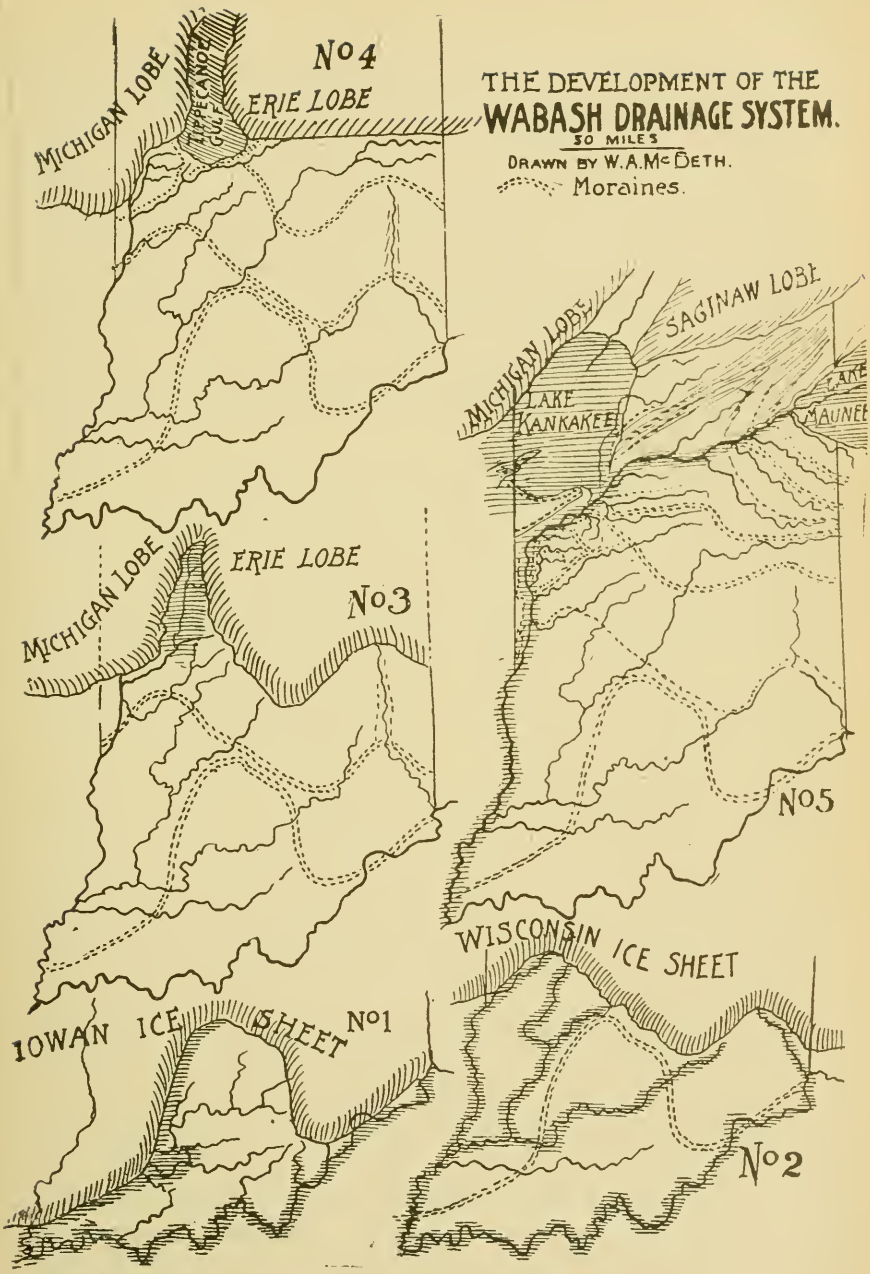
is developing. In the southwest part of Spy Run Lake bottom occurs a complex system of old channels which indicate the part of the lake last drained. This is further shown by the more or less swampy condition of this part. Below the lake bottom the system of meanders is so complex that it is impossible to trace out, with any degree of certainty, the different stages which occurred in the shifting of the stream bed. Along the north side of the flood plain there is an old channel which seems to be the oldest in the system. Near the south side, where the stream is now located, the channels are less obscured, indicating that the creek has shifted its position from north to south and suggesting that probably the complex system of meanders is due to this migration. A number of cross channels connect the old channel on the north with the present one. In developing this system of meanders the stream may have followed channel *abc*, leaving it at *c* and entering its present channel, first at *d* and then at *e* and *f*. It then probably left the old channel at *g* and crossed to its present one by the cross channel *gh*, and at *b* by channel *bo*. Above this point the complexity increases, the meanders are smaller, with a greater number of cross channels. Four very young meanders lie south of the stream, one of which, *rs*, is at times occupied by part of the stream, forming a small island.

The Development of the Wabash Drainage System and the Recession of the Ice Sheet in Indiana.

By W. A. McBeth.

The development of the Wabash drainage system has now been worked out to such an extent as to show that it is not only a subject of interest in itself, but also has an important bearing on the question of the movement and recession of the North American ice sheet. The whole of the axial stream, except a few miles near its mouth and perhaps 30,000 of the 33,000 square miles comprised in its basin, were buried beneath the ice one or more times, and there is scarcely a tributary which does not show plainly the effects of the influence of the ice sheet in determining its course and its drainage area.

Along the line of the lower Wabash, the earlier ice approached within twelve or fifteen miles of the Ohio River, and almost to the limit of ice


THE DEVELOPMENT OF THE
WABASH DRAINAGE SYSTEM.
30 MILES
DRAWN BY W.A. McBETH.
Moraines.
No 4
MICHIGAN LOBE
ERIE LOBE
No 3
MICHIGAN LOBE
ERIE LOBE
IOWAN ICE SHEET
No 1
MICHIGAN LOBE
SAGINAW LOBE
LAKE KANKAKEE
No 5
WISCONSIN ICE SHEET
No 2

movement the evidence of obstruction and readjustment appears. Near the southern limit of the drift the Patoka River is an example of a stream made up of several sections. Three northwestward flowing streams were obstructed in their lower courses by the ice, and compelled to seek westward outlets across divides along the ice border. The lower course of White River was also obstructed and the part within the unglaciated area ponded up in its deep valley through the Knobstone. In the main stream and in many of its tributaries temporary lakes were formed which overflowed over the ice or along the ice border.

West White River is conspicuously a border drainage line as far up as northern Monroe County, as shown in its course through Owen, Greene and Daviess counties.

The position of the Shelbyville moraine indicates that Raccoon Creek was in existence through half its length before the Wabash was uncovered north of Vigo County. Further recession northward brought Sugar Creek into existence. This stream is very distinctly of border drainage type, as shown by the prominent moraine along its north bank from its mouth to southwestern Clinton County. After further recession of the ice sheet Coal Creek took its way north of a region of morainic uplands, until it came against a strong north and south moraine which deflected its north branch in a great bend, remarkably like that of the Wabash. The part of this stream above its great bend is comparatively meandering and its valley, which is very shallow, is in marked contrast with the deep, broad valley below the bend. South Shawnee Creek runs west parallel with North Coal Creek and bends to the north within a mile of where this creek bends to the south. A broad, marshy valley connects the two bends, indicating that South Shawnee Creek formerly turned south. These creeks have their sources at the crest of the kame moraine, which runs northwest from Darlington, Montgomery County, toward Independence, Warren County, and are guided by moraines trending east and west. To the east of the Darlington-Independence divide, the streams flow northeast in a direction opposite to that of the Wabash. They are turned northwest into that stream by a moraine running southeast from a point about five miles south of Lafayette to the southeast corner of Tippecanoe County. The three forks of Wild Cat Creek coming from the east turn north along the western side of a moraine, which lies along the western edge of a till plain rapidly rising to the east. This moraine, in my opinion, is the strong outer moraine of the Erie lobe and marks

the westward limit of Erie ice as a separate lobe. The Wild Cat creeks, above their northward bend, are bordered along their northern bluffs by weak, but distinct, moraines.

Returning to the Wabash, at the great bend we find it following the south side of a strong moraine from the mouth of Tippecanoe River to the point of its southward deflection. The drainage on the south side of the stream through this section was all to the south and west previous to the recession of the ice to the north side of the river. Above the mouth of the Tippecanoe the Wabash becomes probably a distinctly terminal drainage stream of the Erie lobe, and its tributaries have come into existence in pairs on opposite sides of the main stream as the ice withdrew toward its source. The head waters of the southern tributaries have in several instances been pirated by the stream to the south and west of them, as in the case of the deflection by the Mississinewa of a tributary of West White River north of Muncie, and the capture of the Salamonie by the Wabash above Ceylon. The development of these upper tributaries and the former connection of the St. Mary's and St. Joseph rivers and the glacial Maumee Lake with the Wabash by way of the broad valley of Little River extending from Ft. Wayne to Huntington have become familiar facts through the investigations made by Dr. C. R. Dryer and published in the Sixteenth, Seventeenth and Eighteenth Reports of the State Geologist of Indiana. The Tippecanoe River, after the manner of the upper tributaries of the Wabash, may be paired with the Wild Cat Creek. Below the great bend of the Tippecanoe, in Starke County, it drains the western edge of the Erie drift; above that bend it receives its water supply from the Saginaw drift. From its mouth to New Buffalo, ten miles north of Monticello, it has a deep valley (100 feet at Monticello) and varying from one-half of a mile to a mile in width. Above this deep portion, the character of its valley changes rather abruptly to a very narrow and superficial channel, not much too large to carry its flood waters. This shallow valley is remarkably meandering, much of the general course being originally guided by sand ridges. The lower portion of the Tippecanoe was evidently the former outlet of a lake of considerable extent, which covered the country north of Monticello. The earliest lake area may have extended southward to the immediate vicinity of the mouth of the river, where the strong moraine running along the north bluffs of the Wabash changes abruptly near the Tippecanoe battleground to a chain of low gravel mounds, which continue

across Pretty Prairie, a gravelly terrace plain, a distance of three miles to the mouth of the Tippecanoe River. The crest of this moraine at the Soldiers' Home, four miles north of Lafayette, is higher than the surface of the plain at Monticello or Winamac, and the gap has the appearance of having been once the passageway for a large stream from the north. The part of the Tippecanoe from New Buffalo to the great bend is the newest part of the stream. It established its meandering course among the sand ridges along the eastern side of the lake bed and connected the part above the bend, which formerly flowed into the lake, with the part which was the lake outlet, giving an interesting example of a spliced stream.

The description of the development of the drainage of the Wabash system has been traced to the above extent in order to group its main facts together and bring them to bear on the question of the manner of recession of the ice sheet from its basin and some of those basins adjoining it.

Several writers on problems connected with the drift area seem to assume that the ice sheet could not have receded in any other way than from west to east. The Kankakee Lake, the western Indiana bowlder belts and various other problems are perplexing problems on this assumption. While in a general way the view is doubtless true that the recession was in this direction, the solution of several interesting points connected with Indiana drainage becomes simple by the acceptance of good evidence that in western Indiana the recession was from east to west.

The Michigan, Huron and Erie depressions were doubtless lines of southward and southwestward movement which became filled with ice and overflowed before the country between was invaded. Gradually the ice accumulated and covered the crests of the divides, becoming a confluent area with smooth, regular slopes on the surface, but conforming generally on the under side to the relief of the rock surface below. Valleys and low tracts of the preglacial surface would become lines of more rapid flow and the ice would move farther forward along these lines than elsewhere. The arrangement of the moraines in Illinois, Indiana and Ohio shows the influence of this lobate movement to the limits of the drift of any period.

The curving to the north of the glacial boundary in Indiana is easily explained by the stranding of the ice along the north and south belt of resistant rocks, including the Knobstone in that part of the State, while

the lower regions to the east permitted the advance of the ice to the Ohio River, and on the west the ice crept south almost to the mouth of the Wabash in Indiana and nearly to the mouth of the Ohio in Illinois. The last general invasion sent ice much further south in Illinois than in western Indiana.

The recession of the ice was in general the inverse of its advance. It melted away on the divides, became differentiated again into lobes, which gradually withdrew up the depressions along their lowest lines. The evidence is abundant to show that the last ice sheet disappeared along a line running east of the Wabash River from Terre Haute through Crawfordsville to Lafayette before the region traversed by the present river below Lafayette was uncovered. Probably this interlobate melting continued northward along the line of the lower Tippecanoe and upper Kankakee into Michigan.

The evidence that the last ice in western Indiana occupied the region south and east of the great bend of the Wabash after it had receded from the country farther east is embraced in the condition and arrangement of numerous moraines, many overflow channels, and temporary lake beds with their traversing stream lines of different ages.

The moraines along Raccoon Creek, Sugar Creek, the southward flowing part of Coal Creek and the east and west ridges extending across Fountain County, together with a high, sharp, and in some places very narrow moraine running east from the town of West Point, Tippecanoe County, to a point five or six miles southeast of Lafayette, do not seem to have been overridden or much disturbed since they were laid down. They were deposited by ice from west and north of the present river line and according to their shape and trend, evidently by the Lake Michigan lobe. The heavy moraine north of the Wabash and west of the mouth of the Tippecanoe has not been overridden. It is a moraine of the Michigan lobe called, by Mr. Frank Leverett, the "Bloomington moraine," and extends twenty-five or thirty miles farther northeast than he has mapped it.* Moraines trending northwest and southeast in southern Tippecanoe County seem to be outposts of minor advances of the ice from the Erie lobe around the southern edge of the Michigan lobe. These ridges run across the line of division between the lobes and have numerous gaps through them.

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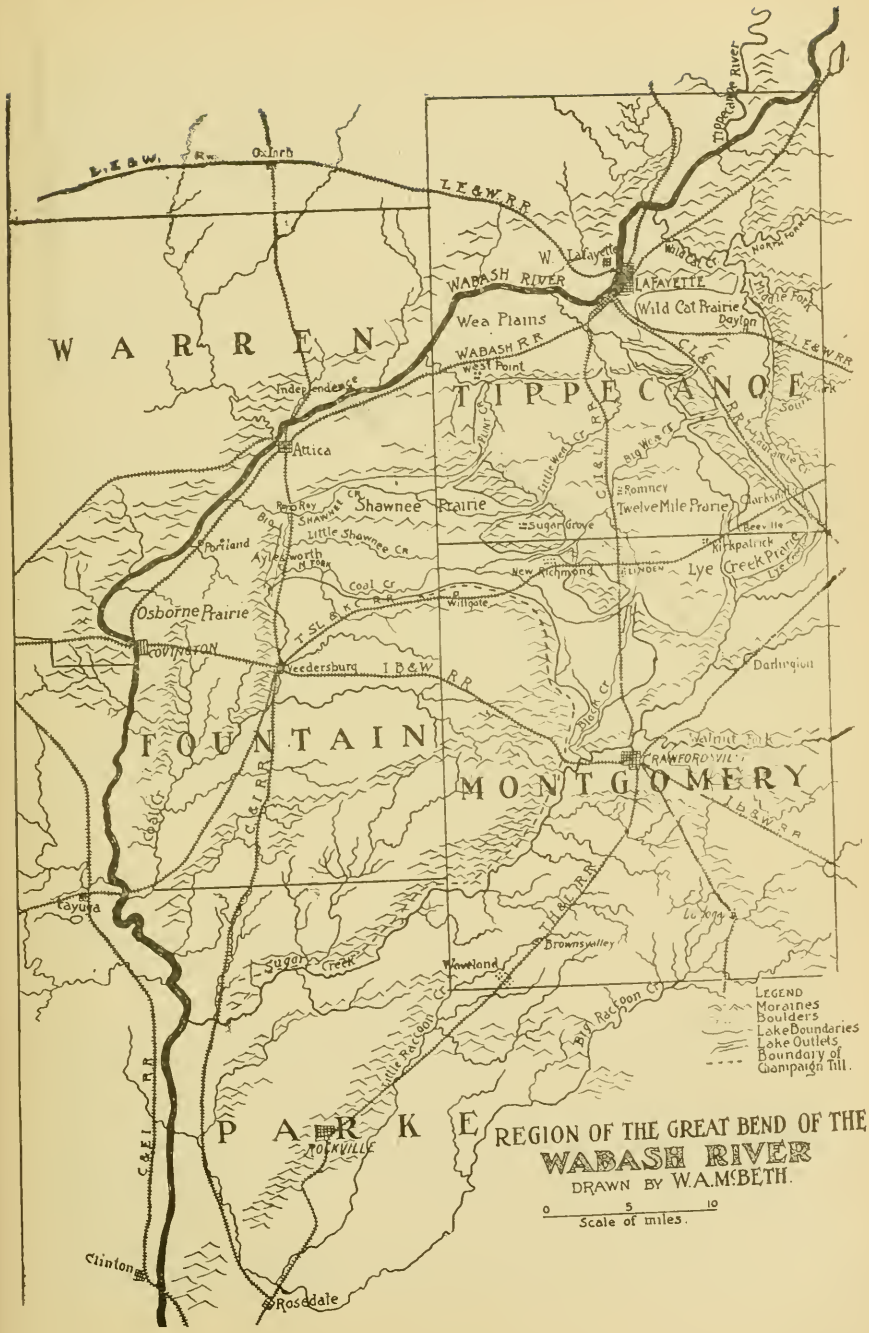
* See map pp. bet. 24-25, in his late U. S. G. S. Monograph XXXVIII on the Illinois Lobe.

These gaps and old channels are numerous and conspicuous in northern Montgomery and southern Tippecanoe counties particularly. Lye, Potato and Black creeks, flowing south into Sugar Creek, have their present sources at gaps in the divide to the north, where they approach in some cases within a few feet of the sources of streams flowing northeast and north into the Wabash.

A map and discussion of this region was presented to this body at its last winter meeting, and the points reviewed are referred to in connection with the present question of recession. The Independence-Darlington moraine has at least six overflow channels across it, from which the water formerly flowed south between this ridge and the eastern edge of what Mr. Leverett calls the "Champaign Till Sheet" in his report mentioned above. This till sheet approaches in the vicinity of New Richmond, Montgomery County, within a mile of the Independence-Darlington ridge, the space between showing long stretches of very fertile level prairies, doubtless the beds of former lakes. North Coal Creek now flows west along the northern bordei of this portion of the Champaign till sheet, to the great bend where it flowed against the eastern edge of the Michigan lobe and was turned south within six miles of the present line of the Wabash and compelled to make its way twenty-five miles to the south before joining it. South Shawnee Creek turned south then and joined Coal Creek at the bend through the marshy sag now connecting their abrupt elbows.

A comparison of the altitudes of these gaps with the altitudes of stations along the Cloverleaf Railway (T., St. L. & K. C.) shows very well the westward slope of the country along the divide between the streams flowing north into the Wabash and those flowing south into Sugar Creek. In the order of their occurrence from east to west the stations and their altitudes are: Clark's Hill, 818 feet; Beeville, 792 feet; Kirkpatrick, 787 feet; Linden, 783 feet; New Richmond, 776 feet; Wingate, 776 feet; and Aylesworth, at the bend of Coal Creek, on the C. & E. I. R. R., 644 feet. Aylesworth is 150 feet lower than Beeville and 130 feet lower than New Richmond. The water then must have been held in by a barrier approximating 150 feet in height to account for the overflow channels south along the eastern edge of the Champaign sheet. The altitude of the overflow channels toward the south would give the lake lying north and east of the divide a depth increasing with the northeastern slope to more than 100 feet at Dayton in eastern Tippecanoe County, whose altitude is 673 feet, as compared with 787 feet at Kirk-


WARREN
TIPPECANOE
FOUNTAIN
MONTGOMERY
PARKE
LAFAYETTE
W. Lafayette
WABASH RIVER
Wea Plains
Wild Cat Prairie
Dayton
West Point
Independence
Attica
Shawnee Prairie
Romney
Twelve Mile Prairie
Sugar Grove
Clarksburg
Beeville
Kirkpatrick
Lye Creek Prairie
New Richmond
Linden
Portland
Aylesworth
Osborne Prairie
Covington
Veedersburg
Williatte
Darlington
Crawfordsville
Fayuga
Sugar Creek
Waveland
Brownsville
Rockville
Clinton
Rosedale
Tippecanoe River
L.E.&W. R.R.
C.C.C.&I. R.R.
T.H.&I. R.R.
C.&E.I. R.R.
I.B.&W. R.R.
LEGEND
Moraines
Boulders
Lake Boundaries
Lake Outlets
Boundary of Champaign till.
REGION OF THE GREAT BEND OF THE
WABASH RIVER
DRAWN BY W.A.McBETH.
0 5 10
Scale of miles.

patrick or 776 feet at New Richmond. The recession of the ice from the present line of the Wabash removed the back wall from this arrangement of features and the gradual cutting down of the valley of the Wabash eventually drained the larger and several succeeding smaller lakes and permitted the establishment of the present drainage of southeastern Tippecanoe County.

It may now be said that an extension of the same process further north and the disappearance of the ice along the line of the Tippecanoe to its great bend, and along the upper Kankakee, while the ice still occupied the country to the west, would make quite simple the problem of Lake Kankakee and other temporary glacial lakes.

The arrangement of moraines along the north bank of the three forks of Wild Cat Creek together with the pirating of the heads of several southern tributaries of the Wabash indicates a comparatively rapid northward recession of the southern edge of the Erie lobe.

The region embraced in the Wabash basin still doubtless presents in almost every county interesting problems for the intelligent investigator who may care to look for them, and the facts and opinions here set forth are intended as suggestions to be verified or rejected by others or myself, after further investigation.

Note: In No. 3 and No. 4 of maps illustrating the development of the Wabash drainage system I have indicated the probable line of interlobate melting. I have suggested the name Tippecanoe Gulf for this reentrant area.

A Theory to Explain the Western Indiana Bowlder Belts.

By W. A. McBeth.

The proximity of the bowlder belt southeast of Independence, Warren County, to the moraine which parallels it a little distance to the west, is a marked relationship. The bowlders lie on and along the foot of the eastward slope of the moraine. Where the slopes are gentle the belt widens out, and on the abrupt slopes the width decreases and the bowlders are more numerous. There are also patches of them on the ridges and knolls that lie to the east at levels lower than the main divide. Bowlders are not infrequent anywhere in the whole of western Indiana, but are