NEWBERRY ON THE OHIO DRIFT

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This is a study of one aspect of scientific method, of error in science. Science is a growth, a series of approximations; as it advances some old views are discarded, new views introduced. The discarded views are seen in the light of fuller knowledge to be in error. Inadequate approximations would be a better characterization; they were the best formulation the earlier science could make. To use the word error is not to condemn; it is merely to acknowledge that advance has since been made.

The theories of an individual geologist, for example, are conditioned by the state of the science at the time, by opportunities for and skill in field observation and laboratory practice, even by personal bias and idiosyncracies. This makes the study of the history of science interesting. It is not merely that at a certain date a geologist held certain views; it is "how he got that way."

An interesting example of views held mid-course in the developing science of glacial geology is Newberry's[1] account of the glacial drift of Ohio. This was followed three years later by a second report which marks a distinct advance.[2] We deal here primarily with the first account.

Newberry was one of the ablest geologists of his day. He had wide experience in the field, and was well acquainted with geological literature and with contemporary geologists. His work in glacial geology was done in the Lake Erie region, his home in youth, to which he returned for detailed field study when head of the Geological Survey of Ohio. Two things should be said: one, that Newberry's primary interest was not glacial geology but stratigraphy and paleontology, and the other, that the Lake Erie region is one of great complexity, so far as its glacial history is concerned.

In 1870 glacial geology was little more than thirty years old. In 1837 Agassiz had outlined the whole subject of Alpine glaciation in masterly fashion. He had gone on in the years following to plaster immense ice sheets, far greater than we now know ever existed, over Europe and America. This was an advance in theory which most geologists found it difficult to follow. Previous to Agassiz geologists had explained the general lowland drift of Europe and America as deposited by icebergs during a period of continental subsidence. Lyell still held to the iceberg hypothesis at the time Newberry was writing. In considering the thinking of any geologist in 1870 it is necessary to keep in mind the prevalence of the iceberg hypothesis at that time, and also that when glacier work was in question it was valley glaciers of the Alpine type which was in mind. Further, almost no attention was then given to the composition of the glacial deposits themselves.

GLACIAL HISTORY OF OHIO

A brief summary of the glacial history of Ohio as worked out by Leverett[3]

[1]Newberry, J. S. Geological Survey of Ohio, Part I. Report of Progress in 1869, pp. 24–33. 1871.

[2]Newberry, J. S. Geological Survey of Ohio, Vol. II, Part I. Geology, pp. 1–80, 1874.

[3]Leverett. Glacial Formations and Drainage Features of the Erie and Ohio Basins. U. S. Geol. Survey, Monograph 41. 1902.

H. P. Cushing, Frank Leverett and Frank VanHorn. Geology and Mineral Resources of the Cleveland District, Ohio. U. S. Geol. Survey Bull. 818. 1931.

and others will give the necessary background for an understanding of Newberry's history of the same region. The history at present accepted is as follows:

1. An earlier ice-sheet and drift, the Illinoian.
2. An interglacial ice-free period.
3. A later ice-sheet and drift, the Wisconsin.

Both sheets crossed the present St. Lawrence-Ohio divide, and covered large parts of Ohio. The Wisconsin glacier did not extend as far south as the Illinoian, so that a belt of older drift borders the Wisconsin drift in central and southern Ohio. The older Illinoian drift is found in places under the Wisconsin drift, sometimes separated from it by a soil or forest layer; but in most places the Wisconsin ice swept away the earlier drift. This separation of the Pleistocene into two and later more periods was not made until after Newberry's work.

4. After the Wisconsin glacier had withdrawn north of the divide, a series of temporary ice-dammed lakes formed between the glacier and the divide. The story of this period is long and involved. Retreats and advances of the ice opened different outlets across the divide, and the lake levels changed with these shifting outlets. Land uplift to the northeast, the center of ice accumulation, complicated matters still more. In these lakes laminated clays were laid down; about their borders beaches, bars and cliffs were formed; and over the bottoms which were bared as the levels dropped, sands were washed from the adjacent lands. This sketch makes no provision for any water bodies in the region caused by subsidence.

NEWBERRY'S SUMMARY

Newberry's history[4] may be summarized as follows:

I. Ice-period; 1–3 (of Newberry's account).

A period of high land and cold climate with the development of "glaciers which flowed by various routes to the sea."

II. Water period.

4. A water period in which the continent stood 500 feet or more below its present level, and the glacier was replaced in the basin of the Great Lakes by an inland sea of fresh water. In this sea "were deposited the fine, laminated clays (Erie clays) which cover so much of the glacial surface in the interior of the continent."

5. Deposition on the Erie clays of sand, gravel and boulders floated by icebergs from the glaciers of the north.

6. Silting up of the old preglacial valleys.

III. Period of continental emergence.

7. Clearing out of old channels.

8. Periods of repose during elevation, permitting river terracing and the formation of shore features at lower and lower levels above the present lake surface.

9. Redistribution by waves and streams of material over surfaces newly exposed by recession of the sea.

For 1870 this is a remarkably skillful presentation of glacial history, especially when we recall that it has taken scores of workers through seven succeeding decades to bring our knowledge to its present state, and that a lot yet remains to be known. Good as it is, it contains errors, our interest in which lies in knowing how they came to be.

THE GLACIERS

Newberry's first period is one of high land level, during which glaciers formed, and "following the direction of the great lines of drainage" flowed to the sea.

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[4]Loc. cit., pp. 28–33. 1871.

Newberry speaks of glaciers, not *the* glacier. In 1870 it was still the Alpine type of valley glaciation that dominated the thinking of the geologist. Little was known of the Greenland glacier, and no clear appreciation of the immense ice sheets of the Pleistocene had yet been reached. More remarkable is his statement, "the direction of the glacial furrows proves that one of these ice rivers flowed from Lake Huron along the channel now filled with drift . . . into Lake Erie . . . following the line of the major axis of Lake Erie to near its eastern extremity; here turning northeast this glacier passed through some channel on the Canadian side, now filled up, into Lake Ontario, and thence found its way to the sea, either by the St. Lawrence or by the Mohawk and Hudson." The glacial furrows do in general parallel the axes of the Great Lake basins, for these troughs were pre-glacial valleys which locally directed the flow of the ice sheet. But Newberry has the direction reversed for Erie and Ontario! It is easy to see how a preconception in favor of the Alpine valley type of glaciation was carried over into the quite different topography of the broad lowlands of the Great Lakes region. But the direction of flow? One would suppose that a careful study of the glaciated surfaces must have shown that the direction of flow in each basin was to the southwest and not to the northeast. That study was not made, the glaciers had to get to the sea, and theory controlled.

Both of these mistakes Newberry soon corrected.[5] By 1874 he had concluded that at the time of maximum glaciation "a great ice-sheet was formed." "Local glaciers" in the valleys were limited to the beginning and closing stages of glaciation. (This holding to valley glaciers is less surprising when we see how the lobes of the Wisconsin ice sheet pushed forward in the larger river basins.) The ice was seen to flow southwest through Ontario and Erie, and the frontispiece of the 1874 report is a beautifully engraved plate, showing the curving grooves about chert concretions on the glaciated limestone surface which definitely fix the direction of the ice motion.

POSTGLACIAL SUBSIDENCE

Newberry's period of land elevation and glaciers is followed by a period of submergence, a "water period when the continent was depressed 500 or more feet below its present level . . . when glaciers retreated northward and were gradually replaced, in the basin of the Great Lakes, by an inland sea of fresh water." Newberry probably considered this water body to be at sea level. Lake Erie is 573 feet above sea level, and a depression of 500 feet or more might bring the region to direct communication with the ocean. In the 1874 report[6] subsidence permitted the northward extension of the Gulf of Mexico until it "reached and covered all the lower portion of our State." This was clearly overdoing the subsidence, for which there is no evidence. Not wholly unreasonably, for there was clear evidence of postglacial lower land levels in the upper Hudson and St. Lawrence valleys, and there was a lot of lake water in the Erie basin. The hypothesis of water origin of the drift should have suggested search for independent evidence of a marine water body in the character of the drift, in marine fossils, in shore lines. That it did not was due to the uncritical acceptance of the current theory of drift origin.

ERIE CLAYS AND GLACIAL TILL

Let us recall that there were ice barrier lakes north of the St. Lawrence-Ohio divide. Within their former area are found laminated lake clays. South from the highest lake beach to the divide and beyond to the southern limit of the drift, the characteristic surface deposit is an unstratified boulder clay or till of direct ice deposition.

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[5]Geological Survey of Ohio, Geology II, pp. 77–80. 1874.

[6]Loc. cit., pp. 7, 79.

Now Newberry's most serious error was his failure to recognize the boulder clay as ice laid and his inclusion of it and the lake clays in one unit (the Erie clays of Sir Wm. Logan), regarding them as deposits in an inland sea. He describes the Erie clays as "generally regularly stratified in thin layers and containing no fossils but drifted coniferous wood and leaves. Over the southern and eastern part of the lake basin these clays contain almost no boulders, but toward the north and west they include scattered stones, often of large size, while in places beds of boulders and gravel are found resting directly upon the glacial surface. They reach up the hillsides more than 200 feet above the present surface of Lake Erie." In Cuyahoga County[7] he reports them to 500 feet above Lake Erie (more than 200 feet above the highest lake ridge). Where the clays are cut by the tunnel to the water crib "occasionally are found in the clay . . . rounded, striated boulders, two, three and four inches in diameter." Clearly Newberry includes in his water laid Erie clays typical glacial till, and carries them far higher than and well south of the margin of the former glacial lakes, indeed so far as to include all the glacial drift of the state.

There are several reasons for this error. Faulty or inadequate observation, which includes a lack of appreciation of the physical make-up of the deposits themselves, is the basal reason. Scattered rounded and striated boulders embedded in unstratified clay does not look like water deposition. Perhaps with the still lingering iceberg hypothesis in mind it was easy to explain the boulders as carried by floating ice. Further, the presence of occasional layers of sand and gravel at all levels in the till may have been misleading. Nor was it always easy in the field to separate till from the overlying lacustrine deposits. The marine laminated clays, Champlain clays, laid down in the Hudson-Champlain and St. Lawrence valleys during the lower land levels of the early post-glacial period, were considered identical with the Erie clays by Newberry. The upshot was that a water laid origin which was good for the lacustrine clays was carried over to the till; and confusion was the result.

ICEBERG TRANSPORT OF GLACIAL ERRATICS

Newberry states that "upon the stratified clays, sand and gravel (i. e., his Erie clays) of the drift deposits are scattered blocks of all sizes, of granite, greenstone (diorite and dolerite), siliceous and mica slates, generally traceable to some locality in the Eozoic area north of the lakes. . . . Most of the stones are rounded by attrition. . . . That these materials were not carried by currents of water or glaciers is certain; as either of these transporting agents would have torn up the Erie clays, which now form an unbroken sheet beneath them. We are therefore forced to the conclusion that they were floated to their resting places, and that by icebergs."

Presumably this statement applies to all the erratics of the glacial area, both within the area of the former lakes and beyond to the southern limit of the drift. It fails to explain the boulders buried in the drift. It indicates lack of careful field study of the erratics, and it requires a standing water body over the whole of the drift area of Ohio. The subsidence-iceberg hypothesis still biased Newberry's thinking.

NEWBERRY'S LATER VIEWS

Newberry's second 1874 report is a distinct advance on the earlier one. He recognizes the presence of a continental ice sheet; the only influence of the valley glacial notion is his retention of valley glaciers in the closing stages of glaciation. The direction of ice motion in the Erie and Ohio basins is corrected.

[7]Newberry, J. S. Geological Survey of Ohio, Vol. I, Part I. Geology, 1873, p. 175.

A main advance is in the clear recognition of ice barrier lakes, instead of pauses in land uplift as explaining the succession of lake ridges.

Little advance, however, is shown in the understanding of the drift. He states that much of the drift or boulder clay was the direct marginal or submarginal deposit of the glacier in its northward retreat, but still lumps till and laminated lake clays in one "Erie clays," and gives the whole a water origin. He still holds to the transport of the erratics by icebergs. There is no real understanding of the till or of the relation of the boulders to the till.

The above discussion is not to be taken as in any sense a disparagement of Newberry's work; but rather as a study of the way in which geological science is advanced by the individual worker. He builds on the work of his predecessors, sometimes on their errors. By his own field work and thought he corrects some of these errors and adds new material. He, like them, is subject to the human chance of error in observation and reasoning, against which no one is immune. His published results bring the matter out into the open for discussion and criticism by fellow workers. His errors can be challenged by other facts unknown to him. His statements may suggest other studies, which may or may not corroborate his views. And so science advances by a process of trial and error, ever working toward a more truthful generalization. In all this Newberry ran true to form. More than many he corrected his own mistakes.