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PHYSIOGRAPHIC HISTORY OF FIVE RIVER VALLEYS IN NORTHERN OHIO*

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INTRODUCTION.

The Area Studied.

The area studied is a portion of northern Ohio about midway in the state from east to west and north of the divide between the Erie and Ohio drainage basins. It embraces parts of Sandusky, Erie, Huron, Lorain, and Cuyahoga counties with portions of Seneca, Wyandot, Crawford, Medina and Summit counties farther south. Field work actually covered the five valleys of Sandusky, Huron, Vermilion, Black and Rocky rivers, with their main tributaries.

Physiographic Provinces.

The region is located on the Lake and Till Plains south of Lake Erie, so its history is linked up rather closely with that of the Great Lakes and of Glaciation in North America.

Structure, and General Physiographic History.

The structure of the area is simple; upper Paleozoic strata dip southeast on the eastern limb of the Cincinnati anticline. The strata lie nearly horizontal. There are no local anticlines or synclines of any importance. There is, however, in some places local bowing up of Devonian and Mississippian shales

*In its original form this paper was submitted by Mr. Champion as a part of the requirement for the degree of Master of Arts in Oberlin College, 1924. Since the degree was granted the paper has been considerably reduced in size, but the authors do not think its value as description and explanation has been impaired. Practically all of the territory described in this paper has been seen by both authors and the paper in its present form is in all respects a joint paper.

accompanied by slight shearing, faulting and brecciation. At Lodi is a fault of 8 feet in the Cuyahoga formation. The structure has very little to do with the subsequent history of the rivers. Initial drainage may have followed jointing and fissuring in the shales, but as there are no important faults, this does not seem likely.

The limestones in the western part of the area dip underneath the black Ohio shales in the central part, and these in turn pass under Berea and Cuyahoga sandstones and associated shales in the eastern part.

Throughout Tertiary time erosion was going on in the Great Lakes region. This Tertiary erosion cycle was very long, for it resulted in the broadening out of the valleys which probably opened in the direction of Hudson Bay, or an old St. Lawrence,[1] into very mature to old valleys. The Great Lakes occupy, in part these Tertiary river basins.[2]

If the weight of the glaciers warped down the crust of the earth that gives opportunity, now the ice is gone, for the present uptilting to the northeast, because when the glaciers withdrew, the resiliency of the earth's crust would respond with gradual uplift.[3] This may be a factor in the explanation of the location of the present drift divide, and more certainly of the lakes themselves. The drainage would not be away from the glaciers, as was the case south of the divide, with the making of outwash plains and eskers, but directly towards their retreating fronts, thus causing lakes wherever free flow was prevented.

There occurred five or six incursions of the glaciers; in our area three distinct invasions of the ice are known. The first two deposited a blue drift, most of whose remnants are unoxidized, analogous to the Illinoian; the third brought the light tan to brown oxidized drift of Wisconsin age. In the Interglacial Periods our area may have been the scene of re-excavation of broad Tertiary valleys or the carving of new connecting rock valleys, as suggested by buried gorges. These gorges could not have been the result of pre-Pleistocene erosion as at

[1]GRABAU, A. W. Niagara Falls and Vicinity. New York State Museum Bull. 45, v. 9, Apr. 1901, pp. 37-54.
SPENCER, J. W. W. Falls of Niagara. Canada Dept. of Mines, Geol. Survey Branch, 1905-6, pp. 412-428.

[2]RUSSELL, I. C. The Laurentian Basin. Journal Geol., vol. 1, pp. 394-408.

[3]HOBBS, W. H. Earth Features and Their Meanings, pp. 344-347.

this time the area was broadly peneplained[4] and gorges would be inconsistent unless made immediately preglacially by waters partially impounded by the ice.

As the glaciers retreated for the last time proglacial lakes were formed, the first of which was Lake Maumee, covering some of western Ohio and of northeastern Indiana as far west as Fort Wayne. Its outlet was past Ft. Wayne by way of the Wabash, Ohio and Mississippi rivers. By farther retreat of the glacier front and the uncovering of a lower outlet, the Lake fell to the Whittlesey stage; its outlet was by way of Ubley, through central Michigan into Lake Chicago; from there its route was by way of Chicago, DesPlaines, Illinois and Mississippi rivers. The third lake stage was Lake Warren, whose outlet was through a lower channel north of Ubley and through Grand River into Lake Chicago; from there on the route was that of Lake Whittlesey. Finally, the drainage of the Great Lakes Region was reversed[5] in the direction of the St. Lawrence Basin due to farther warping and farther retreating of the ice and uncovering of lower outlets to the east.[6]

It is just before the Lake Maumee stage that the rivers[7] of our area began cutting through the till. Some of these rivers first emptied into wide embayments in the lake a little south of their present forks. The present branches of these rivers were separate streams at that time. The history of these rivers has been one of repeated rejuvenation with periods of stability caused by the stand of the temporary lakes, Maumee, Whittlesey and Warren, and by their rapid lowering from one level to the next. This stability is shown by temporary base levels with reference to shore lines. The present erosion cycle is one in which the post-glacial streams north of the drift divide are deepening their beds in lake clay, drift and in Paleozoic strata. These rivers may be characterized as young, although in places defended terraces demonstrate advanced youth.[8]

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[4]WILSON, A. W. G. The Laurentian Peneplain. Journal Geol. Vol. 11, 1903, p. 645.

[5]LEVERETT, F. Mon. 53, U. S. G. S.

[6]PIRSSON, L. V., and SCHUCHERT, C. E. Textbook of Geology, 1915, p. 951.

[7]CARNEY, FRANK. Abandoned Shore Lines of the Oberlin Quadrangle. Bull. Sci. Lab., Den. Univ., 1910, p. 102, f.

[8]FISHER, W. D. Terraces of the West River, (Conn). Proc. Boston Soc. Nat. Hist., Vol. 33, p. 40.

General Physiographic Features.

The area consists of Till and Lake Plains, sloping gently north to Lake Erie; the altitude of the drift divide is approximately 1,000 to 1,100 feet, that of Lake Erie 573 feet, while the altitude of the intervening Lake Plain is from 600 to 780 feet and the till plain rises from 780 feet up to the divide. The Till Plain is generally level, but slightly hummocky in places, whereas the Lake Plains have an even more level surface. These Lake Plains, however, are not wholly featureless, for they are set off into strips, roughly parallel with Lake Erie by ancient lake ridges.[9] These lake ridges are prominent and two are continuous across the entire state. They represent former Post Glacial lake levels. Butternut Ridge represents the Maumee shoreline, Middle Ridge the Whittlesey, and North Ridge the Warren shoreline. There were minor ridges such as Sugar and Chestnut, which may have been formed as off shore bars.

These ridges attain an altitude of from 10-20 feet above the surrounding lake plains and are perceptible as gentle elevations of very regular outline. Because of their good drainage these ridges are utilized for road beds, residences, orchards, gardens and cemeteries.

The main features of the present lake shore are escarpments of blue, fissile Ohio shale, rounded cliffs of buff, yellow lake clay or glacial drift, drowned river mouths with marshy inlets and several sections of sandy beach. Most of the streams run parallel with the lake beach a short distance just prior to their embouchure.

The Till and Lake Plains are being dissected by streams which have cut deep gorges in their lower courses[10] meandering in and out in a sinuous northerly direction.

DESCRIPTIONS OF THE VALLEYS.

This section will consist of a general description of each of the five valleys, followed by a more detailed description of each, from the sources to the mouth. The reader will do well if possible to read, with a topographic map* of each area discussed.

[9]CARNEY, FRANK. Abandoned Shorelines of Vermilion Quadrangle. Bull. Denison Univ. Sci. Lab., vol. 18, pp. 362-369.

[10]DEWEY, HENRY. Origin of Some River Gorges in Cornwall. Q. J. G. S., Vol. 72, p. 65.

*Maps covering the area may be ordered by name as shown on the Survey index sheet from the U. S. Geological Survey, Washington, D. C.

SANDUSKY VALLEY IN GENERAL.

The Sandusky River rises in Jackson township, Crawford County, in several creeks and runs around Crestline. The river flows southwest from the outer foot of Wabash moraine which it follows westward along its southern slope in a circuitous course until it breaks through the moraine on the Wyandot-Crawford county line. It then receives Broken Sword Creek and follows Ft. Wayne moraine until it breaks through that in Pitt Township, Wyandot County. From here it bears northward to McCutcheonville on the southern border of Defiance moraine. Near the moraine it receives Tymochtee Creek. For four to five miles it follows eastward along the southern side of Defiance moraine, then breaks through and proceeds almost northward past Tiffin and Fremont to the Bay. The river drains the larger part of Crawford, Wyandot, Seneca and Sandusky counties. The upper course drains Till Plains and three moraines, the middle part limestone and lake clay plains, while the lower reaches of the river drain only Lake Plain.

This is the longest river studied, having a water course of nearly a hundred miles. The river has a winding and irregular course except for four miles north of Tiffin, where the valley is narrow. From Fremont north the valley opens out very much and becomes shallow. Its few tributaries in its middle part almost make falls when they enter the main stream, for, because of their lesser volume, they are unable to keep up with it, in its erosion of the resistant Niagara limestone. Other tributaries from the east side are Sycamore, Willow, Morrison, Honey, Sugar, Indian and Bark creeks, while from the west side enter Muskellunge and Wolfe creeks. These tributaries often flow parallel with the main stream for the greater part of their courses, showing them to be the result of consequent drainage of the till and lake plain slopes.

The gradient of the river from Tiffin to the mouth is three and one-half feet per mile, from Tiffin to Fremont five feet per mile and from Fremont to the mouth one and two-thirds feet per mile. The gradients of the tributaries are generally much greater. From Fremont north, as we can see from the gradient of the stream, the river is nearer grade than above Fremont, showing the progress of erosion on the main stream.[11] This

[11]DAVIS, W. M. The Geographical Cycle. Geographic Essays, pages 266-272.

steeper gradient is also seen in the presence of several dams just north of Tiffin.

The river has exposed several buried valleys, one south of Fort Seneca, one two miles farther north, and one at Fremont. In the limestone the river gorge is shallow compared with the gorges of the other rivers in shale and sandstone. This is because of the difficulty with which the limestones are eroded. Near the mouth where the stream works in the lake clays its meanders are long and gradual and its banks are low. Here the river has almost reached grade as shown by contiguous marshy areas.[12]

The Sandusky Valley in Detail.

East of the Bucyrus Reservoir the valley of Sandusky River is the normal young valley in drift. A little flood plain has developed. West of the town the river meanders but scarcely systematically yet. It is not old enough. Most of the way for 20 miles to the southwest the river has entrenched itself in the drift. The upper bluffs are moderately steep and are far back from the stream. Three miles below Bucyrus there is an isolated hill close to the north side of the valley made by the combined action of main stream and small branch. In section 26, Pitt Township, the river through the work of a meander is about to cut off an oxbow around a hill, which may thus become isolated.

Two miles north of Wyandot there are two isolated hills in a very broad valley. The stream crosses an old valley here. Three miles southeast of Upper Sandusky the valley again widens and the stream follows a meandering course, in its broad flood plain; apparently another buried old valley.

North of Upper Sandusky the river cuts into hard resistant limestone quite continuously to Fremont. Just north of Upper Sandusky the river turns east where there are rock terraces on the north side of the valley and a broad flood plain on the south. The upper bluffs are composed of local lake clay and drift, while the lower ones are composed of resistant limestone. The river meanders northeast then zigzags north. This winding course is not due to normal shifting of the stream as is the case with normal meandering, but it is due to Till Plain irregularities.[13]

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[12]NEWBERRY, J. S. Geol. Surv. Ohio, 1878, pp. 593, 611 and 625.

[13]LEVERETT, FRANK. Glacial Formations of the Erie and Ohio Drainage Basins. Mon. 41, U. S. Geol. Surv. pp. 583-604.

For two miles north of Old Tymoohtee the stream pursues a straight course in a limestone bed. The river then turns east, north, west, north, then south to get around glacial knobs which obstruct its path. This general crookedness continues to Mexico, where the river turns into the big Defiance moraine. Actual meanders begin at the moraine. They increase in size a little down stream as the river gets larger.[14] The meanders above the Maumee shoreline are an inheritance of those developed at the Maumee Lake stage. The old Maumee shoreline runs through Tiffin. In Maumee time the river meandered back and forth on its broad floodplain just as rivers now often do near their mouths. When the lake level fell the stream entrenched itself again giving rise to terraces. Just south of Tiffin the meanders become straighter as the river cuts deeper into its resistant limestone bed. The upper bluff slopes are often gently rounding, while the lower ones are straight and steep.

Right in the town of Tiffin the river is buttressed by walls so that its banks are not exposed. Where the river banks are exposed, however, they present a bold front of crystalline dolomitic limestone, capped by several feet of surface soil, probably mostly lake clay; limestone is more and more exposed as the river cuts its way into this resistant formation.

The terraces at Tiffin present a rolling surface and possess at least two levels with two fronts, the upper terrace front being more rounded on account of longer exposure to subaerial erosion. Willow Creek enters the Sandusky River about a mile northeast of Tiffin, where it falls over limestone ledges twenty feet in a half mile. A little farther down, Morrison Creek does the same thing. Occasionally the terraces are defended by projecting ledges of weathered rugged limestone, drab and rounded, cherty and full of holes.

The valley is the result of normal down-cutting with successive halts as shown by occasional submature upper terraces. Here the down-cutting has been so rapid that there are neither meanders nor floodplains. Long ledges of whitish limestone crop out along the river banks.

In this resistant rock, erosion produces gentle relief contours; and there are no decided bends in the river until it enters the drift of buried valleys, several miles north of Tiffin.

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[14]Davis, W. M. Development of River Meanders. Geol. Mag. Decade 4, vol. 10, 1903, p. 146.

Evidences of former activity of the river are found in large potholes, undercuts and whirlpool basins high above the present stream.

The descent of the river across the limestone barrier is very rapid as shown by numerous rapids, a falls northeast of Tiffin and two dams farther down stream. The valley is rather narrow to a point three miles north of Tiffin, where it begins to widen out.

The Westerhouse road bridge is about four miles north of Tiffin. A quarter of a mile north of this bridge the river turns a little east and falls over rapids, then follow smooth reaches[15] for we have passed the limestone bed and entered a buried valley, attested by boulders of glacial origin in the stream, the absence of limestone outcrops and the presence of plastic clay banks. This clay is exposed in a road cut a half mile north of the bridge, also in the old Fort Seneca road. Just south of here a ravine enters containing no limestone. The terraces of this ravine are hummocky and irregular, characteristic of erosion in glacial drift. This is more evidence of the buried valley.

This absence of limestone continues in the river banks for a half mile. In the drift area the river has characteristic clay banks with a deeper concave curve of water erosion[16] and more irregular bluffs with even rounded tops at the sky line.[17]

The large curves of the river in Pleasant Township are not true meanders. They are too large for this stream as shown by comparison with other streams. They are due to inequalities of the drift surface upon which the river started and probably to some influence of buried valleys. The smaller curves one or two miles south of Fort Seneca are apparently true meanders and of the proper, consistent size for Sandusky River.

Two miles east of Fort Seneca the river enters and flows very tranquilly northward through a drift-filled buried valley section for about two miles, then it is again confronted by the limestone through which it cuts a rather straight and narrow valley, all the way to Fremont. Wolfe Creek and its East Branch are both on the rock or very near most of the way. Valleys are

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[15]DAVIS, W. M. Elementary Physical Geography, p. 255.

[16]MERRILL, J. H. Principles of Rock Weathering. Jour. Geol., Vol. 4, 1895, p. 850.

[17]CAMPBELL, M. R. Drainage Modifications and their Interpretation. Jour. Geol., Vol. 4, p. 570.

shallow and streams are generally just crooked without systematic meanders. About three miles south of Kansas a rather large loop has been artificially cut off.

Near Fremont a relatively recent stream diversion has occurred. The river is on the rock and flowing east at Ballville. It formerly made a turn to the north then turned back west and went through the gorge (now a black earth celery farm) in the southwest part of Fremont, then flowed east again in the valley occupied now by the little creek. This diversion was caused by the meanders to the east cutting through the drift in a buried valley and thus allowing the river to straighten out and take the present course. The extreme western bluffs of the abandoned valley are seen at the Soldier's Hospital.

At the Lake Shore and Michigan Southern railroad bridge there is a broad, even flood plain on the east side of the stream. Limestone banks are soon lost sight of. North of Fremont the river makes long meanders and its banks are low and composed of till beneath and lake clay above; finally nearer the lake only lake clay is seen in the banks. The meanders are even more slightly curving, the river banks are low and there is much adjacent marshy land. Similar marshy conditions occur at mouths of all streams entering Sandusky Bay. This shows an uptilting of the lake basin to the northeast and a drowning of the mouths of the rivers entering it from the southwest.

HURON VALLEY GENERAL.

The sources of Huron River lie on the Till Plains and moraines south and east of Willard. Two main streams are thus built up, West Branch and East Branch. The river drains Huron and a part of Erie counties. The Branches flow on the Till Plains to the Maumee Beach at Monroeville and Norwalk, then on Lake Plains to Huron and Lake Erie. The branches unite about two miles about Milan.

In the upper courses the branches have low banks and narrow valleys, while near the fork the courses are meandering. The terraces are better marked above the fork, while below the fork they are trimmed off and the valley is more or less gorge-like. Near the mouth the terraces merge into an even, gentle valley slope, no well marked terraces being found. The mouth is slightly drowned as shown by marshy inlets.

A mile south of Monroeville the West Branch cuts down into Huron shale, while the East Branch does not reach shale until two miles south of the fork. Where the river is in shales steep banks are found and clay ironstone concretions stand out in the river bed like tree stumps.

The upper course of the river represents all the features of drift erosion, such as hummocky terraces, uneven banks, landslides, alluvial fans, sand bars and abandoned river channels. The middle course of the river presents youthful features such as trimmed-off terraces, gorges, rapids, large meanders, incipient cut-offs, sand bars and spits, as well as other features found in the normal erosion and denudation of sedimentary rock. The lower course of Huron River presents features of advanced youth such as semi-base-leveled terrace slope, where the lines of individual terrace fronts are obliterated and long and gentle curves in the course of the river.

Huron Valley in Detail.

East of Plymouth, West Branch wanders aimlessly westward upon the till, and has carved out for itself the shallowest of valleys. Near Plymouth it enters the Ft. Wayne moraine and has hilly topography on each side. From there the course of the stream is north. Between New Haven and Graham School the valley is V-shaped and distinctly in infancy.

At Graham School it enters the big Defiance moraine and though very crooked manages to remain in the moraine until within about four miles of Monroeville. The river cuts deeper into the drift, winds back and forth in a northwest direction in its wide drift valley as far as Greenfield School, and there turns north between drift bluffs which become less and less prominent. In this course through moraine the stream meanders well and has a typical flood plain. Finally the river flows right out upon the Lake Plain in a straight course, except for one meander, north for two miles to Standardsburg; there it begins cutting into Huron shale and cuts deeper and deeper into this shale, so that at Monroeville a rather deep gorge has been carved.

At Monroeville the stream begins typical meandering again. This time the curves are distinctly larger than in the moraine because the stream is larger. The town is mostly on a tongue in a meander loop. A half mile to the north there is a drift-filled

gorge exposed in the east side of the present gorge. Here boulders are found at the bottom of the buried valley, while its southeast side rises as a vertical bluff of Huron shale capped with till. A mile farther north in the Milan road there is a south facing scarp of Huron shale buried in drift, which shows that this filled valley may have been three-quarters of a mile wide and that its direction is probably northeast. Since it is so youthful a feature it is no doubt interglacial.

About two miles and a half southwest of the fork the gorge deepens greatly; narrow canyons are also developed in the laterals. There are no terraces. The main stream meanders back and forth across its gorge floor. Occasionally remnants of terraces are found locally defended by rock ledges, but this is unusual. It is at this point that Seymour Creek enters the West Branch. Its deep gorge is evidence of the rapid rate at which dissection of the area is going on.

The streams which unite near North Fairfield to make up East Branch have very young valleys with no terraces. From this junction, the course of the river lies just east of a north and south esker for about four miles; the banks are low and there are no terraces. The stream scarcely meanders at all.

At Macksville there are three or four terraces apparently due to normal down cutting, as farther up stream they do not exist, but gradually come into existence farther away from the river source. Below Macksville for two and a half miles the terraces are broad and the banks of the river are low. The river now turns northeast, leaving the moraine and flows across the Maumee shoreline and Lake Plain in a V-shaped valley cut in lake clays. The river becomes incised; its course more meandering than it was farther up stream and its scrolls of floodplain neatly developed. Terraces adorn the sides of the valley and meanders are rather typical. At the highway between Monroeville and Norwalk there is a broad flood plain near a meander curve. These valley forms signifying great erosion are due to the ease with which the lake clays have been eroded and carried away. The tops of the bluffs are strewn with glacial boulders and the outline of the top of the valley sides is broken by the erosion of numerous laterals.

The river proceeds northward from this meander section in a very crooked course with sharp turns; there are long narrow islands in the stream, sand bars and newly formed tiny fans.

The stream is entrenching itself. This continues to the junction with West Branch.

At the bridge a mile south of the fork, shale is seen cropping out in the river banks and the valley begins to take on the appearance of a gorge; north of here the upper part of the bluffs is hummocky and uneven in spite of the fact that it is composed of lake clays, while the lower part of the valley has the definite outlines characteristic of a bluff composed of shale. This is due to the rapid erosion of many little laterals in the clays.

East of the junction is a low area a half mile wide separated from the river by a ridge. The low strip is open at the west to East Branch and at the other end to Huron River. East Branch formerly took a turn through this area entering Huron at least a mile below the present mouth. Near the present mouth an incised meander came close to West Branch and by lateral planation the ridge between was finally cut out and the present courses established, and this low area became an abandoned channel around an isolated hill.

North of Milan the rolling gently sloping valley walls continue; the stream makes wider meanders on more marshy floodplains; river banks become lower still and terrace fronts become obliterated. Finally at the Lake Shore road bridge at Huron, terrace fronts are no longer seen; there only remains a gradual slope from the Lake Plain above to the water course below.

Meanders are very normal and typical below Milan. They have grown in several instances to full size for such a stream and are migrating down valley trimming the bluffs and laying flood plain as they go. When a few more meanders shall have slipped down the valley the bluffs will be straighter and the meander belt will be clearly lined out.

The river mouth is drowned, as shown by ponding back of lake water for half a mile in the river. A sand bar has been thrown up by the waves part way across the mouth of the river. This is a normal thing when a rather weak stream flows into a lake with much energy.[18]

[18]GOLDTHWAIT, J. W. Abandoned Shorelines of Eastern Wisconsin. Wisconsin Geol. Surv. Bull. No. 17, pp. 48, 49.

GENERAL DESCRIPTION OF THE VALLEY OF VERMILION RIVER.

The Vermilion River rises from Savannah Lake at an altitude of 1,020 feet in an old valley well plugged with drift. The upper course drains Till, while the lower course drains Lake Plains, the river crossing the Maumee beach about six miles from the lake. The area drained is a strip six to eight miles wide, from the center of Ashland, through Huron and the western part of Lorain counties to Lake Erie. It is about to be pirated[19] by the West Branch of Black River, seven miles southwest of Wellington.

The important tributaries of Vermilion River are on its east side, although the river gathers the drainage for the entire basin. The East Branch rises in several heads around New London and flows northeast in a circuitous course for nine miles to a point two and a half miles north of Clarksfield, where it enters the main stream. The East fork rises from the confluence of two creeks just south of Kipton and enters the main stream fourteen miles by river course south of Lake Erie. Chance enters the Vermilion River in a deep gorge still nearer Lake Erie. The gradient of the river from the fork to the lake is lower than from the source to the fork, showing the progress of the process of maturing. The valley is oldest at its mouth but this condition of submaturity is taking possession farther and farther up stream.

Vermilion Valley in Detail.

Vermilion River drains the north end of Savannah Lake; the course of the stream is northwest in a large old rock valley, but between low lying valley slopes. The drift is very hummocky and marshy in places. There are few laterals in this part of the valley. Three or four miles southwest of New London, the old valley becomes wholly obscured by the drift. About two miles southeast of Fitchville the river bluffs become higher because the stream has cut more deeply into the drift. At Fitchville the river crosses the Defiance moraine and from here it meanders in short loops in a northeast direction nearly to the lake. Near Clarksfield there are two and in places three terraces along the bluffs. The valley floor is relatively narrow.

[19]DARTON, N. H. Examples of Stream Robbing in the Catskill Mts. G. S. A. Bull., Vol. 7, 1896, pp. 505-507.

Just east of Clarksfield the river crowds close to the east side, leaving a broad, fertile flood plain on the west and a steep bluff on the east, whose upper slopes are rounded erosion forms in drift. Farther down the slopes, fans are built and hummocks carved from the easily eroded drift. Below the mouth of East Branch the terrace on the east side of the stream furnishes grounds for a sightly residence. Two large meanders and a series of small ones occur between here and Wakeman. When the valley widens, the bluff is far back from the river on one side, while on the opposite side the river usually undercuts steep drift banks.

At the highway bridge at Wakeman gray shale is seen in the river bed and part way up the banks and thus here begins the rock influence in the form of the valley. North of the dam the river valley deepens with some step terracing in the valley sides. A half mile north of Wakeman there are many small laterals which dissect the valley sides, leaving rounded promontories between them.

Three miles north of Wakeman, Berea sandstone crops out in the river bed and here the valley is steep-sided and narrow. Two and a half miles south of Birmingham the river cuts into the Bedford shale, which makes loose and crumbly banks; a half mile farther north the river reaches Cleveland shale which makes steep valley sides, great flat ledges of this fissile shale crop out in the river bed, which at low water is a bare rock flat.

From this point to within three miles of Lake Erie, Vermilion River meanders on a broad level flood plain hemmed in by gorge walls 70–80 feet high and composed of blue, black and red shales.[20] As down cutting has gone on many terraces have been made and the earlier ones have been trimmed off.[21]

Two miles south of Birmingham the East Fork enters the river from the south east in a similar deep gorge; the East Fork rises near Kipton, where two little creeks converge; their valleys are wide and spacious, because of the ease with which the drift is eroded. Chance Creek enters the main stream three and a half miles farther to the northeast; it is a boisterous stream with a rocky and rugged bed. The sides of its gorge are

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[20]DEWEY, HENRY. Origin of Some River Gorges in Cornwall. Q. J. G. S., Vol. 72, pp. 64-66.

[21]FISHER, W. D. Terraces of the West River. Proc. Boston Soc. Nat. Hist., Vol. 33, 1906.

steep and cragged because carved in more resistant shales. Just north of the mouth of Chance Creek in the east side of the valley stands an isolated hill which is the result of the cutting off of an entrenched meander. Below this cut-off meander is another larger one not yet cut off. It has not yet been able to begin its migration down valley, but twists and turns in its own area, gradually widening its valley.

From Rugby down to the lake the bluffs decrease in height because the slope of the land is steeper than the present grade of the stream. Many meanders have developed and slipped along down the valley, planing off the bluffs until they are nearly straight parallel walls bounding the meander belt. Small terraces occasionally occur.

The swampy condition of the lower mile or two testifies again to the recent tilting of the Erie Basin; and the sand bar across the mouth of the valley, almost shutting the river out, is the evidence of the excess of power of the lake waves over the strength of stream current.

GENERAL DESCRIPTION OF THE VALLEY OF BLACK RIVER.

Black River rises in a hundred little rills that begin on the Defiance moraine between New London and Lodi at an altitude of 1,000 to 1,100 feet. West Branch gathers a score of these together near Rochester; Charleymont Creek picks up another bunch a few miles farther east and delivers their waters to West Branch north of Wellington. The East Branch gathers from the north slope of the moraine in Harrisville Township, Medina County; West Fork collects from the south side, and East Fork from Chatham township. These two forks meet, one from the west, the other from the north, near Lodi, and become East Branch. These Branches converge in a northerly direction and meet about nine miles south of Lake Erie.[22]

The upper courses are characterized by many wide valleys which look submature because of the ease with which the drift is eroded; and in some places by channels only, valleys not having been excavated yet. The middle courses are straighter with narrower valleys, due to the resistance of the Berea sandstone and the lower course is characterized by youthful features, such as a winding gorge and many terraces in the black Ohio shale.

[22]NEWBERRY, J. S. Ohio Geol. Surv., 1878, vol. 2, pp. 206-208.

Elk Creek rises two miles west of Lagrange, flows four miles north, entering the West Branch four miles southeast of Oberlin. Wellington Creek rises a little south of Wellington and enters the West Branch three and a half miles south of Oberlin. Plum Creek rises three miles southwest of Oberlin, flows nine miles northeasterly and enters the West Branch five miles east of Oberlin.

Coon Creek enters the East Branch from the west, eight miles northwest of Lodi. On the east side the important tributaries are Crow Creek, entering eight miles, and Salt Creek, entering four miles south of Grafton. The more important tributaries are on the west side of the West Branch and on the east side of the East Branch, showing convergence of drainage toward the Elyria embayment of the Maumee and Whittlesey shorelines.

The gradient of the lower course of the river is lower than that of either branch, showing that the lower course has made greater progress. The East Branch may be considered a little older than the West Branch, as suggested by its lower gradient.

There is a temporary base level just south of the Maumee Lake ridge at La Porte[23] in the valley of the East Branch, as can be seen by its broad valley, wide meanders and low river banks. Just south of the present falls of both branches at Elyria is a second temporary base level, as seen by the low river banks of Berea sandstone and lake clays. This base level was made with reference to the level of Lake Whittlesey. A third temporary base level cannot be found, as the valley has been cut down to such a wide and deep gorge that all evidences of greater age near the Warren Lake level have been obliterated.

The West Branch of Black River works in drift until it reaches Berea sandstone four miles south of Elyria. The East Branch cuts into Cuyahoga sandstone and sandy shales at Lodi and farther north into drift; a few miles south of Grafton, Berea sandstone is reached, which serves for river bed as far as Elyria. From Elyria north with the exception of several drift filled depressions Black River cuts into Berea sandstone for two miles, then the Bedford and Ohio shales are reached. These shales are exposed in its deep gorge to the mouth of the river. The depth of the gorge decreases as the lake is approached due to the decreasing altitude of the Lake Plain.

[23]CARNEY, FRANK. Abandoned Shorelines of the Oberlin Quadrangle. Bull. Sci. Lab., Denison Univ., 1910, p. 102.

Valley of Black River in Detail.

East and West of Rochester, two tributaries of West Branch of Black River unite and continue to flow in a gradually broadening and deepening V-shaped valley. Other laterals converge northeast. There are no large terraces, but many small interlacing ones, and no true meanders, only irregular and abrupt turns characteristic of drift erosion. The valley at the main road west of Wellington has a submature appearance due to the ease with which the drift is eroded. A fringe of tributaries has roughened the topography for a half mile each side of the stream.

Beyond this road to Wellington the valley becomes three-quarters of a mile wide. The bluffs have Hogarth curves.[24] There are many short meanders which are entrenching themselves as evidence of the recession of Lake Erie. The flood-plains are cut up with side channels, meander cut-offs and other signs of aging. In some places uplands are very rough and hummocky and where local heaping of the drift has occurred the valley grows narrower between steep drift hills.

As the stream descends the Till Plain its bluffs become lower and about two miles northwest of Wellington it seems to emerge directly upon the Till Plain. Charleymont valley is very similar and has its shallowest part west and southwest of Wellington. Wellington Creek resembles the other branches very much. It becomes a true meandering stream about two miles above its mouth.

Just above the Wellington-Oberlin road, West Branch adopts a true meandering habit, but its meanders are very small in order to be in harmony with the size of the stream. Where the meandering habit begins the flood plain becomes distinctly broader. Five miles east of Oberlin where the stream turns north, three terraces occur, the highest being an eighth of a mile wide, and the two lower ones only a few feet in width. The high terrace or old flood plain was made with reference to a former temporary base level and now the stream is entrenching itself in its old bed.[25]

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[24]HICKS, L. E. Some Elements of Land Sculpture. G. S. A. Bull., Vol. 4, 1893, pp. 133-146.

[25]CARNEY, FRANK. The Abandoned Shorelines of the Oberlin Quadrangle. Bull. Sci. Lab. Denison Univ., 1910, p. 104.

For about five miles below the mouth of Wellington Creek many good meanders have been made and most of them have migrated a little downstream. For this reason several fine flood plain scrolls occur. Probably no meander in this whole section has shifted down its width, but it will not be long now until several will have done so, thus greatly straightening the course of the bluffs. About a mile below the mouth of Plum Creek a fine typical meander has been cut off. If this cut-off had not occurred so soon, in its down stream migration it would have cut through into the next turn and thus have made a typical isolated hill. The neck today is little more than wide enough for the road.

At the mouth of Plum Creek a nice network of tiny step terraces is seen, some of which coalesce at the mouth. Several other terraces occur up Plum Creek, for it has meandered well much of the way from Oberlin down. About three miles above the junction the river encounters the Berea sandstone and is straighter in its course. At Elyria the stream makes a wide meander west and north, then turns east and follows the south side of the Whittlesey Lake ridge until it meets the East Branch, its whole course here being entrenched in the sandstone.

The East Branch just north of Lodi encounters Cuyahoga shale and is influenced much more by bed rock than the West Branch. From Lodi the East Branch flows northwest in a circuitous course with dissected bluffs and narrow floodplains for about three miles. Then the valley opens out and flood plains are broader, and meanders are wider and more numerous. Between here and Grafton meanders and cut-offs can be found in almost every stage.

Three miles southeast of River Corners some of the meanders have almost cut themselves off; one meander has built out a sand bar[26] cutting off its own channel beyond the newly made sand bar next to the bluff. Sand islands are common in this section. Another meander is closing up its meander curve with a sand bar, while it continues to flow in the cut-off. In another place the meander loop has been abandoned and the stream now flows in the cut-off; the abandoned loop is easily made out by a line of trees which border this abandoned channel. At one place a fallen tree has dammed up the meander curve

[26]TOWER, W. S. Development of Cutoff Meanders. Am. Geog. Soc. Bull., vol. 36, 1904, pp. 589-599.

and so a cut-off has been developed, after which the water rose so much in the meander loop that the old channel is now being carved out again and the main stream now flows in the meander curve.

In this part of the valley the bluffs are dissected and rounded at the top; at the confluence of laterals small terraces are developed with here and there small alluvial fans. Here the terraces are almost always dissected and uncertain. The great width of some of the lateral valleys might indicate the tributaries to be in valleys carved before the main valley existed; but as these laterals are not continuous on opposite sides of the main stream the great width of their valleys must be laid to the ease with which the drift can be eroded. The bluffs of laterals appear more mature, due to surface wash; all their step terraces are trimmed off, whereas in the main stream terraces have been much better preserved.

At River Corners, Black River makes a slender loop to the northeast. On the east side there are bluffs of till twenty to thirty feet high, while on the west, terraces slope back from the river. The upper terraces are rolling and dissected by laterals which have a general northward trend. The high bluffs at River Corners appear to be due to thickened drift which backs up drainage and produces a swamp or kettle just east of the stream. From the loop at River Corners the river flows straight north through a wide flood plain. From here north to Penfield there are many incipient cut-offs and cut-off meanders.[27]

From Penfield six miles northward the river has a winding course. Its meanders become very intricate. There are sharp bluffs of till where the stream makes abrupt turns. The meanders become more and more incised. From about two miles south of LaGrange to a mile north of the LaGrange road there are three steps of terraces. The second terrace front is the most prominent showing that rejuvenation in the present formation of the third terrace front has been very recent. The terrace tops are broad and even, and the terrace fronts are regular and crescentic.

About a mile north of LaGrange road the stream begins to cut its way into Berea sandstone. Step terraces cease and the river bluffs are steep and straight and close to the stream.

[27]TOWER, W. S. ibid.

Dissection is well under way as shown by two prominent laterals coming in from both sides about three-quarters of a mile southwest of Grafton. These laterals have developed little valleys in the drift. In the river itself are numerous rapids, and rectangular blocks of sandstone stand out as bold promontories at turns in the stream.

Just west of Grafton the Black River Valley is characterized by gently rolling slightly terraced bluffs. The stream flows with gentle curves in its course in a westerly direction; its bluffs are composed of alluvium above and Berea sandstone below. The river bed consists of horizontal beds of Berea sandstone jointed into blocks. The stream racing over the resistant Berea sandstone like a mountain torrent has a youthful character.

At the Oberlin Road Bridge west of Grafton where the stream has uncovered many weathered sandstone blocks in the stream bed, the valley sides are very regular, with even upper drift slopes. Thence the stream pursues a straight course northwest for two miles, where the valley, a rock gorge, is very narrow. About three miles south of Laporte the valley leaves the rock and is carved in drift, hence widens; and large meanders are found, which represent the advanced youth of the valley at the time when the East Branch of Black River entered Lake Maumee at Laporte. Just south of Laporte the stream turns east for a mile to avoid Butternut Ridge, the Maumee Shoreline. It then breaks through the ridge, where enters from the east the tributary, which also follows the base of the lake ridge. This tributary makes a wide bend to the south before entering the main stream; the bend may be explained by local heaping of the lake ridge sands. (See Oberlin Topographic Map).

North of Laporte the stream pursues a rather straight course to Elyria; river banks are low and near together, and there are many rapids in the stream bed. Some huge sandstone blocks are exposed by undercuts. The upper valley slopes are straight, regular and gentle, being composed of Maumee Lake clays.[28]

In Elyria the stream flows straight north until it makes a big meander to the east after which it turns west to avoid Middle or Whittlesey Lake Ridge. These Elyria curves of the Branches are rather symmetrical and afford an interesting crotch for the city.

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[28]CARNEY, FRANK. Abandoned Shorelines of the Oberlin Quadrangle. Bull. Sci. Lab., Denison Univ., 1910, p. 102.

At Elyria both Branches of the Black River have cut back gorges in Berea sandstone for a quarter to a third of a mile from the fork. The falls of the East Branch drop over massive layers of gray drab Berea sandstone, while the falls of the West Branch are not so great and the ledges are more broken. The gorges below the falls are very steep sided with bold promontories of massive sandstone; here also are "caves," potholes, undercuts, and many big sandstone boulders.

A buried valley is found in Elyria recognized by the absence of rock and presence of drift filling in many places. On both sides the East and West Branches a little west and south of the fork respectively and across Washington Street to the East Branch above the falls these drift fills are known, locating the old valley thrice intersected by the new. In the main valley a half mile north of the fork at the children's playground, where the valley widens greatly, there may be another buried valley.

Near the fork west of the main stream is an ancient river falls with a pothole and undercutting, and other youthful features. The Bear's den is now nearly below this falls site. At the Whittlesey Lake stage the Branches of Black River emptied by separate mouths. As the lake retreated to the Warren stage the river mouths developed falls at once.[29] As the West Branch turned from paralleling the old lake ridge to fall over its former mouth northward, considerable undercutting at the turn took place. This carried the channel toward the East Branch, which it finally reached. We do not know how far the falls of the East Branch had receded at that time, but the channel where cut through must have been lower than the West Branch top of the abandoned falls or else that branch could not have been taken in; hence we assume that the falls of East Branch had retreated at least as far as the junction point, probably not much farther.

The river which flowed north over the abandoned falls was very young, and did not work there long, since the valley abandoned is not deep, but similar in character to those above the present falls in the East and West Branches.

There is a line of large Berea sandstone blocks across the valley one hundred yards below the present junction. When the lake retreated to the Warren Stage the waters of both East

[29]DEWEY, HENRY. Origin of Some River Gorges in Cornwall. Q. J. G. S., vol. 72, p. 66.

and West Branches made waterfalls over this rock ledge; undercutting took place so that large caves were developed beneath the falls just as are seen in the falls of West Branch today. The cave of the West Branch can still be seen at the bear den. On the East Branch a tunnel was formed by undercutting and by a small trickle working its way through a crevice and enlarging the opening. This made, of the falls, a natural bridge or sandstone arch which in no very distant past fell in, as one can infer from the massive blocks in a straight line across the valley marking the site of the old arch.

North of the line of sandstone blocks the valley widens out into a large amphitheatre with hummocky, irregular, and uneven valley sides of drift. Just north of the amphitheatre sandstone ledges reappear and the valley narrows again to a sandstone gorge a distance of about two miles.

Beyond this gorge section Black River has cut itself a much wider gorge whose bluffs are from 70–80 feet high. This gorge is cut in blue Ohio shale. Within the gorge the river meanders upon a level valley floor. The meandering habit persists practically all the rest of the distance to the lake. This meandering section illustrates several points in the history of such a stream. A node is established by the Warren Beach about four miles north of Elyria. Here the river took a large curve, much too large for a meander, to get around the beach and find a way through it.[30] This curve is so large that the river has not widened the valley much by lateral cutting, but the incised curve with its valley cut deeply in the shale has held the river from more swinging and has prevented the migration of meanders past this place.

Above this restriction the meanders during their entrenching have behaved very normally, widening as they have cut down so that two spurs or meander tongues show the long sloping tip so characteristic of such growth. Further, one meander in this part of the valley about two and a fourth miles below Elyria cut itself off long ago when the river was on a level fully thirty feet above the present, producing an isolated hill. The hill top stood some thirty feet above the cut-off of that date. The straightened stream however abandoned the cut-off and reoccupied the channel west of the hill and proceeded to erode it to

[30]GOLDTHWAIT, J. W. Abandoned Shorelines of Eastern Wisconsin. Wisc. Geol. Surv. Bull. No. 17, p. 48.

the present level. During the down cutting the meanders grew each side of the hill and now they threaten to cut through again where the old cut-off occurred.

The flood plain crescents in this section are very typical. Terraces occur at two or three places.

In this section for three miles below the Warren Beach or as far as the big turn westward into Lorain, the meanders, six or eight in number, are slowly slipping down stream in a very interesting and typical fashion. Four miles southeast of Lorain the river turns sharply to the west and takes a winding course in that direction to its mouth. There is considerable drowning near the mouth, as seen by numerous marshes, and ponding back of water in side streams. The steel company has dredged out a large turning basin for ore boats near their docks.

GENERAL DESCRIPTION OF ROCKY RIVER VALLEY.

Rocky River is the only one of the five streams studied that really heads back in the Allegheny Plateau province, although Vermilion for a few miles below Savannah Lakes, and East Branch of Black River near Lodi both flow in large, old, preglacial valleys.

The West Branch of Rocky River has sources in the plateau near Boneta at altitudes 1,100 to 1,200 feet. The East Branch has many sources in Royalton and Richfield townships in northwestern Summit County, some of which are over 1,300 feet above sea level. The main stream begins a mile north of North Royalton and flows eight miles southeast in an old valley of the plateau, then turns abruptly, enters another similar but larger preglacial rock valley and flows northwest an equal distance without getting anywhere over two miles from the portion flowing in the opposite direction.

Rocky River exhibits the phenomenon of bifurcation just below the earliest Maumee shoreline at Olmstead, and, as was the case with Huron and Black rivers, formerly flowed into Lake Maumee as two separate rivers. The important tributaries enter from opposite sides of the drainage basin and the adjacent sides of the Branches have few tributaries, in harmony with the interpretation that the two Branches entered the lake in the same very old preglacial valley at an embayment of the lake.

The temporary base level of the Maumee shoreline is found recorded in many characteristics of advanced youth north of the falls of the East Branch and about two miles to the south of the fork. The lower temporary base levels are scarcely discernible on Rocky River.

Description of Rocky River in Detail.

West of Boneta the north side of the valley has numerous step terraces above which rises a gentle slope northward to the top of a knob at an altitude of 1,204 feet. The course of the river northwest is irregular, due to the blocking effect of the drift. In this part of the course of the river the laterals come in from almost any direction, because of uneven distribution of drift over the old rock topography. Barbed tributaries do not indicate captures. Terraces are few; the valley is V-shaped, with rolling hills of drift on either side. A mile southeast of the Medina-Cleveland road the flood plain widens for several miles and carries above it terraces with rounded fronts. The town of Liverpool is on a broad flood plain on the west side of the river. From here north to Hardscrabble the river meanders in an ever deepening and widening gorge. Its flood plain is broad and level. A half mile north of Copopa the river has incised its banks and the higher terraces are straight and regular. Between Hardscrabble and Copopa and beyond, the meanders are numerous and well developed. They have migrated freely down stream, trimmed the bluffs until this section has a marked meander belt. A mile below Hardscrabble, a meander has cut itself off and left an isolated hill.

A mile above Westview the river begins cutting into the hard Berea sandstone and so has a valley a great deal narrower, with bluffs steeper and straighter. There are many rock ledges protruding from the river banks; at turns in the river huge rocks stick out. From here north to Olmsted Falls the gorge becomes deeper, straighter and narrower; there are no terraces for the bluffs are close to the stream.

A mile and a half north of Olmsted Falls the river works its way into shale; the bluffs are not so steep as before, because composed of crumbly shale; there are a considerable number of terraces at many points. The river continues in these black shales to the lake. Blufffs vary from strikingly youthful ones to sub-mature, depending upon the time since the river has been

undercutting them. Large laterals through headward erosion have cut their way back into the shale and made ravines deep for side valleys. Such laterals are more numerous on the west side of the valley showing the convergence of drainage toward the Rocky River embayment. The laterals have upper rounded promontories between them and tiny valley systems all their own as evidence of progressive dissection of the area. The main stream is very active, due to the high gradient which is more than ten feet per mile in this part of the river. In the flood plain are often found abandoned channels littered with rock debris as evidence of recent floods.

Immediately northeast of Olmsted there are two isolated hills which are a quarter of a mile in length and perhaps a little less than that in width; their long axes are northeast. (See Berea Topographic Map). The East and West Branches of Rocky River now meet at Cedar Point; a sharp cusp-like bluff of bluish gray shale. At one time the two branches of Rocky River met just north of the north isolated hill. This may be seen by the relatively more mature appearance of the valley to the northwest of north hill than the present valley of the West Branch just west of Cedar Point. It may be shown also that the Branches met here before they met just east of the south hill because the valley north of the north hill has a floor a few feet higher than the floor of the valley east of the south hill, but sloping down stream and the bluffs are more mature in the former valley than in the latter.

It may be seen that the West Branch flowed south in the valley east of the south hill and that the East Branch did not flow north in this valley because the valley northwest of the north hill is a few feet higher than the valley east of the south hill.

The making of the valley between the hills may be explained by undercutting of both branches as they swing toward each other until they cut through and allowed West Branch to enter the other. It then followed East Branch and abandoned its course around north hill because East Branch had the lower valley floor. In a similar way meander curves in the branches undercut towards each other until they met between Cedar Point and south hill. West Branch went into East as before because it there had a lower course. Examine the bluffs of the valleys and sides of the hills to see how their curves and relative steepnesses all conspire to support this explanation for the hills.

East Branch of Rocky River in its upper five miles has no terraces and the bluffs merge imperceptibly into the upland slopes. Probably the stream has not greatly modified the valley since the glaciers left it.

West of West Richfield the valley deepens and has in its lower part a steeper V-shaped profile. The river flows south here to conform to preglacial rock topography which is well mantled with drift. In Southeast Hinckley township it turns west and northwest around the base of a rock hill and enters a preglacial valley which it follows nearly to Berea. It usually exposes drift but occasionally encounters rock. The stream pursues a northwest course in an ever broadening valley with even, gentle upper slopes, the drift mantled bluffs of the preglacial rock valley. This old valley leads east of the town of Berea and is occupied by Abram's swamp and creek to the Big Four tracks, where Gould found a well boring two hundred feet to rock.

Baldwin Creek in its lower course crosses this buried valley which explains its greater width and well developed flood plain in its last mile. Just north of Strongsville the valley is unusually wide, showing the presence of the drift buried valley.[31] In this section to Berea the stream has many small meanders which have migrated down stream planing off the valley walls and widening the flood plain. There are numerous back channels, flood channels and curves with incipient cut-offs. Some of the meander loops are very short and turn back upon themselves around neat meander tongues. The flood plain is very level. The stream is working in drift and Cuyahoga shales.

Through Berea the Branch is in a rock gorge of Berea sandstone, narrow, rugged, youthful and, south of town, much defaced by quarrying operations.

Just north of the town the stream cascades over Berea sandstone making a high waterfall below which the gorge is deep and rugged, with bold promontories of sandstone, caves and undercutting, while the stream bed has potholes and rapids.

A half mile north of the falls, sandstone is no longer seen in the gorge side; instead Bedford and Ohio shales crop out. A

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[31]NEWBERRY, J. S. Geological Survey of Ohio, Vol. 1, pp. 171 and 172.
LEVERETT, FRANK. Glacial Formations of Erie and Ohio Basins. Monog. 41, U. S. G. S., p. 617.

tiny alluvial fan in one place, composed of Bedford shale waste, rests upon the darker blue Ohio shale. Three small drift sections in the valley walls within a short distance below Berea indicate buried valleys.

In about two miles (bee line) above the confluence of the branches, East Branch has eight good meanders. As they developed they became entrenched and began migrating down stream. None has yet moved its width, but most of them have slipped partly out of their initial curves.

On the east side of the stream are many tiny parallel channels the precursors of a fringe of lateral valleys like those on the east side of Abram Creek. Here is also a deserted flood plain or terrace, higher than the present flood plain. On this terrace is a fan which gives a clue to the age of the present flood plain, because the amount of time represented in the making of the fan would not exceed that which the stream took in the cutting of its present channel and the making of the lower flood plain.

Below the isolated hills the valley widens and frequent step terraces have been carved. Abram Creek enters the main stream a mile below the fork in a rocky gorge. Two miles up stream a meander in East Branch threatened to capture Abram's but turned aside in time to avoid the piracy. Two miles south of the Lorain Street bridge a small tributary on the east side enters the main valley headed upstream. It must have had to dodge a subordinate ridge of the Maumee shoreline before entering the lake; then when the lake fell, the river came and took it in. The main stream is now endeavoring to take this tributary in, nearly one half mile above its present mouth. It would then be a splendid hanging valley, with an abandoned valley behind an isolated hill.

Just south of the Lorain Street bridge in the main valley, there is a long isolated hill fifty feet high, composed of drift; to the east are three ravines leading into the abandoned valley behind the hill. It seems probable that the main stream once ran east of this hill and swung west in two meanders, one before going behind, the other after. Subsequently these meanders cut into each other and the river left the course east of the hill for one west. Drift is exposed in the ravine farthest to the south, shale and drift in the middle ravine and drift in the ravine farthest to the north. This whole problem is worked out in a buried valley, probably the one occupied by Abram

Creek farther south. The buried valley is known on the west side from here to the lake. The shale in the middle ravine points to an isolated hill in the old drift-buried valley. The mouth of this buried valley, Newberry found at Kings Camp, two miles west of the present mouth of Rocky River.

Summarized, these several notes on the buried valley, it may be stated that an old preglacial valley partly filled with drift from southeast of Hinckley almost to Berea is occupied by East Branch. In places the stream touches the old rock walls. The buried valley leads almost straight north, across the lower mile or so of Baldwin Creek, east of Berea, and the Fairground, through Abram swamp and creek, to the Big Four tracks, then, on north without a stream until it is crossed by Rocky River just above Lorain Street. From here it leads to the lake on the west side of the present Rocky River.

For a mile north of the Lorain Street bridge, Rocky River has a broad level flood plain lying at the bottom of a ninety foot shale gorge, but at the end of the mile, the valley becomes very narrow and the river turns west around a big loop, then east again and north. The large loop is not a true meander, but is due to the effort of the stream to get through the old Whittlesey Beach. At the west end of this loop the bluffs as well as those of the little laterals entering here, are of drift. This is the evidence that Newberry cited of a continuation of the large buried preglacial valley "two miles above its mouth." Undercutting at the east end of this large loop may easily produce an isolated hill.

North of the meander the river flows straight north for a half mile; here the shale banks are moderately steep. The river swings first to one, and then to the other side of its narrow floodplain. The floodplain appears to the observer at the top of the gorge as long slender ovate beads strung on the blue ribbon of the river.

A mile south of the lake shore road bridge the river meanders to the west and then flows straight north where the gorge is wider and deeper; the precipitous gorge walls are composed of grayish blue shale.

At the lake shore road bridge the river has carved out for itself a steep sided gorge whose walls are composed of grayish, drab, fissile shale, very thinly bedded. Just north of the bridge there is a sandbar whose long axis is parallel with the river course; this bar is composed of reddish alluvium.

At the very mouth of the river, jutting out from the east bank is a double hooked spit, built by alternate deposition by river current, northeast lake wash and west shore current.

On each side of the mouth stand high promontories, (bold "sea Cliffs") of Ohio shale, showing below, a lower concave elongated curve of water erosion, and above, a rounded convex curve of subaerial erosion.[32] The lower curve is the more prominent, so that these bluffs stand out in strong relief silhouetted against the morning sky.

Discussion.

There are some significant features in the physiography of these river valleys that need fuller explanation than has been given them in the descriptive matter. Let us first turn to buried valleys. Buried valleys are not of unusual occurrence in glaciated areas.

There are two kinds of buried valleys, those with gentle mature sides and those with steep bluffs. The latter may be gorges excavated in an interglacial period or immediately before the Glacial period, when the ice dammed up the lower parts of the valleys and drainage was forced to reverse and go over the divides. The former are broad, mature to old valleys of really Pre-Pleistocene time.

In the area under discussion buried valleys are found in several places on the Sandusky River between Tiffin and Fremont, one at Fremont, one in the Huron River a mile north of Monroeville, one at Beaver Creek two miles south of Lake Erie, one in the fork of the Black River at Elyria, and one in the lower part of the Rocky River, whose mouth is at Kings Camp, two miles west of the mouth of the present Rocky River. These seem to be almost if not entirely of the gorge type.

It should be noted that the last buried valley mentioned is not of the gorge type in its upper part. Certainly at the lake it is relatively narrow. Above the Lorain Street bridge it is probably no wider than the present valley and possibly as steep-sided. It is so completely covered from here south to Berea that its character is not discernible, but above Berea no gorge type is known. East Branch flows in its own little valley far down in the large advanced mature rock valley, which leads

[32]Gilbert, G. K. Topographic Features of Lake Shores. Fifth Ann. Rept. U. S. Geol. Surv., p. 83.

from Hinckley township to Binola at least. Whether there is a gorge section continuing south of Berea somewhere is not known. We have found no evidence of it.

The buried valley exposed in the Huron River north of Monroeville and the one exposed in Beaver Creek two miles south of Lake Erie show steep buried escarpments of Ohio shale. These gorges must have been carved out by streams which were rejuvenated upon the retreat of the ice in an interglacial period. These valleys could not have been preglacial, because at that time the surface was carved into broad open valleys. Probably most of the buried valleys in the area studied where there is an abrupt discontinuation of bedrock, are valleys of this type. These gorges were cut in large old preglacial valleys or across divides from one valley to another.

Evidences for the wide preglacial valleys are found in the embayments or the drainage systems which converge toward older lake embayments represented by large curves in the abandoned lake ridges; further buried valleys are actually found in these drainage basins. Old rock hills with slopes of 2–3 degrees are found in many places in our area. These are the higher lands between the valleys or the walls of the very mature, buried, Pre-Pleistocene valleys. Such hills barely protrude now through the drift. One may be seen one and one-half miles south of Berlin Heights, another across East Fork-Vermilion north eastward from Kipton. In the summits of several of them quarries for the sandstone have been opened.

A second topic for discussion is that of river terraces. Terraces in our area are not as well pronounced or as common as might be supposed. In the first place in the lower part of the river courses where terraces were formed, the development of gorges and migration of meanders have trimmed off most of them. In the second place, in the upper part of the river courses where terraces have developed, the loose texture of the drift of which they are composed offers no resistance to surface drainage, so that soon the terrace fronts are dissected and finally the whole becomes a gentle valley slope.

That the absence of terraces in the lower courses of the rivers is due to terrace trimming by the stream through its lateral and down stream shifting is shown by the presence of fragments of terraces that do remain in the lower courses of the river, on the side of the valley opposite from which the stream now flows.

Cases in point are the terraces of Ballville and of Rocky River just south of Cedar Point on the east side of the West Branch. Another evidence of the terrace trimming is the presence of remnant terraces capping overhanging undercut bluffs. The next flood season may find the stream on the opposite side of its valley undercutting terraces that now seem perfectly safe. Many examples of this process can be found anywhere in the valleys on a much smaller scale.

While many of the terraces here cited are due wholly to normal down cutting as seen by absence of terraces near the river mouths and by the present process of down cutting, not a few, indeed, may be due to an interrupted erosion cycle. Examples of such terraces are found in many places just south of the old lake shorelines where the rivers are now entrenching themselves because of further rejuvenation on account of the further lowering of the lake level. These terraces have rolling uneven tops and are sub-mature in appearance.

A third topic of interest is the correlation of valley type with character of rock. There are four types of valleys in the area; the shallow limestone valley, the shale gorge, the V-shaped drift valley and the sandstone valley.

The stream bed of the limestone valley is rough, jagged, rocky and corrugated. The river banks are low and craggy with numerous undercuts; potholes are an important feature of the river bed. The flood plains are broad and undulating; there are a few narrow rock terraces, but generally the bluff rises from the flood plain with a gradual slope to the lake plains above. The rivers of limestone valleys have straighter courses and lower banks than those in the other types of valley. The shallowness of the valleys is primarily due to the general lower level of the land.

The shale gorge as exemplified in the gorges of Huron and Vermilion, Black, and the lower part of Rocky has high vertical bluffs. From the uplands the valley is not noticed until its very edge is reached. The gorge floor is usually wide near the mouths of the streams. The streams meander back and forth from one side of the winding gorge to the other. All the phenomena of the erosion of soft sedimentary strata are found, such as fans, fan deltas, sand bars, small alluvial plains, little islands, meanders and meander cutoffs.

The V-shaped drift valley is in direct contrast to the foregoing types. Its valley sides are very hummocky; interlacing terraces, small rounded promontories and heaps of glacial drift are other features of the valley side. The course of the stream has an irregular outline with sharp turns and local rapids and dams of glacial boulders. The river banks are usually low and composed of glacial drift or gravels. The flood plains are uneven and are cut by many little meanders and irregular turns of the main stream. Occasionally the valley sides are far back from the stream. The graceful Hogarth curve is often displayed in these valley sides where surface erosion has smoothed off their tops.

The sandstone valley is similar in character to the shale gorge. Where down-cutting has gone on for considerable time the bluffs are steep, with deep craggy gorges; where down-cutting has not proceeded so long, low rocky banks, wide flood plains and graceful upper slopes are features of the valley. Bold craggy promontories on a small scale are distinguishing features of the landscape. The reason for differences in the types of these valleys may be found in the way in which the rock resists erosion. Limestone is affected largely through solution, shale is weakest along joint planes, drift due to its loose texture is very readily carried away, while sandstone, very resistant toward solution, is weakest toward mechanical agents of erosion.

Another physiographic feature of interest is the isolated hill. Three have been described in Rocky River gorge, three in the upper course of Sandusky River valley, while there is one of prominence in the lower course of Vermilion River gorge, just north of where Chance Creek enters the main stream, and a small one at the fork in Huron River valley.

Isolated hills may originate in several ways; they may arise simply as islands by the formation of meander cut-offs when the stream has entrenched itself; or they may be the result of undercutting on adjacent sides of two meander loops in an already deeply incised gorge. They may originate at the confluence of two streams when either or both undercut toward each other and so meet farther up stream. Examples of this mode of origin are found in the isolated hills at Cedar Point and in the isolated hill at the fork of Huron River. Another type of origin of the isolated hill may be found in the work of a small lateral in combination with that of the main stream; a

case of this type is that of the small stream coming into Rocky River headed up stream, midway between Lorain Street bridge and the confluence of the branches. The isolation is not quite completed yet.

A good example of the isolated hill derived from the entrenching of a meander cut-off is found in one just north of the mouth of Chance Creek in the lower Vermilion gorge where behind the hill is the outline of the old meander, while the present stream flows in the cut-off.

Another physiographic feature of interest is the parallelism of drainage basins in a part of our area, and the convergence of many of the tributaries toward shore lines of former lake embayments. The former occur where the abandoned pro-glacial lake plains descend rather uniformly to the present lake. The latter by contrast, are found where there were Tertiary Valleys, which were tributary to axial Erie Valley and, in spite of ice erosion and deposition, which still persist strong enough to make embayments in successive abandoned shorelines, and to direct the post-glacial drainage towards their own axes.

Summary Conclusions.

1. The rivers of the area studied are consequent streams upon the till plain, initial upon the retreat of the glaciers, increasing in length at their mouths as the ice withdrew, flowing north from the morainic divide into successive pro-glacial lakes.
2. The direction of the streams has been determined by:
   (a) General northward slope of the Till Plain in Lake Erie Basin as caused by either:
      (1) Pre-glacial erosion resulting in very mature valleys parallel to each other and tributary to axial Erie Valley, as a part of the great Tertiary valley system of the Great Lakes region, or in base leveled inter-stream areas down which parallel streams now flow.
      (2) Crustal downwarping of the Erie Basin.
      (3) Depression due to the weight of the ice.
   (b) Till Plain irregularities, such as moraines, kettles, knobs, and eskers.
   (c) Uncovering of buried valleys.

(d) Blocking effect of present and former lake beaches, causing streams to parallel the lake shore for a distance before their embouchure.

3. Gorges, waterfalls, rapids, incised meanders and high terraces are due to repeated rejuvenation of the streams caused by progressive retreating of Pro-glacial Lake Erie through Maumee, Whittlesey, Warren and other stages.
4. The advanced youth of some of the valleys just south of the old shore lines indicates temporary stability of base level in the successive pro-glacial lakes when the rivers worked at grade near their mouths.
5. There are distinct types of valleys whose physiographic features owe their variety to the character of the rock eroded. The types of valley are the shallow limestone valley, the shale gorge, the V-shaped drift valley and the sandstone valley.
6. Vigorous dissection and denudation of the area is in progress.
   (a) The tributaries of the main stream have a dendritic pattern because slightly modified by irregularities in the drift, such as kettles, knobs and eskers and old shore lines.
   (b) Consequent drainage of the immediate lake slope is vigorous.
   (c) Miniature peneplanation is shown in many valley gorges where isolated hills rise as monadnocks from the valley floor.
   (d) Through headward erosion of the main streams higher gradients have moved farther up stream and the low gradients of the mouth sections have extended in some cases many miles upstream.
7. Convergence of drainage in Huron, Black and Rocky River drainage basins is due to very old preglacial valleys partly obscured by drift.