

## GLACIAL GEOLOGY OF OHIO IN 1874—THE END OF AN ERA<sup>1, 2</sup>

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*Abstract.* The Second Geological Survey of Ohio in 1869–73 produced more or less detailed reports and maps of the 88 counties of which 83 were published in 1873, 1874 and 1878. Each report included a shorter or longer section on "Surface Geology," all organized in a similar fashion, as directed by J. S. Newberry, State Geologist. In 1874 Newberry summarized, in an 80-page essay, the knowledge of glacial deposits in Ohio and the current theories of their origin. The synthesis was developed from his own work and that of M. C. Read in northern and northeastern Ohio, G. K. Gilbert and N. H. Winchell in northwestern Ohio, and Edward Orton in southwestern Ohio. It was recognized that the "boulder clay" was an ice sheet deposit. It was believed that erratics were concentrated on the surface and had been transported by icebergs in an inland lake, which was later drained. An extensive "Forest Bed" recorded a period of warmer climate, named by Orton an "Interglacial Period", the first use of this term. The detailed descriptions, maps and sections are valuable records of the observations of these outstanding geologists as are the explanations they proposed for the Quaternary history of Ohio.

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Although glacial features and deposits have been observed in Ohio for more than 200 years, the earliest scientific observations were by C. F. Volney, who published in 1803 a diagram of outwash deposits in Cincinnati. He recognized the sediments as stream deposits, but did not associate them with glacial melt-water (White, 1973). Observations of till and erratics by Drake in 1815, followed by reports of other workers who recognized widespread polishing, striation, and grooving of rock surfaces were initially attributed to the action of icebergs in an inland sea, but later related to ice sheets (Leverett, 1902, p. 24–29; White, 1973). The theory of glaciation by an ice sheet proposed by Agassiz in 1840 was embraced in the United States by Hitchcock in 1841, and was widely accepted in Ohio by 1851, as shown by the extensive treatment of ice-sheet glaciation in the

geological textbook of Samuel St. John, published at Hudson, Ohio (White, 1967).

The first Geological Survey of Ohio (the "Mather Survey") was established in 1839 and discontinued in 1841. This left Ohio without a survey until the Second Survey (the "Newberry Survey") was established in 1869. The extensive publications of the Second Survey provided an unparalleled exhibit of the knowledge of the time regarding the origin and effects of glacial deposits throughout Ohio.

The publications of the Newberry Survey deserve attention because they mark the end of an era in glacial studies. Immediately after their appearance, new concepts based on moraine studies led to views of much greater complexity and provided a broader framework for understanding the origin of glacial deposits. Leverett's great monograph (1902) marked the height of the "new dispensation," which is still congenial to glacial geologists 75 years later. This new framework is not the subject of this paper, as it has been partly explored elsewhere (White, 1973, p. 13–16, 18–20).

In the Second Survey, the State was divided into four districts, and the reports for 83 of the 88 counties were pre-

<sup>1</sup>Manuscript received May 30, 1975 (#75–37).

<sup>2</sup>In 1926, George White published his first paper in The Ohio Journal of Science, "The Limestone Caves and Caverns of Ohio," Ohio J. Sci. 26(2): 73–116. Dr. White asked us to hold the paper for publication until the March 1976 issue so that we could celebrate his 50th year of contributions to the Science of Geology together. We extend our heartiest congratulations to Dr. White.

pared by 1873. For some reason, Adams, Scioto, Lawrence, Jackson, and Vinton Counties, all unglaciated, were not published. The State Geologist, Dr. J. S. Newberry, a distinguished physician, explorer, paleontologist, and stratigrapher, issued to all his assistants elaborate and detailed "directions for observing and collecting." He directed them to collect information on surface geology—"special materials (clay, sand, gravel and so forth)." He instructed them to record whether these materials were of local or foreign origin, note if they were stratified, and tell their thicknesses and what fossils were present. Was the bedrock surface planed, scratched, or furrowed, and in what direction? What was the composition, extent, and altitude of terraces and lake ridges? What was the extent of peat bogs and marl beds, determined by boring? Were there fossils of elephant, mastodon, or other animals? What was the depth to rock, including that in valleys? (Newberry, 1870, p. 11).

These detailed instructions were taken seriously by all the geologists. The various county reports follow the same general pattern, and all of them include descriptions, some of them very extensive, of the surface geology. The detailed sections and diagrams continue to be useful today. The county reports, all of which seem to have been written by 1873, were published in three volumes in 1873, 1874, and 1878. Those for the northeastern counties were prepared by Newberry and M. C. Read; those for the northwestern counties by G. K. Gilbert and N. H. Winchell; for the southwest by Edward Orton, and for the southeast (mostly unglaciated) by E. B. Andrews. Several counties were reported on by others (see "Contents" for each volume). The staff was notably able and four of the men had already, or were about to achieve, national eminence and were to become members of the prestigious National Academy of Science.

#### NEWBERRY'S "FACTS"

A summary and synthesis of the county reports was prepared by Newberry (1874). He noted that "Drift deposits" cover so much of Ohio that "the Qua-

ternary system deserves . . . as full and thorough an exposition as our . . . space will permit." He had before him the reports of his staff for all the counties of the state, and from these and his own extensive observations, he was able to synthesize the great mass of data, and to relate the Ohio material to what he and others knew of other parts of the Continent.

Newberry summarized the "important facts" in straightforward statements of observations in the first four pages of his essay. In the next four pages, he set forth the "history deduced from facts cited." He then devoted 70 pages to a detailed consideration of all the "facts" he had listed earlier. He included many maps and sections, mainly using those already published in the various county reports by himself and others, but without giving exact citations to their first appearance. These "facts" and "history" will be discussed in the order in which Newberry listed them.

1. *Ice had ground down the surface "as low as the fortieth parallel of latitude . . . The track of a glacier is as unmistakable as that of a man or a bear." The scratches are generally north-south, but locally conform "in a rude way to the present topography." His map of the "Drift Area" is the best depiction to that time of the glacial boundary from New Jersey to Kansas (White, 1973, p. 12, Fig. 4).*

2. *Some of the valleys have been excavated during the "ice period, or an earlier epoch" far below the present lakes and stream levels.*

3. *"Boulder clay," a tough, blue, unstratified clay, with stones, lies upon the striated bedrock.*

4. *At certain places the boulder clay is overlain by fine laminated clay without pebbles, the "Saugeen clay." This is the upper part of the "Erie clay" of William Logan: the lower part of the Erie clay is the boulder clay: both are "parts of one formation."*

5. *Over the surface of the boulder clay is found "over a large area in Ohio and other Western States, a layer of carbonaceous matter, with logs, stumps, and sometimes upright trees . . . the Forest Bed, . . . apparently an ancient soil . . . on the area previously occupied by the ice-sheets." In places in "southern Ohio this horizon is marked by deposits of peat now deeply buried under the later-formed deposits of the Drift". This sometimes contains mastodon and other bones.*

6. *"Above the old soil . . . we find a series of stratified deposits . . . evidently the product of a 'submergence'." These are "sometimes of considerable thickness." In southern Ohio, there are at places "white clays . . . containing boulders." In west-*

ern Ohio and farther west occurs the "Loess or Bluff formation," which is called the "Lacustrine Drift."

7. Boulders of northern rocks may be very large and mark the margin "of the great ice-sheet . . . but most of the boulders . . . appear to have been deposited by another agency, at a much later date . . . they must have floated to their present resting places. The evidence is conclusive that they were transported by icebergs, and hence I have called these the 'Iceberg Drift'."

8. The "hills, ridges, and banks of well rounded gravel and sand, with some boulders . . . correspond closely with the 'Kames' and 'Eskers' of the Old-World Drift. These peculiar accumulations of drifted material were evidently produced by special and local causes . . ."

9. Most recent of the features are the "Lake Ridges" from 100 to 250 feet above the present level of Lake Erie.

### NEWBERRY'S GLACIAL HISTORY

Based on the "facts" he had enumerated, Newberry divided the history of the "Quaternary or Glacial Epoch" into several divisions, which he listed in order as:

1. Period of Arctic climate, formation of glaciers, first local, then general, to cover the whole area, then again local in the waning stage.

2. The movements of the ice were governed by topography and basins and certain valleys were excavated to great depths to form the Great Lakes basins.

3. The continent stood "several hundred feet higher than now," and deep valleys were excavated.

4. A period of glacier retreat was followed by a "water period," and by subsidence, and as ice "retreated northward it thrust out and left behind it a succession of heaps of boulder clay, which now form a nearly continuous sheet over the glaciated surface."

5. "When the retreating ice-sheet had passed the great watershed of Ohio, basins of water began to form along its margin, and in these . . . were deposited laminated clays . . . (to) form the upper subdivision of the Erie clay." This is "usually stratified in thin leaves . . . and contains no boulders." [By "great watershed" Newberry meant the highland extending east-west across

Columbiana, Stark, Holmes, Ashland and Richland counties, which was indeed a very early divide through which the streams mentioned later by Newberry do flow southward.]

6. After the retreat of the ice, forests grew, for perhaps thousands of years, to form the "Forest Bed."

7. Submergence of the land so that the Gulf of Mexico extended to cover all of the lower half of our State. At that time, "the clays, sand, and gravel overlying the peat beds in southern Ohio, the lacustrine clays of northern Ohio, and finally the loess of the Mississippi Valley were deposited. These filled and obliterated many of the valleys of the Forest Bed era, as the Erie clay had done those of pre-glacial date." The Erie clay included both boulder clay and the lacustrine clay of the Erie basin and of southeastern Ohio.

8. During the submergence, icebergs floated from the north and in melting, erratics were "scattered broadcast over all the submerged area."

9. "In this last submergence, portions of the highlands . . . were low islands and shallows, exposed to the full action of shore waves . . . the drift accumulations were assorted . . . and many of the gravel hills and sand banks (kames) of the summit of the watershed produced."

10. "With the subsidence of the waters . . . lines of drainage were established in the gaps of the watershed . . . through these . . . strong currents of water poured," and vast quantities of gravel deposited in the "great drainage lines" of the Wabash, Miami, Scioto, Muskingum, and the Beaver.

11. "The retirement of the sea at the close of the Drift period took place very gradually, with intervals of rest." The terraces in valleys were formed in this "Terrace epoch, the last chapter in the Drift history."

12. The Ohio Valley was emptied, but the lake basin was still filled with water. Various outlets opened at various places "by the

cutting away of barriers, or the warping of the earth's crust." The stationary intervals are marked by wave cut terraces or by "lake-ridges."

Newberry was not certain if there had been a return of the glaciers, "although in southern Ohio, the sheet of pebbly clay which overlies the Forest Bed seems to indicate a return in that region of something like the conditions in which the first boulder clay was deposited." (Newberry, 1874, p. 8).

Newberry regarded the history of the Great Lakes important enough to deserve a final section in his "History" which he listed as:

1. Wearing down of high land to the north in Canada.

2. Establishment of drainage lines in valleys.

3. The major drainage lines were to determine the location of the present lakes.

4. Local glaciers began excavation of the basin.

5. The Great Ice Sheet continued its erosion, and eroded the southern margin, spilling over and cutting the Finger Lakes in New York and deepening some north-south valleys in Ohio, such as the Grand River lowland.

6. Rise in temperature caused dissipation of the ice sheet and the return of local glaciers, which continued some further basin erosion. [Rise in temperature caused dissipation of the ice sheet and led to localization of glacial activity, which continued some further erosion within the basins.]

7. Melting of the glacier, sinking of the continent and flooding of the Atlantic Ocean to Lake Champlain, Hudson Valley and probably through the Mohawk and Lake Erie to the Mississippi.

8. Elevation of the continent and draining of the inland sea. The elevation was irregular and several outlets operated at different times through the Mohawk, later through the Niagara and St. Lawrence and through the Wabash to the Missis-

sippi and other trunk river systems; irregularity of ice may also have contributed to uncovering new outlets.

## DISCUSSION

From Newberry's essay and from the detailed county reports we can determine what the Ohio geologists thought about the glacial deposits and their origin and attempt to find out why they thought as they did in 1874. It is significant that they recognized the "boulder clay" as an ice deposit, made during ice retreat. This was a significant change from earlier explanations of its deposition by water. Here and elsewhere, Newberry stressed the topographic control of direction of ice advance. This is almost the final statement on the "Water Period," in which erratic-bearing icebergs floated in a large body of water and in which the upper part of the Erie clay was deposited. It should be noted that soon after his essay appeared, Newberry (1884) gave up this idea and asserted that the erratics were deposited by an ice sheet.

The idea of an inland body of water in the United States and in North America goes back at least to 1750 and was a firm belief of Volney, Mitchill, Maclure, and Drake. Until about 1830, the flat-lying bedrock strata west of the Allegheny Mountains were believed to have been deposited in this lake, and by implication, the "Drift" was the last deposit in the inland body of water. Thus a mechanism for floating icebergs carrying erratics was at hand. The idea of an inland body of water was as firmly fixed in the minds of these workers as the idea of permanent continents and ocean basins was fixed in the minds of all geologists until only a very few years ago. It should be noted, however, that soon after 1830, it was recognized that the sedimentary bedrock was not a deposit in the inland body of water, but was a series of marine deposits belonging to the Paleozoic Era separated by unconformities and thus separated in time and very much older than the "Drift Epoch." A continuous "Primal Lake" was no longer accepted, but Newberry and his associates could see the lacustrine deposits of a higher Lake Erie as a confirmation of the accepted idea of a

Quaternary inland lake, and then could interpret the clayey tills with not very many pebbles as also a lacustrine deposit. If observations indicated that the erratics were generally concentrated on the surface, this would be a further confirmation of the presence of the lake in which icebergs carried erratics across the surface of the lake. Erratics are indeed concentrated on the surface in belts in western Ohio. At the present day, the puzzling presence of erratics far beyond the accepted glacial boundary in Kentucky (Leverett, 1929) is explained by some as floated by icebergs in a lake, which existed in the Ohio Valley.

In northwestern Ohio, Gilbert had determined that the shore of the highest early lake (highest Maumee) was 85 miles southwest of the present shore of Lake Erie, and to the east Newberry saw that the silts and clays of the earliest lake stages extended from 5 to 15 miles south of the present lake shore. Both noted that the lake clays overlie till. South of the upper limit of the highest lake, the Hiram Till and its correlatives are very clayey, contain few pebbles and are easily confused with lacustrine silty clay. This clayey till extends as much as 40 miles south of the highest Maumee shoreline. The concept of a "Water Period" was fully justified on the basis of the facts available in 1873, and indeed it may be necessary to revive it in a modified form a century later, for over considerable areas in Ashtabula, Trumbull, Mahoning, northwestern Columbiana, and northeastern Stark Counties, the Hiram Till does have lacustrine components, where ponding occurred during and after the ice retreat. Beyond the glacial boundary in southeastern Ohio, widespread silts of lacustrine origin indicate an early Pleistocene lake of considerable extent (Lessig, 1963; Lessig *et al.*, 1968; White and Totten, in press). The presence of shallow ponds as well as more extensive bodies of water, is again being proposed to explain some of the latest glacial deposits in the Allegheny Plateau in Ohio. Studies in Canada now indicate that over tens of thousands of square miles of deposits were formed in shallow bodies of water upon the waning ice or in front of it to form irregular thin

units of reworked secondary materials (Moran, 1969).

The presence of southward-flowing streams in narrow valleys cutting across the ancient divide that extends westward from Columbiana County indicates stream diversions. For each of them, a lake is indeed required to persist until an outlet could be cut across the lowest point in this divide. Newberry believed in a large lake with several outlets, perhaps successive ones, whereas our present-day view is that a number of separate lakes were held in between retreating ice and the high divide.

The lacustrine origin of the loess and of the white clays in southern Ohio was a generally held one at the time and even later. It was not until several decades later that it was generally accepted that the loess was an eolian deposit, and even today it does appear that parts of the loess may have been deposited in local pools and puddles.

The description of the "Forest Bed" in many of the counties is valuable today, as it provides the most extensive information about this unit (which might actually be several units), which Orton (White, 1973) was the first to recognize as indicating an "Interglacial Period."

The final exposition of the theories that had been forming for over 60 years, from Drake to Newberry, carried in itself some of the bases for the next level of glacial theory that was to develop so rapidly after 1874. Gilbert (1873, p. 540-544) and Winchell (1873; 1874) had been the first in the United States to recognize, name, and suggest an origin for the end moraines—those of northwestern Ohio. Winchell had suggested that gravel knolls (kames) in the moraines had been formed by meltwater streams on, in, or at the edge of glacial ice. Newberry barely mentioned the moraines in his summary report, and did not even mention the Winchell explanation of origin of kames. The recognition of the importance of these features was to come very soon, but these were not really a part of the "glacial model" of Newberry in 1874. It was the "new glacial geology" that was to be based on mapping and description of end moraines and upon the deciphering of the history they

revealed of repeated ice advances and retreats, with shorter or longer periods of climatic amelioration and weathering episodes between the advances.

### CONCLUSION

The work of the geologists of the Second Geological Survey of Ohio must be judged on the basis of what data were available to them, what kind of base maps they had on which to record their observations, and what framework or model ("paradigm") they found or constructed to explain these features and their origin. These men were not in error, nor were they mistaken in terms of the science in 1873 (Westgate, 1942). Indeed, they were in the forefront of the science of their time and their contributions led directly to the further development of glacial geology, which in the next 25 years culminated in the work of Leverett and his associates. To criticize rather than to praise them is to criticize them for not having topographic maps, C<sup>14</sup> analyses, X-ray devices for mineralogical determination, coring devices, and a whole host of techniques available a hundred years later. Such criticism is called presentism by a technical historian, and geologists with historical interests are well advised to judge the work of another time in terms of that time, and not in terms of the present. On this basis, Newberry and his associates must be given high marks for their keen observations and respectable theories.

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