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# DISCUSSION OF THE PHENOMENA OF LOCAL GLACIATION IN THE DRIFTLESS REGION

by

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Discussion of the Phenomena of Local Glaciation in the Driftless Region.

G.H. Squiers. March 7 1916

As I have indicated by my caption, this is not intended to cover my whole series of studies in the Pleistocene history of the region save in so far as they have a bearing on the above topic, and on that topic to indicate the general character of the evidence without going into detailed description.

The logical sequence of the discussion would demend that I give first a statement of the observed phenomena, leaving the type of glaciation to follow as the logical deduction, but, for the purpose of this article it seems best to reverse the order, and state first the character of the glaciation assumed, and then the phenomena on which the assumption is based.

There is no reason to doubt that there is always a tendency for snow to accumulate in the valleys under the action of the wind. With a cold climate, and with scanty vegetation this tendency would have been much more pronounced, and the yearly accumulations might easily come to exceed the yearly melting. In such a case the tendency would be toward a filling of the valleys. Assuming them to have been thus partly or wholly filled it is not believed that more than a small per-cent would have presented conditions permitting the development of glacial motion, while a merely stagnant mass would leave few evidences of its existance. In a small percentage of cases however, where there are short, deep vallies, with steep slopes, conditions permitting true glacial motion may be fairly conjectured to have existed. Such conditions are more likely to occur along the Mississippi than elsewher

As a matter of fact, many of the short, but deep valleys opening on to that stream would permit a thickness, and give an angle of slope amply sufficient for that purpose.

Assuming the possibility of such glaciers, what are the indices

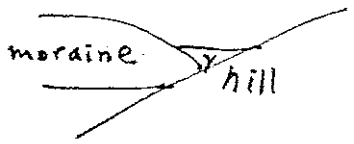
for which we must look to prove their actual existance?

Since all of the material must be derived from the valleys themselves, there is little in the character of the material save its relative coarseness to distinguish it from ordinary outwash.

On account of their shortness - the longest is hardly a mile long, and the most from a quarter to a half mile - there is little hope of finding polished or striated boulders.

We have left us, therefore, only such evidence as is furnished by the external form, and internal structure of the deposits, with such contributary aid as the size of the included fragments may afford.

If these deposits were clearly exposed, so that one might walk about on them, and take in their form at a glance, they would present a comparatively simple problem, but except in one instance, this is not the case. On the contrary, they are more or less deeply buried, and exposed only where deep ravines have cut through them. Only by long and careful study, aided by numerous excavations was I able to determine their form. I was thus able to determine that in a single valley there were two transverse ridges terminating abruptly and having slopes up as well as down the valley, also two others terminating abruptly, but not showing the upward slopes. The structure while not in itself decisive, is in its lack of stratification, and in the positions in which the flat stones have come to rest, much more like glacial, than like any other type of deposit. There is one feature however, in which the glacial character is very strongly shown. For many years I sought in vain for anything corresponding to a lateral moraine, these not being exposed by the ravines. Finally, selecting a point where a main ravine approached the hillside rather closely, through the expenditure of no little labor, I succeeded in obtaining a section.




As shown in the figure the moraine shows a steep slope facing the hill and the structure indicates that successive additions had been made on, and conformable with, this slope. In addition, there were innumerable stringers of fine clay running down among the stones conformable to the slope, which uniting, formed a considerable body of similar clay in the trough, and between the moraine and the hill. Of all these features, however, a casual visitor could see nothing, and I can hardly doubt that my reputation has suffered not a little because those whom I have shown over the ground could not see what I had described. From this standpoint, it is somewhat unfortunate that the only example in which the deposits are clearly and fully exposed is some distance away, on the opposite side of the river, and difficult to reach.

This deposit, which had not been discovered at the time my articles were written for the Journal of Geology, owes its exceptional freedom from concealing deposits to a rather interesting circumstance. As is generally known, the Trempealean Bluffs were once a part of the Minnesota shore, severed some time in the early Pleistocene. The shore has become so thoroughly alligned that we can gain from it no indication as to the point of junction. There are, however, a couple of small valleys several miles up which are undergoing notable rejuvenation. So great a departure from the conditions obtaining in other valleys along the river, is believed to be due to a shortening, and that to a locally rapid cutting away of the shore line.

In one of these valleys there is a ridge near the lower end extending across the valley without a break save for the narrow notch through which the drainage passes and extending some distance up the hills on either side. (There are other valleys showing similar ridges running up the hillsides, but they are covered along the middle.)

This ridge, showing many large masses of limestone, and having a height of about fifteen feet, is very sharp and clear in all its outlines. These features gain added force when we note that above the ridge where there is but a foot or two of soil over the rock bottom, the limestone and other rock material from the bluff tops is represented by only a few scattered fragments. There is but one agent which could have produced such results.

The occurrences referred to in my article, Peculiar Local Deposits on Bluffs Adjacent to the Mississippi, are referred not so much to glacial motion, as to the ability of bodies of ice, or compact snow to determine the lodgement of rock material which may fall on them from above, at places along the outer edge of the ice. The material being supposed to move across the ice - where the slope is steep - under the influence of gravity. In regard to those fronting the river however, I am at present inclined to the opinion that they resulted from a prolonged submergence, with the water level about three hundred feet above present river level.

How widely this type of glaciation may have prevailed is a matter of conjecture, rather than of observation. There are a great number of valleys along the river which present equally favorable conditions, and if I could study them with the same care I have bestowed on the Trempealean Bluffs I should expect to find numerous examples, but a merely curcory examination would reveal little.

The Monroe County Facies.

The features referred to this group show most conspicuously in the valley of the Lemonweir, with Tomah as a central point. In their general aspect they differ so conspicuously from those above described as to present a quite different set of problems. Following the plan adopted for this article I will indicate the nature of the supposed

glaciation before presenting the evidence.

The most important difference lies in the fact that, instead of glaciers a fraction of a mile in length, these appear to have reached several miles. And since, with such length, any slope of the upper surface sufficient to produce motion would have carried the centre above the tops of the bluffs, it must have had the aspect of a small snow field. That such a field could develop here, and not along the Mississippi would find its explanation in the greater altitude. Without attempting to give exact figures, which I do not possess, it may be said that there seems to be a difference of between two and three hundred feet between the altitude of similar geological horizons here, and on the Mississippi at LaCrosse. This difference would, of course, be insignificant save in a region where the general level lay quite near the snow line, but under such conditions might easily be ample. It is to be observed that these glaciers should not be classed with those of mountainous regions, even though they were confined to, and their courses determined by the valleys. They seem to have belonged to a class which is rather rare among existing glaciers, but may be conjectured to have been rather common in the incipient stages of continental glaciation.

Another very conspicuous difference is found in the character of the deposits which here are almost wholly residuals, most conspicuously chert, but with sand as the most abundant constituent. Unlike as this may be to the deposits of other glaciers, it in no wise conflicts with the rule that a glacier acts upon, and carries forward the materials encountered in its course.

The limestone (Lower Magnesian) which caps the bluffs is extraordinarily rich in chert, Besides the great number of nodules scattered through pretty much the whole thickness, there are solid beds several feet thick. Under such conditions it is a matter of course that

chert residuals occur in the valleys in corresponding abundance, and in all stages of deangulation. It follows also, that the massive beds of chert would form the outjutting ledges, and limestone the reentrant angles, so that, with probably only moderate erosive power it would be the chert, rather than the limestone which a glacier would pluck away, and at the most it would have been in contact with the limestone only a small fraction of a mile out of a course of several miles. For the balance of the distance the only rock , both on bottoms and sides of valleys was sandstone, which being soft, crushed easily, and was carried forward as sand. This, mixed with the residuals must have been the material, carried forward by glaciers, since there was no other.

I think that without sufficiently weighing the evidence geologists have been rather predisposed to consider these residual deposits as associated with the remnants of an old peneplain, similar to those reported from various localities in the Mississippi and Ohio Valleys; but although residuals no doubt do occur in the driftless region in such relations - I have myself met with some, - those under consideration are emphatically not of that class. Although they have a vertical range of over two hundred feet, if we reckon from the rock bottoms of the valleys and occur at all intermediate elevations, in all sorts of topographic relationships, there is not one which occurs primarily as the capping of a peneplain remnant. Those portions of the deposits which are open to observation, for a considerable proportion are buried under the one hundred feet or more of alluvial filling, are more characteristically associated with the hill sides. The outer limit of the deposits is very sharply marked wherever it is open to observation extending up and down the hills with as little regard for topography as the most typical glacial deposits; for example, there is a broad rounded hill S.W. from Tomah, having three

summits not far apart and separated by shallow depressions. The east side of this hill is deeply covered, the west quite free from the deposits. The border runs up the south slope, crosses the hill so as to cover two of the summits, but fails to reach the third, and then passes down the north side of the hill. From this hill the deposit passes under a swamp, and emerging a mile or so away rises for some distance along a gentle slope, and then ends abruptly in a front about as steep as a railroad embankment and about fifteen feet high, this being the thickness of the deposit as shown by a swell on the summit. The margin then rises onto a tabular hill several square miles in extent following at a variable distance back from the southern brow of the hill, but nowhere extending more than a small fraction of the distance across its level top. The southern slope is covered throughout its whole extent.

The most striking features occur on Bear Creek. Starting from thee point where the Tomah Oakdale road enters the valley, one may note the following features. On the west side there is a sharp reentrant angle in the valley wall, bounded by almost vertical cliffs. In this angle, piled against the walls is a considerable body of the deposits. On the opposite (east) side, a ridge appears near the top of hill, not very large, but distinct. As we descent the valley it drops to lower levels until it is near the bottom. A little farther down the east wall of the valley ends abruptly, leaving open country to the eastward, although the west wall extends a mile or two further down. From the point where the ending of the east wall removed the confinement on that side there is a heavy bounding ridge of the deposits. For a couple of miles this shows the rolling irregular contours characteristic of moraines, but further down it takes on the flat topped delta like form which it has where cut through by the Milwaukee road at Oakdale. Just at the point where the eastern wall fails, and the

deposits spread out, there is one of the most characteristic of glacial phenomena. A small short valley, itself too small to have contained a glacier, joins the main. Across this a ridge of deposits has been built forming a dam, complete save for the narrow notch cut by the drainage. I can hardly say more of it, than that every feature, and outline is about as distinct and sharply defined as it well could be.

The form, and distribution of the deposits constitute only a part of the evidence to be considered. As I have stated, aside from sand, chert is the most abundant and conspicuous component of the deposit- the proportions vary greatly in different deposits - but perifferous concretions are rather abundant in some of the deposits, and in the outmost ridge considerably exceed the chert in abundance. These are derived mostly from the lower sandstone horizons, and their only source, in any quantity, must have been the rock floors of the valleys. As all the visible deposits are far above these, we cannot escape the conclusion that they were elevated; but, this is scarcely true of the sand and the chert.

I may remark that the great volume of material found in these deposits required a correspondingly extensive source of supply.

I was not able to spend as much time in the heads of the valleys as elsewhere, consequently the erosive work of the glaciers was not as well studied as the other phases, but I encountered in one of the valleys a hill spur which was denuded of soil, scarped and rounded in a very striking manner.

There remains one other feature to mention. Between the two outmost deposits there is a depression now occupied by a peat bog, probably once a lake. The shores on either side are high and steep. It is clearly not an eroded basin, nor is there any assignable reason why, under normal sub-aerial conditions, such a basin should have escaped filling to the height of the country bounding it.

If, however, a glacier advancing at first far enough to form the outmost deposit, had later developed a fault plane along the line of the next inner deposit, (a natural result of the underlying rock contours) a portion of the front of the glacier would have been left as a stagnant mass. This, becoming covered with debris, would have melted slowly, and the final result would have been a depression.

La Crosse County.

The features here are associated with the high bluffs forming the divide between LaCrosse and Lewis' Valleys.

The apparent size of the glaciers, the longest about four miles, might indicate a small central snow field here, also, but this is not certain. As near as I can judge from imperfect data a glacier of that length, having a front one hundred and fifty feet high, and a rise of the upper surface of seventy-five feet to the mile would hardly have capped the higher bluffs. Here,also residuals are the most abundant and conspicuous component, though chert is much the less abundant than in Monroe County. The most conspicuous difference however, lies in the fact that these contain both limestone, and soft sandstone, in considerable abundance.

The largest glacier above referred to occupies the branch valley traversed by the Salem-Mindoro road, and which joins the main valley at Mindoro village. The village is in fact built on the deposits forming its terminal moraine. The morainic form is not however very distinct being cut away or buried far a considerable distance in the deeper portion of the valley. It has been built out into the main valley several hundred feet, producing a quite notable constriction. (The main valley I may remark, is bounded only by low hills on the north, and could not itself have contained a glacier.) If there are other transverse ridges in the valley, they are concealed. In the upper end of the valley residuals are rather rare, as though they had

been pretty thoroughly cleared out.

What appear to be results of glacial erosion are however well shown in the valley. The several spurs setting into it from either side have all been truncated, and present steep slopes fronting the valley, while spits of characteristic deposits extend down the valley from the lower angles of the truncated spurs. The real significance of these features is emphasized by the fact that similar spurs composed of the same rocks, projecting into the main valley show no trace of truncation, but slope off so gently that all are under cultivation. The little valleys which lie between the truncated spurs are also abnormally steep where they join the larger, these steeper slopes being alligned with the truncated fronts of the spurs, and the valley itself shows distinct modification toward the U form.

The other occurrances in Lewis' Valley are of subordinate importance. There are no other branch valleys of any size, and such deposits as may occur inthe smaller valleys are so generally covered as to be traced with difficulty. However, an interesting feature occurs some four miles down the main valley, a detached hill whose top and sides are heavily covered by the characteristic deposits, residuals, lemestone, and soft sandstone. It also contains a number of sandstone concretions, some of considerable size, whose horizon of occurrence is lower than the top of the hill, so that here also we have clear proof of the raising of material from lower to higher levels.

It is not probable that similar centres of local glaciation will be found elsewhere in the driftless region, for the reason that conditions are nowhere else quite as favorable. Both in Monroe and in LaCrosse Counties the occurrances are associated with the extreme northern limits of theLower Magnesian Limestone, and, taking account of the dip, this means a somewhat greater altitude. (The greater depth of the valley fillings, and the less gradients of the valleys in this belt

belt as compared with those in the lead region seem to indicate a little down warping along this belt, indicating that the elevation was then greater than now, but even more important than the greater elevation was the greater depth and steeper sides of the valleys.

While it is my belief that wind drift accumulation would have been quite general throughout the inland valleys, it is not probable that many of them would have offered conditions favorable for glaciation.

Crystalines.

Local glaciers would of course have no power to collect other material than that which lay in their paths; but if some other agent before the development of the local glaciers had distributed extra local material so that any of it lay in their paths they would naturally have carried it forward with the rest; but, if anything of the sort happened, the evidence is not yet forthcoming. At Trempealean, the only crystalines that I have found in place, aside from the river gravel, were all contained in a lenticular deposit ten or twelve feet in diameter and about three feet thick, apparently an iceberg deposit.

I think the evidence is conclusive that the region has not been overspread by a continental glacier since the various deposits now occupying the valleys were laid down, but what may have happened before that time is less certain.

I was told by a well digger at Tomah that in a well near Valley Junction he found crystaline gravel at the bottom, one hundred feet down, not, however, in any great quantity. This might have been glacial, but it is quite as likely that it marks a point where the stream had cut through to the Pre-Cambrian. Valley Junction lies north of the limits of local glaciation, but, if a continental glacier had extended as far south as Tomah, for instance, leaving deposits, we should expect to find traces of them in some of the outer ridges, also on some of

the peneplained uplands N. of Tomah. Search has not yet been sufficiently thorough to determine whether such is the case or not.

That one of the earlier continental glaciers may have extended further south than the limits heretofore assigned is quite probable. I think I wrote to you a couple of years ago regarding the deposits of crystalines in Trempealeau Valley. The occurrences lie in a belt at least nine miles long, - perhaps longer, my route above Taylor was on the opposite side of the river -. The deposit has undergone mature erosion, and originally, if not quite continuous, was at least much more nearly so than now. The remnants indicate a width of something like a mile; and a well thirty feet deep on one, did not reach the bottom. It was therefore, a heavy deposit, fairly comparable to some of the medium sized moraines about Neilsville. The three most abundant components are crystalines, sand, and the harder residuals from the sandstone,

Fair exposures are obtained in two places where cement block factories are using the material. As seen in these openings the crystalines range from six or seven inches downward. As compared with other outwash valley deposits in the Black, Beef, Chippewa or Mississippi valleys, it is extremely coarse though there were none exposed that would be classed as boulders. The sand is very abundant - whence its value for cement work.

The largest fragments were, however, the sandstone residuals, mostly concutionary masses. Some of those seen in the exposures approached two feet in diameter, and probably much larger ones might be found. As these naturally lie about on the surface, as left by the decay of the enclosing rock their intimate mixture with other materials, in deposits thirty feet or more thick is a circumstance not easy to explain if these are the remains of an outwash valley deposit. Under such conditions they should rather have been buried while it would have

been a natural and necessary result of direct glacial action.

Concerning the occurrence on Beef River S.E. of Mondovi, I can only say that there is a ridge of pronounced morainic form and of considerable, but undetermined length, and that it contains crystaline gravel. The total lack of excavation or other means of getting below the grassy surface made the gaining of further information impossible in the time at my disposal. I may add, that when I made these discoveries I was doing archaeological work for the state, and the geological work was only incidental. I could not vary my route in order to search for features which might serve to explain or connect these accidental discoveries.

I have myself been much interested in the thin, but wide spread deposits found on the uplands on either side of the Mississippi; and have long recognized the problem they present as a perplexing one. I should hardly venture to discuss it had not my own line of study brought it strongly to my attention, for the reason, that, if the deposits are glacial, and the explanations advanced to account for their unusual character are accepted, it involved certain corollories, as to the conditions in the immediate valley of the Mississippi, as well as in the innumerable branch valleys bordering it. If a glacier crossed this valley from either direction it must have not only produced notable erosive effects on both sides, but also heavy deposits, especially in many of the branch valleys which lie transverse to its course. Considering also that the main valley presented a trough five to six hundred feet deep, it would almost certainly have deflected enough of the glacial flow to produce a notable valley glacier, which should have left many evidences of its existance. The argument is, of course, that all these erosive and depositional effects have been removed in the long subsequent periods. What this really means may be understood

when I say that there are now in the various small valleys among the Trempealean Bluffs, deposits aggregating eighty to one hundred feet in thickness, of alternating material, coarse and fine, stratified and unstratified, representing at least two periods of submergence reaching limits three hundred feet or more above present river level, also an intervening period of elevation and erosion, the whole representing a long period of time. But, if there were ever any extensive deposits of crystalines, they not only antedated this series, but so far antedated it, that the deposits were practically all cleared out before the present series was begun. But, if such a thing could happen in relatively deep and mature valleys, how does it happen that the deposits are preserved in steep ravines, where the torrent courses are on the rock, or in numerous other localities from whence under the supposed conditions they should have been long since removed. In fact, the deposit exists under conditions which seem to me altogether inconsistent with the assumed great antiquity.

Such being the case, I have been led to question whether there might not be some other possible explanation, and it seems to me that there is. I have mentioned the fact that there have been at least two periods of submergence reaching at least three hundred feet above the river, but there is evidence of a still deeper submergence.

Our Trempealean Bluffs bear every evidence of having existed for some time as bare rocks. The Loess now covering them is not the product of rock decomposition in place, it rests on a thoroughly fresh, surface, showing an entire lack of partly decomposed material. Even the residuals have been removed, save in reentrant angles, and the crevices so cleaned out that only Loess similar to that onthe top is now to be seen in them. Such a state of affairs could hardly have come about under ordinary subaerial conditions. If, however, standing as islands in a considerable body of water they were subjected to wave

action, it would have been q quite natural result. Similar conditions, though not quite as pronounced are rather general on the bluffs fronting the river so far as I have been able to visit them. The other eivdences on which we usually rely to prove the existance of lakes, beaches, and other shore phenomena are rather evanescent and it is to be noted that about all that have been described belong to the last period of glaciation, but it would seem to be rather a gratuitous assumption to regard lakes as confined to that period.

If there had been a submergence sufficient to overtop the bluffs, even if to no great depth, it would have permitted a somewhat wide distribution of floes and small bergs, and the transported material would naturally have taken the form of the thin, but uniform deposit which we find. That this hypothesis encounters difficulties I freely admit, but it seems that they are hardly as serious as those besetting the glacial hypothesis.