

THE GLACIAL BOUNDARY IN INDIANA.

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This paper is chiefly a review of the work done on the determination of the Illinoian glacial boundary and the character of the drift border in Indiana. The paper comes as a result of some recent observations on the drift border in Brown and Jackson counties, Indiana, where the boundary line is somewhat indefinite.

Previous to 1876, few or no efforts had been made in the United States to definitely locate the southern limits of the Pleistocene drift sheets, but during that year and later considerable attention was given to the phenomena and significance of the terminal moraine. One of the first maps to appear showing the outer margin of the glacial drift was by T. C. Chamberlin,¹ published in 1879. This generalized map, bearing the date of 1878, shows the approximate boundary of the glacial drift across the several states from Long Island to Montana. The boundary is shown as entering Indiana from Ohio, near Lawrenceburg and passing directly southwest across the state, crossing the Wabash in the vicinity of New Harmony. The glacial boundary across the northeastern part of the United States as it is now recognized is shown in figure 1.

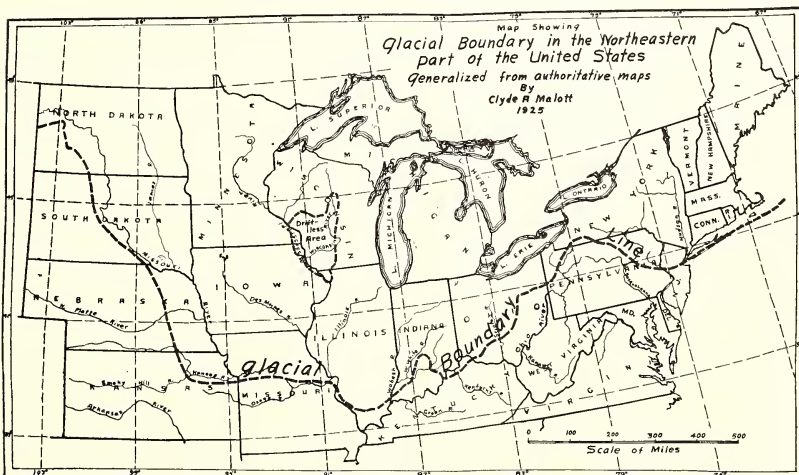


Fig. 1.—Glacial boundary in the northeastern part of the United States. Indiana is located in a middle position near the southern margin of the great glaciated part of northeastern United States. Note that the most outstanding irregularity occurs in southern Indiana.

¹Chamberlain, T. C., On the Extent and Significance of the Wisconsin Kettle Moraine, Trans. Wis. Academy of Sciences, vol. IV, 1879, pp. 201-234.

The more careful tracing of the outer margin of the drift was initiated by George H. Cook and John C. Smock, of the New Jersey Survey. The boundary line was traced westward from New Jersey across Pennsylvania by H. C. Lewis and G. F. Wright, in 1881. During the summers of 1882 and 1883 Wright, under the auspices of the Western Reserve Historical Society, Cleveland, Ohio, traced the boundary line across Ohio and Indiana, and in the next two summers, under the direction of the U. S. Geological Survey, continued his work on the boundary line, mapping it across southern Illinois and reviewing his previous work in Pennsylvania and Ohio.

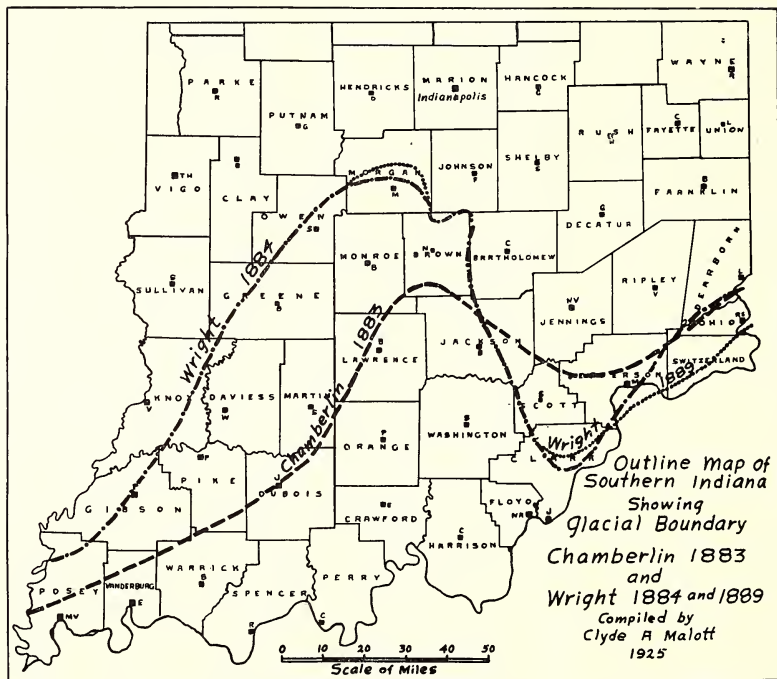


Fig. 2—Glacial boundary in Indiana according to Chamberlin 1883, and Wright 1884 and 1889.

In the meantime, Chamberlin² in 1883 published a paper in which occurs a map showing the “approximate limit of drift”. This boundary line is an incidental feature of the map and is not discussed in the text of Chamberlin’s paper. The boundary is indicated as entering Indiana near Lawrenceburg and passing southwest north of Madison, thence northwest into southern Brown County, thence southwest through western Lawrence County, through Jasper in Dubois County, and thence continuing southwest, crossing the Wabash River into Illinois, west of Mt. Vernon. (See figure 2.)

² Chamberlain, T. C., Preliminary Paper on the Terminal Moraine of the Second Glacial Epoch, Third Ann. Rept., U. S. Geol. Surv., 1883, pp. 299-402.

The following year, 1884, Wright³ published the results of his work in tracing the glacial boundary westward to the Wabash River. The boundary line is traced across Ohio and into Kentucky above Cincinnati. Passing south of Cincinnati, it "recrosses the Ohio entering Indiana a little below Aurora. In Indiana the line continues to bear in a southerly direction through Ohio and Jefferson counties, grazing the edge of Kentucky again opposite Madison, and reaching its southernmost point near Charleston in Clark County, Indiana. From here it bears again to the north through Scott and Jackson counties to the line between Bartholomew and Brown, and follows this to the northeast corner of Brown. There again it turns to the southwest, touching the northeast corner of Monroe, where it again bears north for ten miles to near Martinsville in Morgan County. Here again the line turns to the west and south, passing diagonally through Owen, Greene, Gibson, and Knox counties, and in Posey as far as New Harmony".

The maps published by Wright in 1884 are the first which represent an actual tracing of the boundary in Indiana. This boundary line of Wright's is shown in figure 2 of this paper.

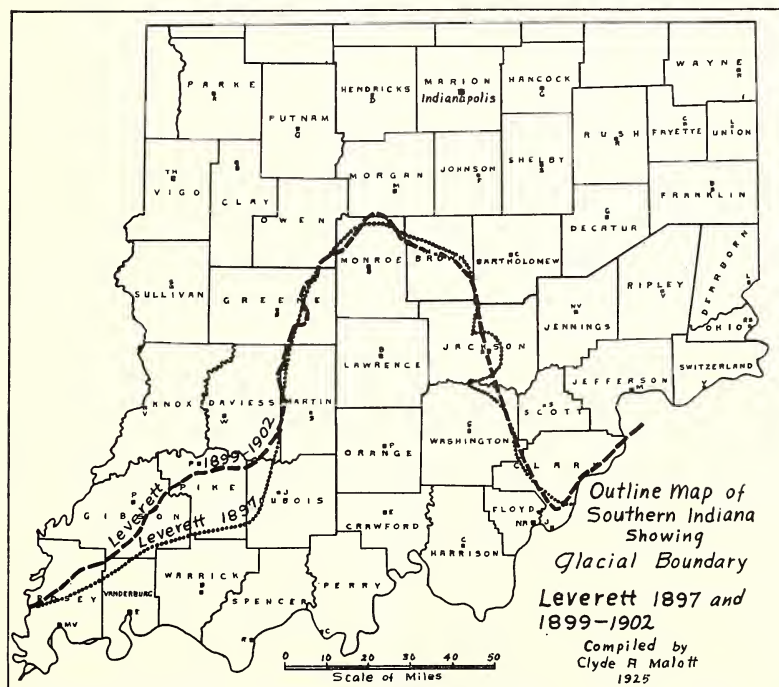


Fig. 3—Glacial boundary in Indiana according to Leverett 1897 and 1899-1902.

³ Wright, G. F., Results of Explorations of the Glacial Boundary between New Jersey and Illinois (Abstract), Proc. Amer. Assoc. Adv. Sci., vol. 32, 1884, pp. 202-208; The Glacial Boundary in Ohio, Indiana and Kentucky, Western Reserve Historical Society, Cleveland, Ohio, 1884, 86 pages.

In 1889 Wright published his book, "The Ice Age in North America". This book went through several editions, the last of which was published in 1911. In the first edition, pages 120 to 165 are devoted to the "Boundary of the Glaciated Area in North America". Here detailed maps by states show the glacial boundary from Nantucket Island to the Mississippi River. The glacial boundary in Indiana is given on a map on page 143. It is somewhat different from his 1884 map. (See figure 3.) In the text the boundary line is discussed in a single paragraph on page 142. "Through Indiana the glacial boundary, after following the Ohio River to within ten or twelve miles of Louisville, Ky., suddenly bends to the north, leaving a large triangular portion of the state unglaciated. The base of this unglaciated triangle extends from Louisville to the Illinois line, and its apex is about thirty miles south of Indianapolis. The exact course of this part of the boundary is along a line running from the neighborhood of Louisville northward through Clark, Scott, Jackson, Bartholomew, and Brown counties to Martinsville in Morgan County, where it again turns west and south parallel with and west of the West Fork of White River through Owen, Greene, Knox, Gibson, and Posey counties, crossing the Wabash River into Illinois near New Harmony, the seat of Owen's celebrated socialistic experiment."

Wright's work on the glacial boundary and the drift border phenomena under the direction of the U. S. Geological Survey during the '80's led to the publication of Bulletin 58 of the U. S. Geological Survey in 1890.⁴ In this official publication but little more is presented than had previously been published by Wright. The criteria by means of which the glacial boundary was determined are discussed in some detail. The boundary across Indiana and the character of the drift adjacent to the boundary are discussed on pages 65 to 70. A map of southern Indiana showing the drift boundary is presented on page 65. This map is essentially like his 1889 map, but lacks the precision of the latter in that the county outlines are omitted. The drift border and adjacent drift phenomena are given in some detail under county headings. He notes that till occurs as far south as Charleston, Clark County. No till or boulders extend west of the Knobstone escarpment south of the Muscatatuck River. He notes till and boulders along the face of the Knobstone escarpment in northern Jackson and southwestern Bartholomew counties to within 200 feet of the crest. Apparently northern Brown County was partly covered by glacial ice, as large boulders occur south of the high divide between Bean Blossom and Salt creeks. Till is mentioned as occurring at Needmore in Brown County. Monroe County is regarded as free from glacial deposits except in the extreme northeastern corner. On the western side of the re-entrant driftless area in Indiana, Wright does not follow so closely the boundary line as it was later determined. Wright's line is drawn west of the West Fork of White River southwest from Martinsville, whereas the line as later determined lies several miles east of this stream.

Before Wright's work on the glacial boundary was completed, studies had been initiated which had for their objective the determination of the

⁴ Wright, G. F., The Glacial Boundary in Western Pennsylvania, Ohio, Kentucky, Indiana and Illinois, with an Introduction by T. C. Chamberlin, Bulletin 58, U. S. Geological Survey, 1890.

history of the glacial period. These studies took up the details of the structure and stratigraphy of the deposits and the relationships of the form phenomena characterizing continental glacial deposits. The work of Chamberlin, Salisbury, Upham, Leverett, Hobbs, Taylor, Alden, and others has clearly revealed the structure, stratigraphy, and relationships of the glacial accumulations, and it has been determined definitely that a series of ice sheets were formed and were wasted away, one after the other, and that these several ice sheets are responsible for the vast glacial deposits within the arms of the Missouri and Ohio rivers south of Canada. Intensive study was carried on in Wisconsin, Iowa, Illinois, Ohio, Michigan, New York, and other states. The determination of the actual limits of the continental ice sheets became incidental in the study, and gradually the glacial boundary line has been more accurately mapped than was possible in the first period of study carried on by Wright and others.

During the late '80's and through the '90's, Frank Leverett carried on intensive studies in Indiana and neighboring states for the U. S. Geological Survey. In 1897 his report on "The Water Resources of Indiana and Ohio" appeared in the 18th Annual Report of the U. S. Geological Survey, Pt. IV. Plate XXXVI of this report is a double page map of Indiana and Ohio, which shows the glacial deposits in color. In the text of the report no attempt is made to give the details of the glacial boundary, but reference is made to the map. Except in the southwestern part of the state, from Posey to Martin counties, the boundary line departs but little from his later more accurately determined boundary. (See figure 3). Leverett notes: "The glacial boundary, except where touched by the later ice invasion, is seldom characterized by a definite moraine ridge, and in places is very vague. Indeed, the earliest or Illinoian ice invasion, so far as its deposits are exposed to view, had not such a pronounced moraine-forming habit as the later invasion."

During this same period, C. E. Siebenthal, then of the Indiana Geological Survey, was carrying on certain studies in southern Indiana. Incidental with his other work, Siebenthal made accurate observations of drift border phenomena. In 1897 his description of the drift limit through Monroe County was published incidental with his part of the report on the Bedford oolitic limestone.⁵ He carefully and accurately traced the boundary through Greene County. This boundary line is shown on the map of Greene County appearing as part of "Sheet C" of Ashley's coal report, published in 1899.⁶ In this report of the Indiana Geological Survey, the glacial phenomena of southwestern Indiana are frequently mentioned, and the glacial boundary is referred to specifically on pages 1,098 and 1,158, with respect to its location in Dubois and in Pike counties. Also a brief statement concerning it is given on page 83. On page 66, the glacial boundary is shown on an outline map of southwestern Indiana, crossing Posey, Gibson, Pike, Dubois, Daviess,

⁵ Siebenthal, C. E., *The Bedford Oolitic Limestone*, 21st Ann. Rept., Ind. Geol. Survey, 1896 (1897), pp. 300-301.

⁶ Ashley, G. H., *The Coal Deposits of Indiana*, 23d Ann. Rept., Ind. Geol. Surv., 1898 (1899), p. 776.

Martin, Greene, and Owen counties. Presumably, Ashley is accountable for this map, though in the text of the report Leverett is mentioned in a number of places as having called attention to special glacial phenomena. The glacial boundary in southwestern Indiana as presented on this map is almost exactly like Leverett's 1899 map below, and it is likely that Leverett furnished the data for it.

In 1899, Leverett's monograph on "The Illinois Glacial Lobe" appeared.⁷ In this important monograph, the first of a series by the same author, Leverett gives the details of the Illinoian drift sheet in Illinois and southwestern Indiana. The border or boundary in Indiana is traced in considerable detail on the western side of the re-entrant driftless area. The boundary crosses the Wabash a short distance south of New Harmony where it passes east and north to near the Monroe-Morgan county line, the northernmost point of the boundary in Indiana. (See figure 3.) The determination of the boundary through Greene, Owen, and Monroe counties is credited to C. E. Siebenthal. This boundary line of Leverett's in southwestern Indiana, as described on pages 35 to 37 and shown on plates VI, VIII, and IX of his monograph, lies from 5 to 20 miles east of the boundary as mapped by Wright. It departs but little from boundary lines of subsequent maps.

Leverett's second monograph⁸ on the glacial deposits appeared in 1902. Here the descriptive characteristics and relationships of the glacial deposits are continued eastward from middle Indiana. On pages 222-223 the border of the Illinoian drift is described as passing southeast from northern Monroe County to the Ohio River above Jeffersonville, and on pages 255-257 and 263-267, the character of the drift border and the structure of the drift sheet back of the border are discussed in considerable detail. It is noted that in northeastern Monroe County boulders are plentiful, but till is scarce. A bulky ridge of stony, almost gravelly till of brown color is described as rising 60 to 70 feet above the valley bottom of Bean Blossom Creek at Needmore in Brown County. Till is banked against the north slope of Bean Blossom Valley, "but the dividing ridge south of Bean Blossom carries only boulders and occasional thin deposits of till. The boulders have apparently been rolled down ravines south of the divide to some distance beyond the margin."

It is noted, also, that the drift border in Salt Creek Valley connects with a glacial terrace that leads down the valley beyond the limits of Brown County, and "on the elevated uplands in eastern Brown County the drift in places is 40 feet thick, but is usually a thin deposit, scarcely sufficient to form a continuous drift sheet."

"Upon passing from Brown into Jackson County, Ind., the drift border descends from the Knobstone escarpment southward through Jackson, northeastern Washington, and southwestern Scott counties into Clark County. It continues southward in Clark County to the Ohio River at Jeffersonville, Ind., and there makes an abrupt turn to the east. The border apparently follows up the Ohio valley about to Bethlehem, Ind.,

⁷ Leverett, Frank, *The Illinois Glacial Lobe*, Monogr. 38, U. S. Geol. Survey, 1899.

⁸ Leverett, Frank, *Glacial Formations and Drainage Features of the Erie and Ohio Basins*, Monogr. 41, U. S. Geol. Surv., 1902.

25 miles above Jeffersonville, before rising to the uplands south of the river, thus making a pronounced loop in the Devonian shale basin."

Chestnut Ridge near the drift border in southeastern Jackson County is discussed in considerable detail. South of Chestnut Ridge in the Scottsburg Lowland the drift sheet is practically continuous, but on the uplands along the extreme border there is in places only a scattering of boulders to indicate glaciation. It is inferred that south of the Muscatatuck River the extreme drift border lies along the Knobstone escarpment until the vicinity of New Albany and Jeffersonville is approached.

The Ditney⁹ and Patoka¹⁰ folios of the U. S. Geological Survey appeared in 1902 and 1904 respectively. The areal geology maps of these two folios show in color the detailed geology of about 1,650 square miles in southwestern Indiana, embracing portions of Posey, Vanderburg, Warrick, Spencer, Gibson, Knox, Pike, and Dubois counties. The Patoka map laps over into Illinois where it covers about 200 square miles. The Pleistocene deposits are differentiated and are shown on the maps under several separate conventions.

The glacial boundary across the Patoka Quadrangle is shown by a heavy brown line. This line, beginning at the south, appears on the map near the southwest corner of the quadrangle about seven miles south of New Harmony. It takes a northeasterly direction with minor bends, passing through the village of Springfield, and thence about one mile south of Wadesville, one mile north of St. Wendells, about two miles south and two miles east of Bryant, and off the eastern edge of the Patoka Quadrangle about four miles east of Fort Branch.

In the vicinity of the Wabash River the till sheet is covered with loessial deposits and is largely obscured. The relief of the region is low and few sections of any depth may be had. The border is mapped indirectly from the presence of outwash deposits and low ridge-like accumulations of drift. Normal morainic features are absent. Large areas within the drift border near Poseyville, Cynthiana, and Fort Branch are composed of flat lacustrine plains, marking the sites of rather extensive glacial lakes.

The glacial boundary across the Ditney Quadrangle is not shown by a definite line, as on the Patoka Quadrangle. Fuller, on page 4 of the Ditney Folio, says: "As the boundary marking the limits of the Illinoian till is approached, the till plain is seen to be less perfectly developed. Rock begins to show through it with greater frequency, and it finally diminishes to a relatively thin mantle, which conforms to the contour of the rock surfaces. In general the till appears to continue with a thickness of several feet almost if not quite to the outer limits of its occurrence, though occasional areas of rather small size are found some distance back from the margin where no till appears to have been deposited." The geological map of the Ditney Folio shows much outwash material extending south of the till sheet in the northwestern part of the quadrangle. The margin of the outwash is shown at the western edge of the quadrangle about six miles southwest of Francisco, about

⁹ Fuller, M. L., and Ashley, G. H., Ditney Folio, No. 84, U. S. Geol. Surv., 1902.

¹⁰ Fuller, M. L., and Clapp, F. G., Patoka Folio, No. 105, U. S. Geol. Surv., 1904.

where the mapped glacial boundary passes off the eastern margin of the Patoka Quadrangle. From this point it extends northeast to a point about one mile east of Francisco, where it turns eastward to the north edge of Oakland City, and thence northeasterly to about three miles southeast of Petersburg, where it joins the mapped till sheet. From this point the till sheet margin passes nearly east, crossing the Pike-Dubois county line about one mile northeast of Otwell. After continuing eastward for about one mile the drift margin turns northeast to the northeastern corner of the quadrangle area. It is a question whether the outwash limits in the vicinity of Francisco and north of Oakland City mark the glacial limits. Certainly the drift margin is near, and this outwash limit may well be used as the glacial boundary, though the writer of this review has placed it a short distance north of the outwash limits on the map which he presents with this paper.

In the Ditney Folio, Fuller states that the data suggest quite strongly the existence of a drift sheet older than the Illinoian, but in the review given in the Patoka Folio in collaboration with Clapp, he rejects the idea of an older drift sheet. Also in the Ditney Folio, Fuller considers the possibility of a transient advance of the glacial ice as far south as Boonville, some 20 miles south of the mapped limits near Oakland City. The basis of this possibility is the presence of isolated weathered pebbles and boulders of suggestive glacial origin. It is very improbable that any of the region between Oakland City and Boonville was ever transgressed by glacial ice. Leverett spent a few days in 1924 looking for the evidence to which Fuller calls attention, but failed to find anything which would verify Fuller's suggestion.¹¹

The geological maps of the Ditney and Patoka folios show the glacial boundary from the Wabash River some seven miles south of New Harmony to East White River in northwestern Dubois County with as much precision as may be obtained practically. Little if any improvement may be made. Thus we may consider the boundary to be definitely mapped and established. This part of the glacial boundary traverses a distance of 70 miles. The total boundary line in Indiana is 240 miles in length.

In 1904 Blatchley¹² published a map showing the glacial boundary in Indiana which deserves mention here. Leverett's 1899-1902 boundary is generally followed except in the vicinity of the junction of East White and Muscatatuck rivers southwest of Brownstown in Jackson County. Here Blatchley's map shows that a distinct lobe of the ice sheet protruded westward in a westward extension of the lowland west of the Brownstown hills. The Brownstown hills, a high upland mass or group of hills consisting of about 25 miles entirely surrounded by low land within the limbs of East White and Muscatatuck rivers in southern Jackson County, were surrounded by glacial ice and are represented as a small unglaciated area surrounded by drift. (See figure 4). Blatchley does not discuss the drift border in the text of his paper.

¹¹ Personal communication, July 12, 1924.

¹² Blatchley, W. S., *The Indiana of Nature: Its Evolution*, Proc. Ind. Acad. of Science for 1903 (1904), pp. 33-59.

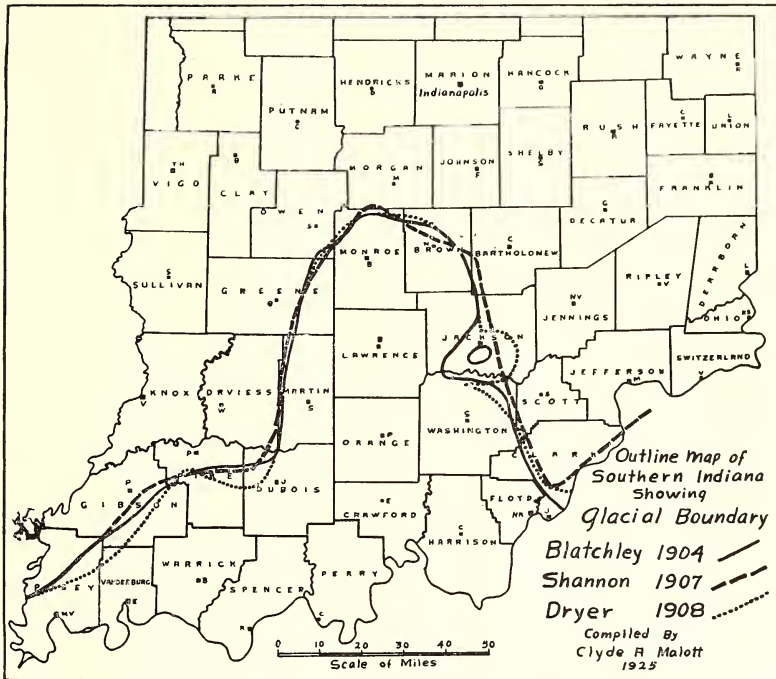


Fig. 4—Glacial boundary in Indiana according to Blatchley 1904, Shannon 1907, and Dryer 1908.

In 1907 Shannon¹³ published a map of East White River drainage in southern Indiana. The glacial boundary is shown on this map. It departs but little from Leverett's 1899-1902 boundary line, probably being generalized from it. Shannon did much work in southern Indiana and was well acquainted with the marginal features of the Illinoian drift sheet. He may well have improved upon the previously published maps. Incidentally he discusses a part of the glacial boundary in the text of his paper which the map accompanies. "At its extreme limit," Shannon writes, "the ice deposited but little drift; and as a rule there is not a well defined ridge of drift along the glacial boundary From the north line of Jackson County, following the boundary to the west and south, it is in many places hard to trace as a well defined line. The ice-sheets must have been very thin, since the topography shows little if any modification. In many places, however, heavy beds of gravel and till lie against the hill slopes to the north and east. Many large granite boulders are also piled up along the hill sides and scattered along the streams."

Charles Dryer is responsible for several maps which show the glacial boundary. As a rule they depart little from Leverett's boundary lines upon which they are based. In the 1908 edition of his "Studies in Indiana

¹³ Shannon, C. W., Drainage Area of East Fork of White River, Proc. Ind. Academy of Science for 1908 (1907), pp. 53-70.

Geography" a glacial map appears with acknowledgment to Leverett. The boundary line on this map is highly generalized from Leverett's maps and departs from them considerably in a number of places. It extends farther down in northwestern Vanderburg County and includes a larger area in northwestern Dubois County. In southwestern Indiana it includes within the drift margin the greater part of the lacustrine deposits. The apex of the re-entrant angle in northern Monroe County is not shown as an angle, but rather as a great smoothly sweeping semicircle. In Jackson County it swings in a semicircle east around the Brownstown hills, returning west south of them, and then turning abruptly back southeast through northeastern Washington County, somewhat as in Leverett's 1897 map. (See figure 4.)

In the Proceedings of the Indiana Academy of Science for 1910, Charles Brossman presents a map accompanying his brief paper on "Water Supplies in Indiana." This map shows the glacial boundary, chiefly following Leverett's 1899-1902 boundary, though a suggestion of Blatchley's 1904 map is present in it.

Edward Barreet, state geologist of Indiana from 1911 to 1919, uses Dryer's 1908 boundary line on maps published in three different annual reports of the Indiana Geological Survey. It occurs first in the 36th Annual Report for the year 1911, accompanying a brief discussion entitled, "Glaciation and Soils". The same map upon which is superimposed the progress of soil mapping appears in the 38th and 39th annual reports for the years 1913 and 1914 respectively. The boundary and moraines of these maps are credited to Leverett.

Harry W. Wood uses Dryer's 1908 glacial map to accompany a paper entitled, "The History of Indiana During the Glacial Period", published in the 40th Annual Report of the Indiana Geological Survey, for the year 1915. This map also is credited to Leverett.

In 1915 the work of Leverett and Taylor, entitled "The Pleistocene of Indiana and Michigan and the History of the Great Lakes" appeared.¹⁴ This authoritative treatise is chiefly a description of the glacial features of Indiana and Michigan, including the features of the great glacial lakes leading up to the present Great Lakes system. It deals mainly with the Wisconsin drift of the Saginaw lobe and the neighboring portions of the Lake Michigan and Huron-Erie lobes, though the pre-Wisconsin glacial and interglacial formations are given some attention. With respect to the glacial boundary across Indiana, Plate VI and page 62 of the monograph are of chief interest.

The glacial boundary as shown in figure 5 is taken from Plate VI of Leverett's monograph. This boundary as described in the text on page 62 corresponds to the map except from northern Monroe County southeast into northern Jackson County. The text states that at the Monroe-Morgan county line the glacial boundary line "turns somewhat abruptly southeastward across the northeast corner of Monroe County to Needmore in Brown County and passes north of Marshall to Mt. Liberty in eastern Brown County. Thence it runs southward near Brownstown, Mt. Sidney, Little Fork, Vienna, and Henryville to the Ohio

¹⁴ Leverett, Frank, and Taylor, Frank B., *The Pleistocene of Indiana and Michigan and the History of the Great Lakes*, Monogr. 53, U. S. Geological Survey, 1915.

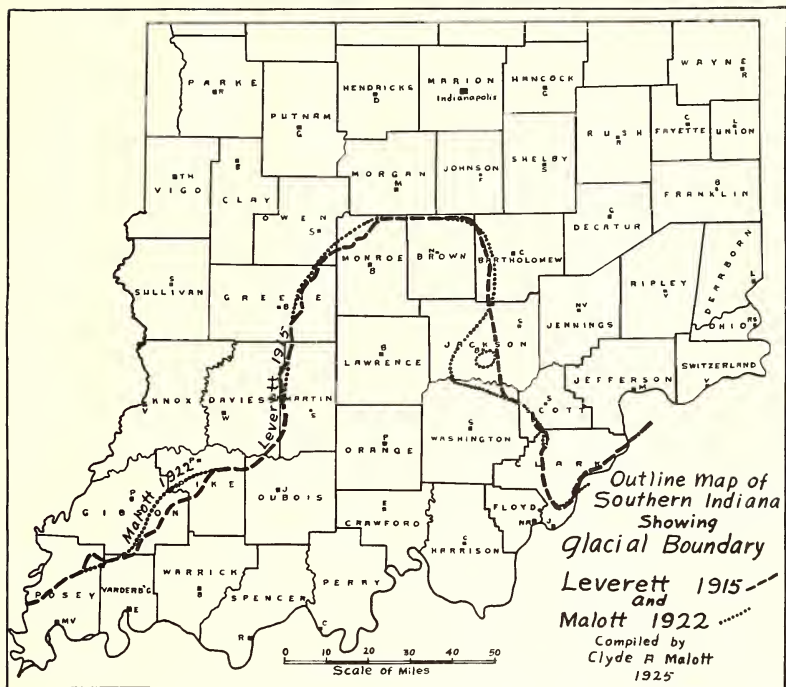


Fig. 5—Glacial boundary in Indiana according to Leverett 1915 and Malott 1922.

opposite Louisville". The map, however, shows that the boundary line passes nearly due east from the middle part of Monroe County just south of the Monroe-Morgan county line. It continues east for about 20 miles to the extreme northeast corner of Brown County where it turns south-east and enters Bartholomew County. The boundary in Bartholomew County runs south along the Knobstone escarpment and enters Jackson County about three miles east of the southeastern corner of Brown County.

This discrepancy of Leverett's map and text is noted on page 144 of the "Handbook of Indiana Geology" where the writer discusses the glacial boundary. Leverett in a personal communication¹⁵ states that he is "at loss to understand why the glacial boundary is so put forth in Monograph LIII." In his preceding map of 1899-1902 the boundary through Monroe and Brown counties is about as described on page 62 of Monograph LIII.

In 1922 the writer's "Physiography of Indiana" appeared as Part II of the "Handbook of Indiana Geology".¹⁶ On page 66 the glacial boundary is shown on a physiographic map of Indiana. Again it is shown on an inserted glacial map of Indiana, pages 106-107. This glacial boundary line is discussed on pages 143-144 of the text. It is here re-

¹⁵ January 22, 1924.

¹⁶ Handbook of Indiana Geology, Publication No. 21, Indiana Department of Conservation, 1922.

produced in figure 5, where its coincidence with and its departures from Leverett's boundary are shown. The greatest departure from Leverett's boundary is in Jackson and northern Washington counties where the line is patterned after that of Blatchley's 1904 map. In the text the evidence for so drawing the line is given. In northeastern Monroe and in Brown and Bartholomew counties the line substantially follows Leverett's 1915 map. Attention is called to the occurrence of large boulders south and west of the line in Brown and Bartholomew counties, and it is suggested that the glacier for a short time advanced beyond the mapped limits.

In 1924 Frank Leverett of the U. S. Geological Survey, F. J. Breeze of the State Normal School, Muncie, Indiana, and the writer arranged to spend a few days together in the study of a part of the glacial boundary across Indiana. It was agreed that the boundary line from the Wabash River in Posey County northeast to northern Monroe County is pretty well established, but from northern Monroe County southeast to the Ohio River in Clark County the boundary line is much less definite and rather difficult to trace, and it should receive attention. Both Leverett and the writer were of the opinion that the scattered boulders and other evidences of glaciation in middle and eastern Brown County might possibly prove to be remnants of an older drift sheet than the Illinoian, and this tentative opinion had been discussed through correspondence. This opinion was not substantiated in the investigation which followed.

Apparently the glacial boundary passes from Monroe County into Morgan County in the northwest of section 2, township 10 north, range 1 west, as an exploration down Bryant's Creek in an approach towards the glacial boundary revealed no glacial boulders until the west side of section 2 was approached. After entering Morgan County the boundary continues east of north for nearly two miles and then turns east and southeast, re-entering Monroe County approximately on the ridge north of Hackers or Little Indian Creek. It continues south of east to the vicinity of Hubbard Gap, in the northwest quarter of section 11, township 10 north, range 1 east. Many boulders occur in the stream leading south from this gap, and outwash material extends up the hill on the east flank of the gap. From Hubbard Gap the boundary apparently continues southeast to the vicinity of Needmore in Brown County. Near here it pushed against the south valley side of Bean Blossom Creek and rose over the high divide south of Helmsburg, discharging glacial boulders into the streams leading into Salt Creek. Several large boulders may be seen along Little Owl Creek about three miles northwest of Nashville. An isolated patch of gravelly outwash occurs on the hill at the farmhouse just north of Owl Creek School in the southwest quarter of section 11, township 9 north, range 2 west.

One mile north of Nashville on the west side of Greasy Creek Valley, Mr. Leverett discovered a small patch of till. Many boulders are present along Greasy Creek. The till proves beyond doubt that the ice sheet came over the high divide between Bean Blossom and Salt creeks and approached the vicinity of Nashville near the center of Brown County.

Boulders from six inches to three feet in diameter occur occasionally in the valleys north of West Point, four miles east of Nashville. Boulders are plentiful in the bed of a small creek flowing west and in the road leading to Pikes Peak, about five miles southeast of Nashville. Mr. Breeze called attention to drift occurring in the vicinity of Beck in southeastern Brown County. Here it occurs in sufficient quantity to have some topographic influence, and to notably affect the character of the soil of the locality. Till occurs in a field in the vicinity of Lockman or Buffalo about three miles west of the Brown-Bartholomew county line. From the above evidence it appears that the glacial boundary line passes southeast from near Nashville for a few miles and then turns south on a line some three or four miles west of the eastern boundary of the county. It is to be noted that this line is several miles west of the Knobstone escarpment. (See figure 6.)

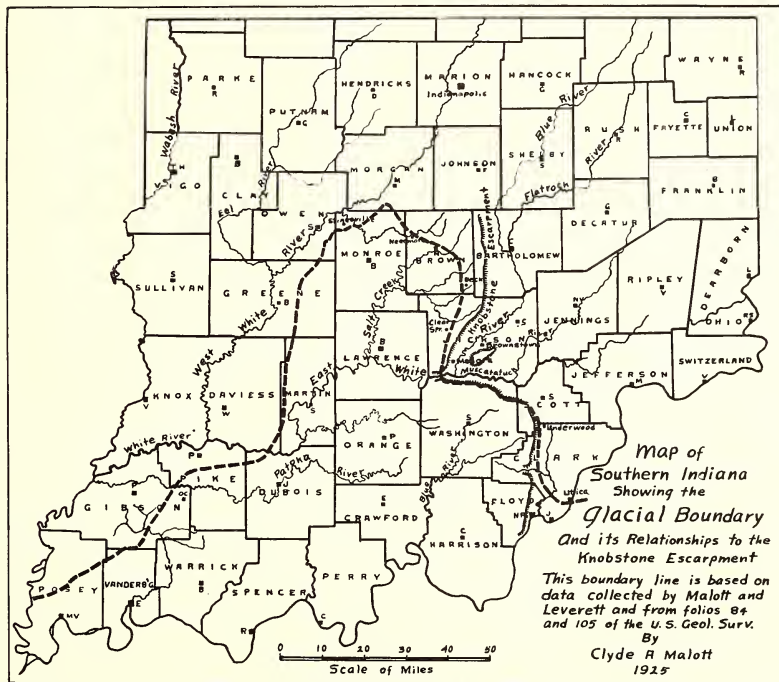


Fig. 6—Glacial boundary in Indiana showing its relationships to the Knobstone Escarpment.

Again till was discovered in quantity about four miles north of Freetown in Jackson County. Boulders and weathered material resembling till were discovered a short distance southeast of Clear Spring well back of the crest of the Knobstone escarpment. Rolland Brodhecker of Brownstown sent the writer samples from large granite and quartzite boulders found in the ravines between Freetown and Clear Spring. The writer recently discovered an exposure of several feet of typical

till in a road cut along State Highway 4 about three and one-half miles northwest of Medora and well back of the Knobstone escarpment. The till exposed in the road cut occurs about the center of section 29, township 5 north, range 3 east. About 10 feet of it is exposed, the upper part being so weathered that it little resembles till.

The evidence is conclusive that the greater part of Brown County was once covered by glacial ice, and that in western Jackson County the drift boundary is well west of the Knobstone escarpment. But the area lying west of the Knobstone escarpment in Bartholomew, Brown, and Jackson counties bears little topographic evidence of glaciation. It appears that the Illinoian ice sheet advanced to its limits in this area and then immediately melted away, leaving but scant evidence of its temporary occupancy. The respectable glacial plain in Bartholomew County and the abundant drift in Jackson County along and east of the Knobstone escarpment indicate that the ice sheet remained against the escarpment for a considerable period of time. It is likely that it acted as a topographic barrier which stayed the ice for the greater part of the time, but it is an interesting fact that for a brief period the ice sheet moved beyond the escarpment in Bartholomew and Jackson counties. (See figure 6.)

In southern Jackson and in northern Washington counties it is evident that the Illinoian ice sheet pushed westward in the lowland apex around and west of the Brownstown hills, probably reaching into the rather constricted portion of East White River valley in the vicinity of Sparksville. The ice came against the north facing portion of the Knobstone escarpment south of the Muscatatuck River in Washington County, but it never rose to the crest of the escarpment. Small patches of glacial drift may be found here and there, but none above an altitude of 800 feet. Two small patches of glacial drift occur along the side of State Highway 24 on the ascent up the "Millport Knobs", south of the Muscatatuck River bridge. The drift here is between 700 and 800 feet in altitude. It is very probable that the higher parts of the Brownstown hills were never topped by the glacier. Drift occurs about and among them to an altitude of somewhat over 800 feet, but the higher hills show no evidence of glaciation. It is likely that they remained as a nunatak or several small nunataks above the surrounding glacial ice.

Apparently the ice sheet came against the Knobstone escarpment through Scott and part of Clark counties, failing to reach it in the vicinity of New Albany. Small patches of drift occur west of Silver Creek and south of Muddy Fork in Clark County. No drift or erratics could be found in the lowland area in Floyd County north of New Albany. Leverett states¹⁷ that the drift border passes eastward north of Jeffersonville and a little south of Watson. It crosses the Ohio River near Utica into Oldham County, Kentucky, where it continues east and northeast past Goshen several miles south of the Ohio River.

The glacial boundary as shown in figure 6 is believed to be approximately correct. It traverses a distance of approximately 240 miles in the state, and the re-entrant angle made by it leaves approximately

¹⁷ Personal communication, July 12, 1924.

6,000 square miles in Indiana unglaciated. Only eight counties were untouched by the Illinoian ice sheet. These counties are Lawrence, Orange, Floyd, Harrison, Crawford, Perry, Spencer, and Warrick. All the counties within the unglaciated area were directly or indirectly affected by glaciation with the possible exception of Orange. The Ohio River counties contain valley train material in the form of terraces along the Ohio, and erratics carried by the water and drifting ice are present. Lawrence County contains prominent terraces of glacial origin along Salt Creek and East White River, as these streams were important conveyors of glacially derived material. No stream receiving glacial waters entered Orange County, but Lost River in its lower course was ponded back as far as the "rise" near Orangeville, and its valley floor is deeply alluviated. Alluvial terraces occur along Lost River in the western part of the county, and these owe their origin to the excavation of silts accumulated while the valley was ponded. Orange County, however, is the only county in Indiana which contains no glacially derived material.

