

ARTICLE IX.

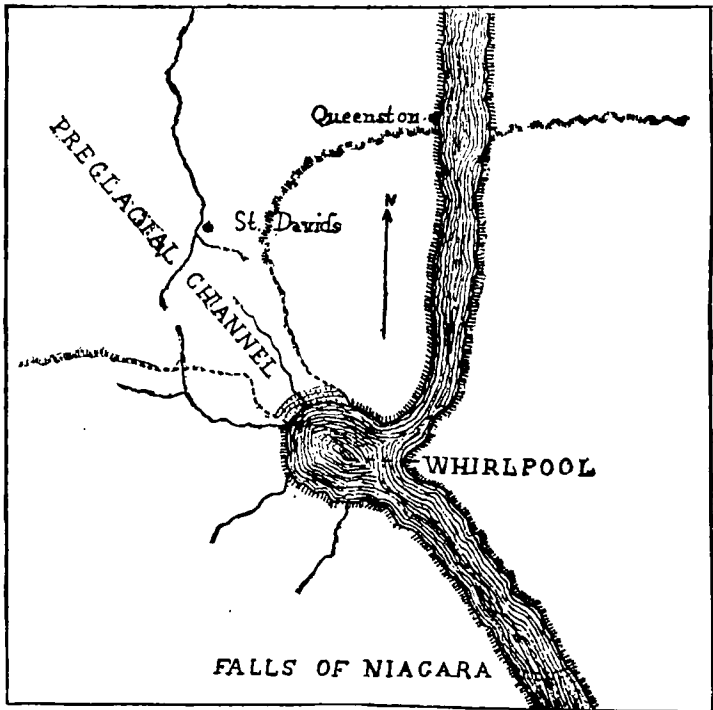
THE NIAGARA GORGE AS A CHRONOMETER.

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THE supposed great antiquity of the lower portions of the Niagara gorge has been one of the chief difficulties in the way of accepting a moderate date for the close of the glacial period. And, as there is a pretty general belief among anthropologists that man appeared before the glacial period closed, the age of the gorge below Niagara Falls connects itself directly with questions of human chronology, and hence becomes, even in the strictest interpretation of the word, a sacred subject; and its discussion will therefore rightly find a place in the *Bibliotheca Sacra*. During several years past a great mass of facts have accumulated concerning the glacial period which have not been brought within range of common apprehension, and which give an entirely new phase to the current ideas about the drainage of the great lake basins. Having recently, in the light of these facts, been led to study the Niagara gorge on the ground in person, I will briefly present the conclusions which probably now must be accepted.

The situation will readily be understood by reference to the accompanying plate. From Queenston to Lake Ontario the Niagara River flows through a level country whose surface is but slightly elevated above the water level. At Queenston the level of the land suddenly rises, by a perpendicular escarpment, from two hundred and fifty to three hundred feet, and maintains this general height to the shores of Lake Erie. The line of the escarpment both east and west is seen in the plate. From the falls to Queenston—a distance of about seven miles—the river flows at the bottom

of a gorge which has been formed by the recession of the waterfall. Just below the present cataract, at the new suspension bridge, this gorge is thirteen hundred feet wide. At the railroad bridge, a mile and a half below, the gorge is but eight hundred feet wide, and continues at about that width through the remaining distance, though at places it is even narrower. Throughout the whole distance the sides of



the gorge are perpendicular, and two hundred or more feet in height. On the west side, however, at the whirlpool, there is a remarkable break in the continuity of the gorge. Here, as will be seen by reference to the plate, the face of the wall is penetrated by a circular excavation about fifteen hundred feet in diameter, into which the whole volume of the water pours, and whirls around tumultuously before making its exit through the gorge to the north.

The western side of the whirlpool is not bounded by a perpendicular wall of rock, but in place of it there is a vast and miscellaneous collection of rock and rubbish, such as was everywhere deposited over this region by the action of ice during the glacial period. On going two or three miles in a westerly direction, to the vicinity of St. Davids, there is an opening in the escarpment about two miles wide, which as you go towards the whirlpool becomes filled to the brim with a glacial deposit. The discovery of this opening toward St. Davids early led Professor Hall, of the New York Survey, to suspect that there was a buried channel, which in preglacial times led from the whirlpool to St. Davids; and this view is now pretty generally entertained, though, as will be seen, we need not suppose that a river of anything like the dimensions of the present Niagara ever flowed through it or was concerned in making it. Indeed, if you follow westward from the whirlpool the outcrop of the rocky embankment, you find that in about half a mile the two escarpments approach to within certainly five hundred feet of each other. Whether the channel of the supposed outlet towards St. Davids is even narrower cannot be told without extensive excavations; since from this point onwards two miles to the west everything is covered with the ordinary glacial deposit, consisting of clay, sand, gravel, and boulders. The inference, however, can hardly be avoided that a buried channel of some sort extends through to St. Davids. The first three small streams indicated on the plate, emptying into the amphitheatre of the whirlpool from the south and west, have cut down to the rocky escarpment, and now plunge over it in cascades. The third one, though cutting much deeper, nowhere discloses the rock.

Conceding, then, the existence of this preglacial channel, the question arises, Did the drainage of the great lakes ever pour through it. To this we may now answer with great positiveness, No; and this for several reasons:

First, the preglacial channel is short. It is only about three miles from St. Davids to the whirlpool; and even if

we might consider the portion of the channel from the whirlpool to the falls an extension of the St. Davids channel, it still would be a small amount of work to have occupied the Niagara River during the long periods which antedated the glacial epoch. It has rather the appearance of being a channel formed by some of the smaller streams draining a local area. It is barely possible that this smaller stream may have eaten its way back from the whirlpool well up towards the present site of the falls; though this seems hardly probable, from the shape of the amphitheatre surrounding the whirlpool. That seems more like the common receptacle into which two or three small streams poured, and united their current to flow through the old gorge towards St. Davids. Still, it is difficult to show that some one of these streams had not worn back a considerable distance farther towards the present falls; in which case the work done in that part of the channel by this preglacial stream will have to be subtracted from the total amount of work supposed to have been done by the Niagara River since the glacial period.

The fact that the preglacial drainage of the lake region was not through the present channel of Niagara River is evident also from general considerations, showing that the preglacial outlet from Lake Erie must have flowed at a level several hundreds of feet below the upper portion of Niagara River. This is evident from the depth of the buried channels of numerous streams now entering Lake Erie at its present level. The Cuyahoga River, for example, flowed for twenty-five miles or more along the bottom of a preglacial channel two hundred feet beneath its present bottom. This is proved by numerous borings which have been made at various points above Cleveland. To allow these streams of that low level an outlet, we are compelled to suppose that Lake Erie did not exist; for this body of water is nowhere more than two hundred feet in depth. In place of the Niagara River, then, there was probably a river of corresponding size flowing somewhere through the bed of Lake Erie, and reaching the head of Lake Ontario through a

channel that was completely obliterated or buried during the glacial period, and has never been reopened. Indeed, Mr. Spencer thinks he has discovered marks of such a channel extending from near the mouth of Grand River in Canada to the extreme western end of Lake Ontario.¹ Whether Mr. Spencer has discovered the exact line of glacial drainage is not important for the question in hand. But no fact is much better settled than that the main drainage of the great lake basin before the glacial period was by some other channel than that now occupied.

All this has important bearing upon the next point, which is, that in the present Niagara River the portion of the gorge which is below the whirlpool has been formed since the glacial period; so that we must extend our calculations of time elapsed since the glacial period sufficiently to allow the present river to wear the channel all the way back from Queenston to the whirlpool, and so much of the channel from the whirlpool to the present falls as had not been removed by the action of the smaller streams, to which reference has been made.

That the portion of the gorge below the whirlpool has been formed since the glacial period is evident from two facts:

1. The banks of clay, sand, and gravel, such as now come up to the water's edge above the falls, extend continuously, at varying distances from the edge of the present gorge, not only down to the whirlpool, but beyond it, well on towards Queenston. As you go at right angles from the gorge at almost any point throughout this entire distance, you find the bare rock extending for a score or more yards, when you encounter accumulations of sand, gravel, and pebbles, such as everywhere forms in the bed of a stream; while a little ways farther back, the original unstratified glacial deposit, such as sealed up the old channel between the whirlpool and St. Davids, is encountered. All this shows as plainly as can be that formerly the river in its present volume poured over the surface of the

¹ Second Geological Report for Pennsylvania. Q^t, p. 359 q.

rock to the vicinity of Queenston, and there made its fearful plunge to the lower level.

2. The other fact pointing to the same conclusion is, that certain fresh-water shells are found north of the whirlpool in the sandy deposits of which we have spoken, and that these are identical with those now found in the bed of the stream above the present falls.

Granting, now, that the gorge from Queenston up to the present falls is the work done by the Niagara River since the glacial period, we have here the *dividend*. If we could obtain in the annual rate of retrocession the *divisor* we should be able to obtain the number of years required to do the work. It is true that we should have to assume that the rate was uniform; and this we may do without great probability of error. The successive strata do not vary in such a marked degree as to introduce into the problem any great uncertainty from this source. That the water should form a cataract, rather than a continuous series of rapids, is due to the facts that the strata of rocks near the bottom of the gorge are much softer than those at the top; hence the lower strata yield more rapidly to the erosive force of the falling water, permitting the upper strata to be undermined, and compelling them to fall in fragments into the chasm, where in due time they are ground to powder. All sorts of estimates have been in circulation as to the rate at which the falls are receding. Desor thought the rate could not be greater than a foot in a century; but there are probably few who would now agree with him in this manifest extravagance. In 1841 Sir Charles Lyell and Professor Hall estimated that the rate was probably one foot a year, which would make the lower part of the gorge about thirty-five thousand years old.¹ From the fact that Lyell failed to present any data upon which he based this inference, it seems probable that he had none which were at all definite, and that his estimate was a mere surmise arising from momentary impressions. On the contrary, Lyell's guide was confident that the American Fall had

¹ See Lyell's *Travels in America* (First Series), Vol. I. p. 27.

receded at the average rate of two feet a year during the twenty-five years he had observed it. And Mr. Bakewell, an eminent English geologist, who had given much personal study to the question, estimated that for the forty years previous to 1830 the rate of recession had been about three feet a year. Mr. Bakewell having carefully studied the phenomena again in 1846, in 1851, and 1856,¹ finds no occasion materially to revise his estimate. In 1841 Professor James Hall had an accurate map of the falls made for the New York Geological Survey, and determined with great care a number of points to which future reference might be made with view of determining the exact rate of recession. In 1875 another and independent survey was made by the United States government. Dr. Julius Pohlman of the Society of Natural Sciences in Buffalo, after having thoroughly gone over the ground, carefully compared these maps, and reported upon the subject at the recent meeting of the American Association for the Advancement of Science held at Minneapolis (Aug. 1883), where the question was discussed by the leading geologists of the country, including Professor Hall. Dr. Pohlman's conclusion is, that, after "allowing even a wide margin for possible inaccuracies, we must admit that some portions of the Horseshoe fall have receded at least one hundred feet in these thirty-four years, while in the American side differences of from twenty to forty feet are seen, although the northern point of the falls on the American side as well as a monument which marked the edge of the Horseshoe fall in 1841 have remained unchanged." Professor Hall, in expressing doubts as to the correctness of this conclusion, could only do so by supposing that one or other of the surveys was inaccurate; or that, being made by different persons using different methods, they could not well be compared with each other. Mr. James T. Gardiner, director of the New York State Survey,² was led to nearly the same conclusion with Dr. Pohlman; and, in response to

¹ See American Journal of Science for Jan. 1857, pp. 87 and 93.

² See Report for 1879.

recent inquiries from Professor A. Winchell,¹ says that the assumption that the Horseshoe fall has receded one hundred feet during the last thirty-three years cannot involve any great degree of uncertainty. Thus from the best light we now have, it seems altogether probable that the cataract is receding at a rate that would suffice to produce the whole chasm from Queenston up in less than twelve thousand years; and if, as is not unlikely, any considerable portion of the gorge above the whirlpool had been formed by preglacial agencies, even that relatively short period must be considerably abbreviated.

ARTICLE X.

ASSYRIAN RESEARCH AND THE HEBREW LEXICON

BY PROFESSOR D. G. LYON, PH.D., HARVARD COLLEGE.

LAST year Professor Friedrich Delitzsch published, in the *Athenaeum*, of London, a series of articles on the Importance of Assyriology to Hebrew Lexicography.² Several publishers, who appreciated the excellent quality of the articles, at once offered to reproduce them in a more permanent form. The result is a small book, entitled: *The Hebrew Language viewed in the Light of Assyrian Research*.³ For the treatment of this subject no scholar is so competent as Professor Delitzsch. An enthusiastic student, with a genius for language, he has been for several years occupied with the compilation of an Assyrian, and also of a Hebrew, lexicon. His acquaintance with the lexicographical material of the Assyrian and Babylonian monuments is certainly greater than that of any other scholar. His little volume, containing only eighty-five pages, is the product of a mind evidently possessed of its subject. The style is simply charming. There has certainly not appeared for many a year a book more important for Semitic study. Any person interested in the Hebrew of the Old Testament will find this a welcome volume.

Two great principles guide Delitzsch in his lexicographical work.

¹ See Winchell's *World Life*, p. 371.

² May 5, 12, 26; June 9; July 21, 28; August 25.

³ London: Williams and Norgate. 1883.