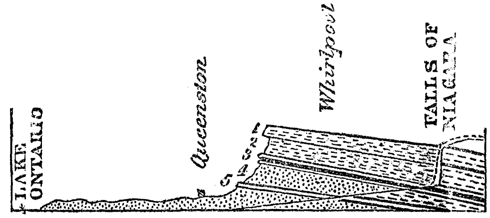
## *THE NIAGARA GORGE AS A CHRONOMETER.*

THE recession of the falls of Niagara will be understood by reference to the accompanying figure.

The strata, as will be seen, dip gently (twenty-five feet to the mile) toward the south. The upper stratum (No. 1) consists of compact Niagara limestone about eighty feet in thickness. Underneath it (No. 2) is the comparatively soft Niagara shale of about the same thickness. Nos. 3 and 5 are also strata of hard rock, with a softer rock intervening. The river formerly plunged over the escarpment at Queenston, about seven miles below the present cataract, and where the perpen-



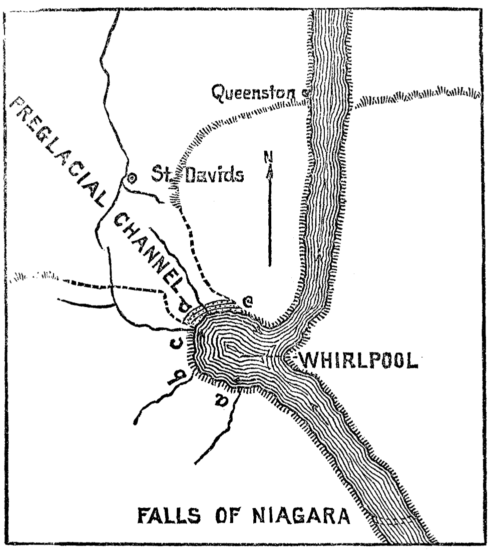

SECTION OF THE STRATA ALONG THE NIAGARA RIVER, FROM LAKE ONTARIO TO THE FALLS.

dicular fall must have been upwards of three hundred feet. From that point to the present cataract, the river now occupies a narrow gorge from five hundred to twelve hundred feet in width, and from two hundred and fifty to three hundred and fifty feet in depth. The manner of the recession is easily understood from a glance at the diagram. The softer rocks (Nos. 2 and 4) rapidly wear away, thus undermining the harder rocks above, and leaving them to project over, and finally to break off in huge fragments, and fall to the bottom, where they would lie to obstruct the channel, were it not for the great momentum of water constantly pouring upon them, and causing them to grind together until they are pulverized and carried away piecemeal. The continuity of the underlying soft strata insures the continuance of a projecting stratum at the top, and a perpendicular plunge of the water when passing over it.

Double interest attaches itself to the Niagara gorge, when we consider the evidence of its post-glacial origin, and thus are permitted to regard it as a chronometer of the glacial age.

That the Niagara River can have occupied its present channel only since the glacial period, was shown by Professor Newberry when he proved that the Cuyahoga River, emptying into Lake Erie at Cleveland, occupied in preglacial times a channel about two hundred feet below its present bed, borings in the bed of the Cuyahoga extending that distance in glacial clays before reaching the rock. To receive a tributary at that depth, the level of Lake Erie must, of course, have been correspondingly depressed; and, as the lake is nowhere much more than two hundred feet in depth, we may confidently say, that, before the glacial period, such a body as Lake Erie did not exist, but instead a wide valley through which a great stream, corresponding to the present Niagara, found its way to the head of Lake Ontario, through a deep and continuous gorge. Professor Spencer, indeed, thinks he can trace the course of this preglacial gorge from near the mouth of Grand River in Canada, northward to Lake Ontario.[1]

We might also infer the relatively late origin of the present channel of the Niagara from the small amount of work which the river has done in its present channel. The Allegheny and Ohio rivers, which lie outside the limit of glaciation, illustrate in a striking degree the extent of *preglacial* erosion. For a distance of more than a thousand miles, these streams occupy a continuous eroded trough, averaging about a mile in width and from three hundred to five hundred feet in depth; whereas the gorge in the Niagara River below the falls is only about seven miles in length.




That the Niagara gorge is post-glacial, was also shown as early as 1841, by Professor James Hall of the New-York survey, who pointed out to Sir Charles Lyell[2] the probable course of a preglacial channel, now filled with glacial *débris* extending from the whirlpool to St. David's, where the level of Lake Ontario is reached. A glance at the accompanying cut will explain the situation. From the falls to Queenston, the perpendicular bank of the gorge, from two hundred and fifty to three hundred feet in height, is continuous upon the east side; but upon the west side, about halfway down, occurs a remarkable indentation known as the 'whirlpool.' Following this bank around, the small streams *a*, *b*, and *c* expose the rock before descending to the whirlpool, and the rocky bank re-appears at *e*. But between *c* and *e* no rock appears, although the stream *d* has worn a channel from fifty to a hundred feet deep. The sides and the bed of *d* consist of the familiar glacial deposit called 'till,' or 'bowlder clay.' The distance from *c* to *e* is about five hundred feet. Following up the channel of *d*, one comes, at the distance of a half-mile, to the general level of the banks of the river above the cataract, and of the escarpment of Niagara limestone, from which the river emerges at Queenston. The opening of the supposed pre-glacial channel to the northwest is, as is shown in the plate, much wider than its entrance at the whirlpool, and the descent of three hundred feet to St. David's is rapid. The broad opening toward St. David's is also filled with gravel rather than with till; and this gravel extends southward over the higher level towards the falls, somewhat like the familiar 'lake-ridges' of Ohio.

It will be seen that the existence of a preglacial channel from the whirlpool to St. David's — a distance of about three miles — is somewhat hypothetical, since for a space of two miles the original features of the country are wholly disguised by the glacial deposit, and no wells have been sunk to a sufficient depth to test the question properly. The well to which Sir Charles Lyell referred was probably about the head of the stream *c*, which is really in the gravel outside the escarpment. Still there is little doubt that before the glacial period there was a narrow gorge, about two hundred and fifty feet deep, extending from the whirlpool, and perhaps a little above it, to the Ontario level at St. David's. But it is equally clear that the river which wore this gorge was not the Niagara, since a stream of that size must, during the long preglacial period (measured by the eroded channel of the Ohio and Allegheny), have worn a gorge far longer than that between the whirlpool and the present falls. The preglacial channel from the whirlpool to St. David's was probably, therefore, as Dr. Pohlman suggests, the work of a comparatively small stream, with a drainage basin occupying not more than two or three counties in western New York.

Considering, now, the gorge from Queenston to the falls of Niagara as the work done by the stream since the close of the glacial period, and

[1] See Second geological report of Pennsylvania, $Q^4$, pp. 359 sq.

[2] Lyell's Travels in America (first series), vol. i. p. 27.

taking that as the dividend, if we can determine the annual rate at which the falls recede, and take that for the divisor, our quotient will represent the time that has elapsed since the glacial period. The accompanying map gives a more definite idea of that divisor than we have ever before had. The lower dotted line represents the margin of the horse-shoe fall as mapped by the New-York geological survey in 1841, under the direction of Professor James Hall. The upper line is that made in 1875 for the U.S. geodetic survey. By comparing the two, a pretty correct calculation may be made as to the amount of recession of the horseshoe fall in the interval of thirty-four years. This cannot vary much from a hundred feet upon the whole line, being, as the commissioners calculate, two hundred and seventy feet at certain points.

Until this last survey, the attempts to estimate the time required for the cataract to recede from Queenston to its present position have been based upon very insufficient data. Mr. Bakewell, an eminent English geologist, gave personal attention to the problem as early as 1830, and, from every thing he could learn at that time, estimated that the falls had receded about a hundred and twenty feet in the forty years preceding. He recurred to the problem again in 1846, 1851, 1856 (*American journal of science*, January, 1857, pp. 87, 93), and was each time confirmed in the belief that the apex of the horseshoe fall was receding, on an average, three feet a year. On the other hand, Sir Charles Lyell, upon his first visit, in 1841, 'conceived' (upon what basis he does not tell us), that, at the utmost, the rate could not be more than one foot a year, which would give us thirty-five thousand years as the minimum time. But, as it appears, the result of the recent survey is to confirm the estimate of Mr. Bakewell, thus bringing the period down to about seven thousand years.

Two elements of uncertainty, however, tending to lengthen the estimate, should be noticed. In the first place, the recession may have been somewhat slower while the hard stratum, No. 3, was exposed. In the second place, the deposits of gravel running southward from St. David's, and corresponding to the lake-ridges, indicate that subsequent to the glacial period this whole region was slightly submerged beneath a shallow body of water; in which case, the recession of the gorge would have begun only upon the emergence of the land. And we have no means of telling how long an interval may have elapsed between the withdrawal of the ice and the withdrawal of the water.

On the other hand, it is probable that the channel of the preglacial stream extended somewhat above the whirlpool, thus reducing amount of work done since glacial time.

The above estimates are confirmed, also, by the small amount of change that has taken place in the species of animals during that period. The mollusks found in the river above the falls at the present time, are identical species with the shells found in the deserted river-channel at the top of the escarpment opposite the whirlpool, while nearer the falls the bones of the mastodon have been found in the same deposits; all which corresponds with a vast amount of other evidence, going to show that the present species are, in the main, identical with those existing at the close of the glacial period. The theory of evolution is relieved from a heavy burden by supposing a recent date for the close of the glacial epoch; for the changes since that epoch have been so slight, that the time allowed by the physicists is insufficient for the whole development of organic forms, unless the rate of change is more rapid than must be the case if the glacial period is thrown very far back.

G. FREDERICK WRIGHT.

## *NIAGARA FALLS CONSIDERED AS A SOURCE OF ELECTRICAL ENERGY.*

THE first suggestion of the possible employment of Niagara Falls as a source of electrical energy, and the distribution of this energy in the shape of light and power, is due to C. W. Siemens. It was a large suggestion; and it took root speedily in what may be termed 'cosmical minds.' The way, however, to its fulfilment, has not been made plain to business enterprise. The most noteworthy remarks upon the subject were made by Sir William Thomson in 1881, at the York meeting of the British association. His remarks and calculations were in substance as follows: With the idea of bringing the energy of Niagara Falls to Montreal, Boston, New York, and Philadelphia, a total electromotive force produced by the dynamo-machines at the falls was taken at 80,000 volts. This was between a good earth connection at the falls, and one end of a solid copper wire of half an inch in diameter, and three hundred statute miles in length. The resistance of the circuit was so arranged that there should be an electromotive force of 64,000 volts at the remote end, between the wire and the earth connection. The calculations showed that a current of 240 webers