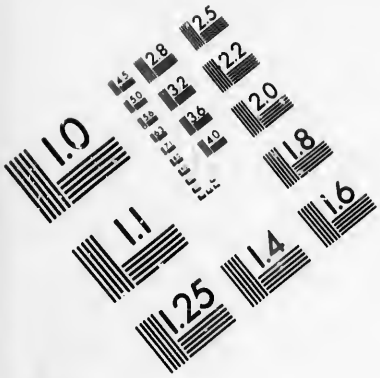

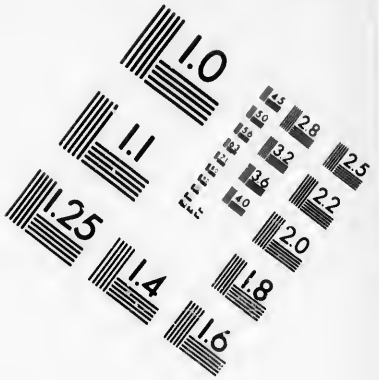

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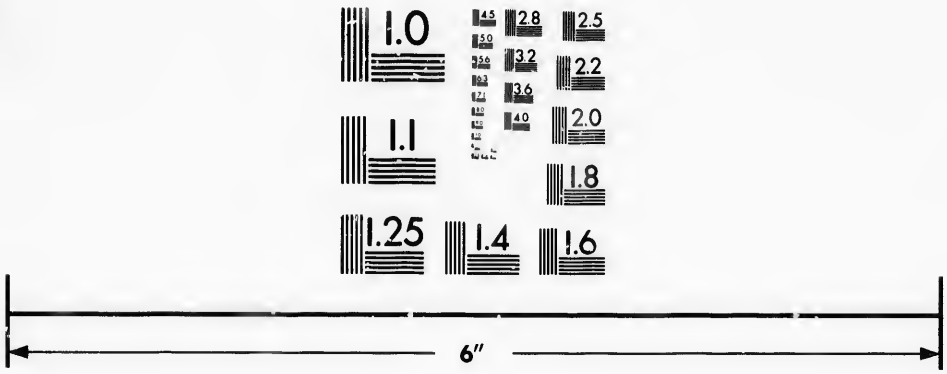

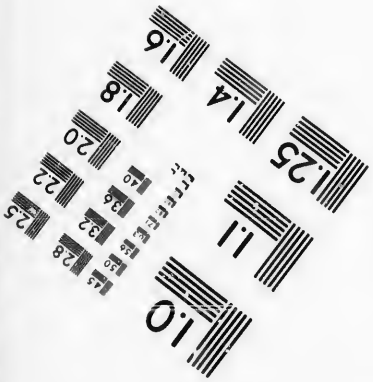

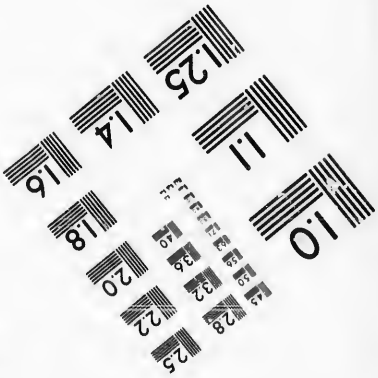

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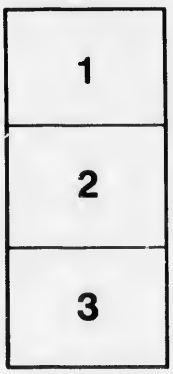

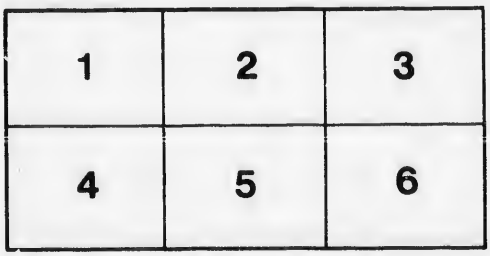

[From The American Journal of Science, Vol. III, March, 1897.]

THE SCOURED BOWLDERS OF THE MATTAWA VALLEY.

By F. B. Taylor.

Art. XIX.—*The Scoured Bowlders of the Mattawa Valley;* by F. B. Taylor.

Introduction.

The author spent the last week in September and the first half of October just passed in exploring the valley of the Mattawa river in the Province of Ontario. The chief object of search was to discover whether there is any clear evidence of the recent flow of a great river eastward along this course to the Ottawa valley. For this is the site of a supposed former outlet of the upper Great Lakes. It has been supposed, first by Mr. G. K. Gilbert, and later by Prof. G. F. Wright and the author, that there was a period since the disappearance of the ice-sheet during which Lakes Superior, Michigan, and Huron discharged their waters eastward to the Ottawa valley along the present course of the Mattawa river. During this period Lake Erie alone retained its outlet through Niagara river to the basin of Lake Ontario. It does not fall within the intended scope of this paper to discuss all the facts relating to the existence of the Nipissing-Mattawa river, as the ancient outlet river may be called, nor to discuss exhaustively the facts relating to its duration and date. It will suffice here to state that from several kinds of evidence the existence of the great outlet river is believed to be established beyond a doubt; and further, that it endured for a comparatively long period of time and ceased to exist probably considerably less than ten thousand years ago. Hence, while it is geologically a very recent thing, it may very properly be spoken of in a historical sense as ancient.

No more conclusive evidence of the existence of the ancient river could be expected than that which has been gathered this season from a study of the numerous bowlders that lay in its rapids. The volume of the river, it is fair to assume, was practically the same as that of the St. Clair river to-day, and was equally steady in its flow. In rapids of moderate velocity, where the river flowed over a sill closely paved with large bowlders, the action of the current rolling small quantities of gravel over, around and between the bowlders produced certain wearing or scouring effects which are very characteristic. The forms so produced are not known to be made in any other way. It is the object of this paper to present a brief account of these peculiar bowlders as they appear to-day in the valley of the Mattawa, many of them as much as forty feet above the present river. A few remarks will also be added about the conditions and the processes of their production.

The bowlders which show these modifications are almost all large, ranging from about two to twenty-five or thirty feet in diameter. Bowlders of large size are extremely numerous on the areas where these forms are found, completely covering over the surface of the ground. They are all of very hard crystalline rock; some are red or gray granite, and some are greenstones, but by far the greater number are of the hard foliated gneiss which is so common in the surrounding region. Many of the large bowlders of gneiss, even after the long exposure to weather which they have undergone, show no signs of fracture or breaking. So far as observed the bowldery areas of the former rapids of the river appear to be associated with belts of morainic accumulation.

Varieties.

One may best learn the processes by which scoured bowlders are made by studying the action of the current in bowldery rapids of the modern river at a time of low water. In passing over and among the bowlders the current is very much disturbed. It is turned aside suddenly and thrown this way and that; it strikes against the front or the sides of some bowlders and passes through narrow passages between others; it glides smoothly over the tops of some and falls heavily on the tops of others, and in a few cases it is thrown into a vortex whirl in an angle or slight depression on the surface of a bowlder. Just as the billows in a rocky rapid remain constant in position, so these various turns and whirls in the current beneath the surface remain constant in place and action so long as the bowlders lie unmoved. Thus the currents that play upon a bowlder are generally constant in the particular manner of their action. Where sand and small pebbles are being borne along in small or moderate quantities, they follow the deviations of the current from bowlder to bowlder, and each sand-grain and pebble does a little work of abrasion as it goes along. Every one that follows the same course among the bowlders performs its iota of work upon the same part, so that the wear on each bowlder comes where the current impinges upon it. In the course of time, but very slowly, the bowlders are worn into the fantastic shapes which are here called scoured bowlders. The forms which the bowlders take under the scour of the sand- and pebble-bearing current are quite varied. But after examining several hundreds of specimens it became apparent that all could be classified according to their forms under a few heads, although a few individual cases would have to stand as intermediate forms. Six varieties may be distinguished as follows:

Scoured Bowlders.

1. Pierced (Ring-bowlders).
2. Basined.
3. Niched.
4. Guttered.
5. Facetted.
6. Smoothed.

The table of varieties of form as given above is offered only provisionally. For it is quite probable that a more extended study of the subject would suggest some modifications. In forming the table, however, the writer has had the advantage of discussion and joint observation with Dr. Robert Bell, Assistant Director of the Geological Survey of Canada. Shortly after the beginning of the study of the bowlders at Mattawa, Dr. Bell arrived from James Bay and during three or four days delay from other causes, gave a part of his time to the study of the scoured bowlders. The names of some of the varieties as presented in the table were suggested by him. These names are based mainly on forms of scoured bowlders found on the terraces at Mattawa and in the modern rapids of the Mattawa and Ottawa rivers. The observations of this season, however, are not the only ones that the writer has made. Basined bowlders were observed in 1895 in the rapids of the Ottawa both above and below Mattawa and also in the rapids of the Nipigon. Some of the less pronounced forms were found in 1894 in several of the streams that course down the slopes of the Alps, in the Maggia especially, and to some extent also in the Toce and Ticino. In 1893 a few basined bowlders were seen in the Au Sable and Saranac rivers in the Adirondacks. The first bowlders of this kind noted by the writer were seen in 1888 and 1889 in some of the rapids of Grand river above Hot Sulphur Springs in Middle Park, Colorado, and they were also seen in several other rivers in the same state. Some of those in Grand river show well-developed potholes.

Distribution.

Scoured bowlders of the more pronounced types may be produced in almost any stream of large or moderate size provided certain conditions of stability obtain. The bowlders must be permanent in position for a long period, and the general direction of the current must not change. There must also be a fairly constant supply of sand and gravel, moderate in amount, for the current to roll along as it moves over the bowlders. Streams meandering in alluvial plains are not likely to show effects of this kind. Even streams flowing in drift beds suffer so many alterations of their courses, due to caving banks and

deepening beds, that they produce generally only the smoothed variety, which does not require constancy of position. Nearly all streams produce this simplest form. Scour effects on bowlders are sometimes found even in small streams, where their courses are permanently choked with great bowlders through which the stream trickles constantly. But so far as known to the writer, the Mattawa valley is the first case where the existence of a great ancient river now extinct has been inferred from such evidence.

Besides the scoured bowlders on the terrace at Mattawa there is but one other place higher up the Mattawa valley where these peculiar stones were made in large numbers in rapids of the ancient river. At Des Epines rapids, eight and one-quarter miles above Mattawa, scoured bowlders are developed in great profusion and perfection of form at heights entirely above the reach of the modern river. At this place bowlders with deep basins or potholes in them were found on the north side over forty feet above the water.

On a comparison of the results of observations on the several bowldery rapids of the ancient river, a very clear explanation of the plentiful occurrence of scoured bowlders in some rapids and their scarcity or absence in others was found. Wherever a stream of sufficient volume to transport gravel in considerable quantities descended from the adjacent high drift-covered country and poured its contribution into the ancient outlet at or just above a rapid, scoured bowlders are numerous. But where the water that passed over the bowlders issued directly from a lake, and hence without any such supply of gravel, scoured bowlders are few or absent altogether. Boom creek entered the ancient outlet on the south side about a mile above Mattawa and furnished an abundant supply of gravel for the current to roll along over the bowlders of the Mattawa terrace. That Boom creek did in fact supply a large amount of gravel is attested by the present existence of a very considerable delta of sand and gravel 50 to 60 feet above the modern Mattawa river where the creek enters the old channel. The influence of the ancient outlet current is shown by the fact that these sediments have been carried down that side of the channel quite extensively and spread over part of the bowldery terrace. At Des Epines rapids the gravel supply came from the Amable du Fond river, which enters on the south side less than half a mile above. This stream is nearly as large as the Mattawa itself and it cuts extensive gravel beds a short distance above its mouth.

On the other hand, in the bowldery rapids at the head of Lost river (foot of Turtle lake) no basined bowlders and few even of the less pronounced forms of scour were found. They

appeared to be absent also in the ancient bowldery rapids next below Pim'si bay and at the Rapide des Rochers below Lac des Aiguilles. At all these places the current issued directly from a lake and was probably clear and free of gravelly sediments.

So far as seen the best place to observe bowlders being scoured by the work of the modern Mattawa river is at the Chute des Parasseux, fourteen miles above Mattawa.

Descriptive Details of Varieties.

Pierced and basined bowlders are in reality merely two stages of the same process. When the current begins to cause pebbles and sand to spin round and round on one particular spot on the surface of a bowlder, the process of wearing out a basin is begun. Given only time enough, with constancy of the conditions on which the whirl depends, and the basin will sink deeper and deeper into the solid bowlder until the bottom is cut through and the basin becomes a hole. The bowlder is then pierced through and becomes a ring-bowlder. The hole is usually nearly circular on cross section, but sometimes tapers towards the bottom. The periphery or outer surface of the stone generally shows considerable irregularity, for the hole is seldom symmetrically placed. Otherwise these bowlders have the common sub-angular form. Pierced or ring-bowlders are the highest type or variety of the several forms produced by scour. They are scarce, even where other lower varieties are abundant. Only one was found on the course of the ancient outlet river within the Mattawa valley, and this lies in such a position and at so low a level with reference to the modern river that it probably was made by it. This ring-bowlder lies in a side channel at Parasseux Chute. A dam was constructed across the head of the rapids several years ago and this left a side channel east of the present rapids dry. In the bottom of this channel about opposite the middle of the present rapids below the dam lies the ring-bowlder. It is broken in two pieces, but they are separated only a few inches and their former solidity as an unbroken ring is at once obvious. The hole is not perfectly circular, but has a large diameter compared with the diameter of the bowlder itself. The hole is about eighteen inches across, while for about one-third of the circumference the ring of rock is only six or seven inches thick.

But the most magnificent specimen of this variety that the writer has seen is on the bank of the Ottawa river near Klock's, ten miles below Mattawa. This bowlder is large—about seven feet long, five wide and four thick. The hole is

about eighteen or twenty inches across at the top, but tapers to about eight or ten inches at the bottom. The bowlder has evidently been slightly tilted since it was bored out, and may, indeed, have been moved a considerable distance. It lies at the edge of the water a few rods up stream from the residence of the Hon. James B. Klock, and is readily visible only at low water.

From the Rev. E. Macnab of Mattawa the writer learned of another ring-bowlder which may be seen on the bank of Lake Temiscamang at the narrows at old Fort Temiscamang near Baie des Pères. In this case a tree grew up through the aperture and finally broke the bowlder in two. The stone was literally strung on the tree.

Basined bowlders are much more numerous. They are fairly abundant in the rapids of the ancient outlet at Des Epines rapids and at Mattawa and also in several of those of the modern Mattawa and Ottawa. They exist in all stages of development ranging from a saucer-like depression barely deep enough to hold a spoonful of water to well-developed potholes a foot or more in depth. Occasionally one is found which is very irregular in shape —a peculiarity which is generally due to some unevenness in the composition of the rock. Several bowlders were found in which a well-developed basin had a deep cut in the rim or on one side. This appeared to be due to the wearing through of a thin side wall. A good specimen of this modified form lies on the edge of the railroad cut about forty feet south of the overhead bridge opposite O'Farrell's hotel in Mattawa. This one is about 35 or 40 feet above low water in the Mattawa. Many basined bowlders were found at heights from fifteen or twenty up to about forty feet on ground east and southeast of the hotel. On the north bank at Des Epines rapids three good specimens were found forty feet above the modern Mattawa and several others were found at lower levels.

Niched bowlders that can be surely distinguished from other forms are hardly so common as the basined variety. The niche is a shallow hollow worn into the side of the bowlder, in form somewhat resembling a wall-niche for statues or statuettes. A number of examples were found at Mattawa concerning which there can be no doubt. For the bowlder had evidently received its marks of scour *in situ*. This was the case with the great bowlders especially. In the case of many small bowlders, however, the worn cavities may have had a different origin. If a small bowlder had a small shallow basin worn on its top and then had been turned over on its side, the basin would then have the appearance of a true niche. No doubt many have had this origin. But in several instances it was plain that the niche had been worn while the bowlder was in exactly the same position as to-day.

Shallow, smooth-worn hollows are often found on the slanting sides of bowlders, and sometimes on stones no larger than a foot in diameter. The origin of such forms can seldom be made out with certainty unless it is clear that the stone has remained unmoved. In a few cases two bowlders lying close together had complementary grooves or hollows in them. Probably nearly all true niches were caused by the diversion of the current by one bowlder so as to strike the side of another.

Guttered bowlders in typical form are almost as rare as ring-bowlders. It requires a bowlder having considerable flat or nearly flat surface area on its top to lead to the formation of a gutter. Hence this variety is confined mainly to bowlders of large size. The flat surface must have some slight inequalities that will tend to guide the sand and pebbles which the current rolls along. If these irregular features are so arranged that the wearing materials are always guided along the same path they will finally wear it smooth and deepen it more or less, making a sort of gutter across the surface of the bowlder. Such smooth-worn grooves are often found where streams flow over solid rock ledges. But they are not so common on bowlders. Where they exist under such circumstances that the bowlder has clearly not been moved, they show the direction of the current very accurately. There is one fairly good example of this variety in Mattawa, and also several others less noteworthy. But even this best one is not so strongly marked nor so perfect as could be wished. Still, it has the distinct characters of a gutter, and was produced by the process just described. Twenty-five or thirty rods north of the bridge on the east side of the Mattawa river at its mouth are several very large bowlders. One is of gigantic size, having dimensions of about 27 feet in length, 24 feet in width and fully 15 feet in height, with probably a third of its bulk buried under ground. It is about 150 feet back from the river and the ground at its base is about ten feet above the water. It is a block of foliated gneiss and shows considerable differential weathering or wearing on its sides where the black hornblendic bands project as ribs nearly horizontal, while the gray quartz-feldspar bands between are relatively depressed by being worn or dissolved out. The top of this great bowlder is somewhat uneven, but it slopes in a general way toward the south-southwest or up-stream with reference to the Mattawa. The uneven features of the top surface present their sharper edges and bolder faces toward the northeast. A fairly well developed gutter runs across diagonally from corner to corner in a straight line. Starting at the southwestern corner, it runs up a slope of about 20° to the northeast. Near the lower edge the surface is comparatively plane, having few irregularities and the gutter is scarcely noticeable. But within a foot or two a slight depression appears between very gently sloping sides, and the sand and

pebbles seem to have been gathered into this and so started on their course. This depression was plainly an original feature of the surface of the bowlder. But on close inspection it was found that the bottom had been made a little more even and smooth by the sand that had trailed along through it. Then for two or three feet the surface is flat and the sand and pebble current appears to have spread out or divided in two or three parts. Over this space the gutter is not clearly discernible. Then another depression begins and runs three or four feet to the sharp edge of a cavity about one foot in depth. On approaching the edge the gutter becomes very marked, and the edge where the moving materials ran over into the cavity is worn and hollowed out smooth into a shape like the lip of a large water pitcher. After passing out of the cavity and up the face of the bowlder again, the worn track reappears directly in line with that just described and becomes more pronounced as it approaches another worn-down notch or pitcher-lip where the gutter passes off the bowlder into the air. This worn track crosses the whole extent of the bowlder in a direct course, and from its relation to the worn notches in the sharp edges it is plain that the course of the sand and pebbles was from southwest to northeast and not *vice versa*. In sighting backward along the gutter, one looks directly up the course of the Mattawa. At the same time the bowlder stands in such a position that it would be openly exposed to higher waters from the northwest descending the valley of the Ottawa. But there are no marks indicating the action of a current from that direction. The top of the bowlder at the present time is about 25 feet above the water at low stage.

In another way the giant bowlder shows conclusively that a great current of water has played around it. It stands in a sort of basin and rests its lower visible edges against smaller bowlders from between which all finer material has been swept away. Open holes now filled with water extend some distance down under the edges of the great bowlder. The other bowlders now immediately surrounding the great one are mostly small. It seems probable that the great bowlder was at first buried more deeply than now. The gutter may, therefore, have been made mostly in the earlier stages of the great river, when sand and gravel would pass more readily over its top. The basin it lies in suggests this, and it is hard to see how sand or gravel could be carried up onto the top of the bowlder, as it stands related to the surrounding ground to-day, in sufficient quantities to accomplish such a work.

There is another cluster of very large bowlders near the railroad trestle northeast of the great bowlder mentioned above. Some of them show faint gutters also and nearly all of them show basins or some other well-marked product of scour. Among smaller bowlders the gutter is frequently rep-

resented by notches in the rims of shallow basins. These are well marked sometimes, showing where the sand and pebbles left the basin, and occasionally a notch is found also on the up-stream side where they entered, if the bowlder be not too small and its up-stream rim too narrow.

Facetted bowlders have plane faces or facets worn smooth. Probably in nearly all cases the facets existed in the rough before the scouring. It would be hard in any given case to prove that this was not true. Still, it is possible that facets have sometimes been made by scour when the facet shape did not previously exist. This variety is fairly plentiful.

Smoothed bowlders are far more abundant than all the other varieties put together. Almost every bowlder that has a more specific mark of scour shows smoothed surfaces also on other parts. A smoothed bowlder is one that has simply been made smooth by scouring and may not have received any other more definite mark in the process. These bowlders may have been angular or subangular or rounded before the scouring began, and without having their general form changed they were made smooth over all surfaces alike. In the old channels where the scoured bowlders occur almost every one shows more or less of this effect. There are great numbers of scoured bowlders along the roadside near the Presbyterian church in Mattawa and farther east for a quarter of a mile. Near the church there are many fine examples of smoothed and basined bowlders. Some of them are polished so smooth on one or more sides that they glisten a little in the sunshine even when they are dry. They have a smooth, soft feel under the hand, not like a pane of glass, but rather like a surface of finely embossed leather. Most of the bowlders along the road near the church have been moved in road improvement or in clearing ground for buildings. It is probable that the most highly polished parts of the best specimens were previously on the under side or buried, and so protected from the weather ever since they were polished. This suggests that many, at least of the smaller bowlders, were turned over and partly buried during the time of the great outlet river. They were scoured and polished and turned over before the river ceased to flow. It is quite possible that other forms of scour may be found on bowlders which would suggest the propriety of adding more varieties to the list given above. But the forms found by the author, and examined also by Dr. Bell, seem to be fairly well covered by the names suggested.

One other possible variety deserves mention. When the deep cut was made through the bowldery terrace in Mattawa for the branch railroad up the Ottawa, some very curiously shaped stones were found in the gravelly top layer. Among others was one roughly cone-shaped, but flaring out slightly at the base. It is almost perfectly round on any horizontal sec-

tion and tapers smoothly up to a point about two inches through. Its shape may perhaps be best described by saying that it is like an Irish peasant's hat. The crown is rather pointed and the rim projects downward and outward from it through a very gentle curve. The base or bottom of this stone is flat and smooth and showed no rough surface where it might have been detached from the solid mass. From similar specimens seen before, the writer at once recognized this stone as the detached core of a pothole. It is about ten inches high and rather narrow and slender, and hence suggests a pothole of relatively great depth. But the edges around the base or rim are also apparently worn smooth. This makes it very difficult to account fully for its origin. It seems probable that this stone was bored out of a solid bowlder. In that case it is the core left from the making of a ring-bowlder. The bowlder itself might have been smooth on its bottom before the making of the pothole began, and this would go some way toward explaining the smooth bottom of the core-stone. Such stones as this might be set down as an independent variety of scoured bowlders. But so little was learned of the occurrence of this specimen that its place and manner of origin seems to be a matter of some doubt. Nevertheless its smooth and apparently fresh-polished surface suggests that it is a scour product of the rapids of the recent great outlet river. As Dr. Bell has suggested, the ring bowlder out of which this "stone hat" or core-stone was bored may be lying close by hidden in the gravelly, bowldery surface layer (three to seven or eight feet deep), which covers that part of the terrace. Mr. Macnab pointed out another curiously hat-shaped stone on a veranda in the village. It had the shape of a "son'wester," but was clearly the product of differential weathering (perhaps afterwards smoothed in the rapids) rather than of scouring by current action. Dr. Bell deposited the first mentioned specimen in the museum at Ottawa.

Summary.

Some idea of the magnitude of the great outlet river may be gathered from the fact that at Des Epines rapids the mark of its upper limit is quite plain at 50 to 55 feet above the present stream, and the width of the channel at that height is between 600 and 700 feet. The average depth across the channel is 35 to 40 feet, and yet the current was swift enough to produce many of the finest types of scoured bowlders. Here and in Mattawa there are other bowlder fields as heavily covered as those on which the scoured bowlders are found. But they are above the level of the ancient outlet river, and although they were examined closely no scoured bowlders were found upon them. There are also other bowldery tracts at low levels at several places above Mattawa. But they are situated

on the shores of lakes or expanded portions of the valley. Some of these too were explored, but were found devoid of scoured bowlders. It was only in the rapids of the ancient outlet, where a swift and powerful current flowed over them, and where there was a supply of gravel for the current to roll along that the higher types of scoured bowlders were made.

The principal conclusions suggested by the scoured bowlders may be summed up briefly as follows, and in these Dr. Bell is in substantial agreement with the author.

1. The modified bowlders which show the more pronounced forms of scour must have remained a relatively long time in one position and in a current which was substantially constant in strength and direction of flow in order to have received their deep worn and peculiar markings. This conclusion is further supported by the fact that all the bowlders are of hard crystalline rock—mostly of the hardest gneiss and granite.

2. There must have been a constant but not too voluminous supply of gravel or pebbles for the current to roll along over the bowldery bottom in order that the work of scour might be accomplished.

3. Many of the bowlders, especially the larger ones, were scoured *in situ* and in some cases the forms of their scour marks show clearly the direction in which the current flowed.

4. All the indications gathered from the bowlders of the morainic terrace upon which Mattawa is built show that the scouring current came from the Mattawa valley and not from the Ottawa. And this is true, although the best examples relied upon for this conclusion are situated so as to be equally exposed to any current that might have come down the latter valley.

5. The scoured bowlders typified by those at Mattawa and Des Epines rapids constitute a distinct class, which has received secondary modifications of form in consequence of relatively long continued and powerful current action.

6. Beds of scoured bowlders like those here described, marking the place of rapids in great rivers no longer in existence, may serve (with due consideration of other attendant conditions) as valuable aids in the study of later Pleistocene history, especially in the bowldery Archæan areas of the north.

In the opinion of the writer the scoured bowlders are one of the best of several lines of evidence that clearly establish the existence of the great Nipissing-Mattawa river as the outlet of the three upper Great Lakes in very recent times. The conclusion maintained heretofore by Gilbert, Wright and the author, but on evidence less complete, seems now fairly proven, viz: that for a considerable period of time, while this northern outlet was active, Niagara Falls was robbed of much the larger part of its water.

Fort Wayne, Ind., Nov. 28, 1896.