

MAP OF THE MOHAWK VALLEY REGION

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TOPOGRAPHY AND GLACIAL DEPOSITS OF MOHAWK VALLEY

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PRESENT TOPOGRAPHY

The Mohawk river, having its sources among the highlands of Lewis and Oneida counties, pursues a course of 130 miles to the Hudson. The direction is southerly 20 miles to Rome, then south of east to the discharge at Cohoes and Waterford. The altitudes, which do not depart widely from the present floodplain of the river, are, as given by Macfarlane for the New York Central railway, as follows :

Rome.....	445	Fort Plain.....	305
Oriskany.....	423	Palatine Bridge.....	304
Whitestown.....	415	Sprakers.....	301
Utica.....	410	Yosts.....	300
Frankfort.....	402	Fonda.....	299
Ilion.....	400	Tribes Hill.....	305
Herkimer.....	398	Amsterdam.....	279
Little Falls.....	376	Cranes Village.....	270
East Creek.....	334	Hoffmans.....	266
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The river level at Aqueduct, 4 miles below Schenectady, is 205 feet, and at Cohoes, above the falls, 130 feet; below, 70 feet. The Nine Mile, West and East Canada, and Garoga creeks, are the more important tributaries from the north, while the Oriskany, Sauquoit, and Schoharie enter from the south. The immediate valley is narrow and steep-sided to Delta, six miles above Rome, where it enters the Iroquois basin. This basin contracts to a river valley eastward from Rome, but continues broad and open toward Little Falls, with a concavity of bounding slopes which suggests powerful glacial erosion. At Little Falls the well known gorge continues for about two miles, followed by a fairly open valley to Schenectady, except at the Noses and Hoffmans. Near Schenectady the valley widens as it enters the great Champlain-Hudson lowland, and the river zigzags by a shallow and immature channel to the Hudson.

The importance of the valley as a topographic feature is not appreciated until one stands on some commanding point of view on the uplands. We then discover a great trench 1,500 feet deep and from 12 to 20 miles wide. Such points of view are Starr hill, in northern Oneida county—altitude, 1,793 feet—and Tassel hill, near the south border of the same county—altitude, 1,948 feet. Northeast of Utica, within 6 miles of the

valley, several hilltops rise to 1,500 and 1,600 feet. The foothills of the Adirondacks come down close to Little Falls, while the Utica shale area about Johnstown and Gloversville is reduced to levels of 600 to 800 feet. On the south the Catskills grade down to the plateau level of central New York, lying south of the Helderberg escarpment, with common altitudes of 1,500 to 1,700 feet. An exceptional slope appears at Rotterdam, where an altitude of 1,385 feet is attained within a mile and a quarter of the valley bottom. One thousand to 1,400 feet are common heights for the southern parts of the Fonda and Amsterdam atlas sheets. Geographic reasons for town sites abound. Six cities lie upon the short course of the stream, and more than that number of large and important towns. A ford, waterfall, or open ground at the mouth of a tributary is the usual physiographic factor in the history.

PREGLACIAL DRAINAGE

CRETACEOUS PENEPLAIN

Studies of the region are not sufficiently matured for confident assertion. Besides large tracts to north and south, the Herkimer-Sprakers section of the immediate valley is yet unmapped, but considerations have developed which seem worthy of statement. Until the district is mapped, it is reasonable to assume from much general observation that the plateau south of the valley, extending into Pennsylvania, is a part of the uplifted and dissected peneplain described by Davis and others for the eastern and southern Atlantic region. The structure is the same as in northern Pennsylvania, "a peneplain on which successive formations crop out, one shingled on the next as we cross the country."*

These formations originally extended much farther to the north, carrying the peneplain to an undetermined distance in that direction. An outlier of Potsdam, Calciferous, and Trenton is now found at Wellstown, 12 miles from the body of these formations, at Northville. The Hamilton rocks would overreach much of the present course of the river if carried northward for an equal distance from their present outcrop, and the same may be said with stronger emphasis for the Helderberg series of limestones. Into the northern edge of the great peneplain, the Mohawk valley was cut by prolonged erosion.

COURSE OF ADJUSTMENT

It is assumed that the ancient constructional streams led from the Adirondacks south and southwestward across New York into the Penn-

* W. M. Davis: The geological dates of origin of certain topographic forms on the Atlantic slope of the United States. Bull. Geol. Soc. Am., vol. 2, p. 560.

sylvania region. It is also assumed that the Hudson valley is a product of Tertiary erosion,* and that there was a Laurentian valley before the elevation of the Cretaceous peneplain. Westgate points out that the Laurentian drainage is of the subsequent order, and that the adjustment by which waters originally flowing southward were led to course along the strike of the Paleozoic beds, may have taken place in the Permian-Cretaceous interval.† It is assumed in this paper that the southern Adirondack streams and Susquehanna headwaters may be truly considered as descended, without serious modification of location or direction, from streams consequent on Paleozoic topography.‡ It is to be also remembered that the Mohawk valley is near and roughly parallel to the pre-Cambrian-Paleozoic contact. This contact line is irregular, both on account of Adirondack folding and the Mohawk valley faults. Overlying the relatively thin Calceferous and Trenton, and less subject to the irregularity produced by faulting, is a thick but yielding mass of Utica and Hudson River shales. Given therefore the growing Hudson valley and a steep upland on the west, with the tough Adirondack masses on the one hand and the hard Helderberg and Hamilton terranes of eastern New York on the other, it was to be expected that a valley would be formed with headward cutting westward along the Utica-Hudson strike. But for the irregularities above noted the river would almost surely have kept the north boundary line of the Paleozoic, as is conspicuously the case with Black river, which flows for 50 miles with slight divergence from this line. Dr Bell, of the Canadian Geological Survey, has made some interesting observations as to the effect of glaciation on such a contact.§ Apparently the Mohawk headed west as far as Little Falls. The Mohawk may therefore be considered a monoclinical valley, though structural irregularities and inequalities of glacial erosion have somewhat disguised this chief character. In harmony with this view, Dana many years ago noted that the southern plateau was higher than that lying to the north.|| He, however, defined the valley as "geoclinal." In similar fashion, as it seems to the writer, a subsequent valley was formed from the ancient Laurentian valley, heading to Little Falls. West of Rome it may have passed along the axis of Oneida lake or farther south. In any case the form of the Iroquois basin on the east appears to be due to

* W. M. Davis: The Catskill delta in the Postglacial Hudson estuary. *Proc. Bost. Soc. Nat. Hist.*, November, 1891, p. 319.

† Lewis G. Westgate: The geographic development of the eastern part of the Mississippi drainage system. *Am. Geologist*, April, 1893, p. 245.

‡ On the probable character of such topography see Chamberlin and Salisbury: Driftless area of the upper Mississippi valley. *Sixth Ann. Rep. U. S. Geol. Survey*, p. 224.

§ Robert Bell: On glacial phenomena in Canada. *Bull. Geol. Soc. Am.*, vol. 1, p. 296.

|| J. D. Dana: On the existence of a Mohawk Valley glacier in the Glacial epoch. *Am. Jour. Sci.*, 2d series, vol. xxxv, 1863, pp. 243-249.

the narrowing and thinning eastward of the Medina, Clinton, Niagara, and Salina formations.

The Adirondack waters on the south and west were thus diverted by the Mohawk, the Black, and what we may call a "Rome" river. The Susquehanna was robbed of much of its territory, and its beheaded affluents now contest the ground in a losing struggle with the southern tributaries of the Mohawk, for in steep gradients and proximity to tidal water the Mohawk has a large advantage over the upper Susquehanna. Some headwaters of the Oriskany and Sauquoit seem clearly to have been pirated away from their former connection southward. This conquest of territory finds an apt parallel in the landward migration of the Appalachian divide and the beheading of the rivers of Kentucky and Tennessee by the "Appalachian" river.*

COL AT LITTLE FALLS

The existence of a water parting at this point is set forth briefly, but with much confidence, by Chamberlin. His language is as follows:

"It was here, as I think, that a preglacial watershed parted streams that, on the one hand, flowed eastward to the Hudson, and, on the other, westward to the Ontario basin. Neither glacial erosion nor accumulation has been here sufficient to obliterate the main features of the preglacial topography. The watershed may be quite confidently and exactly located near Little Falls. The cutting of the upper and broader rock-gorge of the Mohawk at that point appears to have been the work of the earlier Glacial epoch and of interglacial drainage. It certainly antedated the close of the Glacial period, for the ice passed through it, rounding and scoring its ledges, but appears to have in no great degree modified its form or enlarged its capacity."†

The writer believes that the above conclusion is fully sustained by further studies. The Little Falls station of the New York Central railroad is not far below the top of the gneiss at that point, and the altitude is 376 feet. Thence the river descends for about a mile and a half to an altitude of 322 feet at the fault. Restoring at least 118 feet for postglacial gorge-cutting in the gneiss at that point, we find a barrier having an altitude of 440 feet. We must add to this an unknown amount for glacial or other erosion during the long progress of the Glacial period. As will appear later, the Little Falls fault determined the position of the divide by interposing the most resistant rock-mass between Hudson valley and lake Ontario. In addition, we have the important fact that the rock bottom of the valley descends, though not uniformly, from Little Falls to

* C. W. Hayes: Southern Appalachians. Nat. Geog. Monographs, p. 322. Hayes and Campbell: Geomorphology of the southern Appalachians. Nat. Geog. Mag., vol. vi, p. 108.

† T. C. Chamberlin: Preliminary paper on the Terminal moraine of the second Glacial epoch. 3d Am. Rep. U. S. Geol. Survey, p. 362.

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the region of lake Ontario. The arrangement of tributary streams to the west is also more normal to a westward than an eastward flowing stream. An inspection of the course of the Sauquoit, Oriskany, and Nine Mile creeks will support this suggestion, particularly if the hint given later as to the former course of the West Canada creek proves tenable. The upper Mohawk for several miles above Rome probably also took a more westerly course. Decisive weight cannot be given to the arrangement of streams in this case, however, since a normal dendritic arrangement is hardly to be expected if a subsequent Rome river diverted its tributaries from consequent courses.

ROCK TOPOGRAPHY WEST OF LITTLE FALLS

Information concerning wells between Little Falls and Oneida, as above indicated, demonstrates descent of the rock floor westward, and also seems to prove the existence of a rock basin between Utica and Little Falls. The records at hand are given below.*

At Herkimer a well was put down by the West Canada creek, perhaps a half mile from the main valley, disclosing the following succession:

	<i>Feet.</i>
Black loam.....	5
Coarse gravel.....	20
Lacustrine clay.....	100
(40 feet north of well clay is only 30 feet thick.)	
Fine gravel.....	22
Sandstone boulder.....	7½
Gravel (to rock).....	2½
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At Mohawk, on the south edge of the valley, a well at the knitting mill, by the canal, shows this section—rock not being reached:

	<i>Feet.</i>
Sandy loam.....	18
Blue clay, no pebbles.....	20
Thin beds of gravel and sand, including much quick-sand.....	106
	<hr/> 144

At Ilion we have the following from the well at the Remington Standard Typewriter works. The mouth of the well is at 405 feet above tide, and the location on the south edge of the floodplain. The drift is 195 feet in thickness, mainly of fine gravel. Two beds of quicksand, each

* The writer is indebted for well records to Dr E. G. Kern, of Herkimer; Messrs B. B. Van Deusen and A. N. Russell, of Ilion; E. A. Rowland and Dr W. L. Kingsley, of Rome, and P. H. Foley, of Utica. The last has drilled extensively in central New York.

8 to 10 feet, were encountered, but their position is not given. There is no clay in the section, though clay is common south of the canal, in the town, adjacent to a tributary stream. Thus a well at the Armory is 72 feet deep and shows—

	<i>Feet.</i>
Sandy loam and gravel.....	11
Blue clay, about	60

The clay is reported as fine, with pebbles rare, but, if present, believed to be waterworn. Another well, a quarter of a mile south of the canal and 90 feet deep, shows alternating clay, quicksand, and some layers of coarse sand or fine gravel.

In the eastern part of Frankfort village, 20 rods south of the canal, the well of Mr George Tapling affords this section:

	<i>Feet.</i>
Loam and gravel.....	16
Fine blue clay, no sand or pebbles.....	48
Quicksand to clay.....	3
	<hr/>
	69

At Harbor, 4 miles east of Utica, rock appears at about 45 feet. In Utica several wells are well spaced across the floodplain. The first is by the river, on the south edge of the floodplain, with depth to rock, 63 feet. The second is at the tollgate, with rock at 58 feet. The third is between the tollgate and Deerfield Corners, with rock at 42 feet. At Deerfield Corners rock is found at 33 feet and thence at less depths to the south side. Rock continues at about these depths to Stanwix, near Rome, and then descends to the west. None of the wells from Stanwix eastward, sunk midway of the valley, show fine, smooth clay without pebbles, but the usual material is "clay hardpan." As a rule, the stones are coarser toward the bottom. One $4\frac{1}{2}$ feet in diameter is noted, while those of from one to one and a half feet in diameter are said to be very common. These statements are on information of Mr Foley.

A well was bored for gas by the Rome Factory and Building Company near the Central railway. The drift section is appended:

	<i>Feet.</i>	<i>Inches.</i>
"Top dressing"	3	7
Sand.....	17	
Clay	20	
Quicksand.....	25	
Clay.....	20	
Hardpan to rock.....	31	
	<hr/>	<hr/>
	116	7

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Several other gas wells at Rome show the following drift sections, in all cases to the rock :

<i>Second Rome Well.</i>		<i>Fourth Rome Well.</i>	
	<i>Feet.</i>		<i>Feet.</i>
Artificial filling.....	16	"Sandy loam".....	75
Clay.....	14	Clay.....	39
Coarse gravel.....	87	Hardpan.....	8
Stones and hardpan.....	8		
	<hr/>		<hr/>
	125		122
 <i>Third Rome Well.</i>		 <i>Fifth Rome Well.</i>	
"Sandy loam".....	70	"Sandy loam".....	50
Clay.....	7	Hardpan.....	8
Hardpan.....	6		
	<hr/>		<hr/>
	83		58

The "sandy loam" reported is probably a fine silt-like sand. A general section shows hardpan, probably boulder-clay, overlain by fine clays, and these in turn by fine sands, with one thick intercalation of gravel. At the Rome cemetery rock was found at 70 feet. At Saint Marys cemetery, northwest of Rome, a boring of 166 feet did not reach rock. The material was nearly all sand and gravel. At the Silver Plating works, Oneida, the depth is (probably) 170 feet to rock. At the Warner Electric and Power plant, Oneida, a depth of 117 feet was attained without striking rock. Nearly all the material was quicksand. A slight layer of gravel was found at 50 feet, another at 100 feet, and 3 to 4 feet of coarse gravel with cobblestones were penetrated at the bottom. About Durhamville 40 to 60 feet of fine clays are common, overlain by 15 to 18 feet of sandy loam and glass sand. At Sylvan beach, Oneida lake, 150 feet were traversed without rock. At a depth of 22 feet 60 to 70 feet of clay were encountered, underlain by gravel. The altitudes of the rock bottom at the several points are approximately, as deduced from the above data, as follows :

	<i>Feet.</i>
Little Falls.....	376
Herkimer.....	241
Mohawk.....	252
Ilion.....	210
Frankfort.....	329
Harbor.....	358
Utica.....	347
Rome.....	320
Sylvan Beach.....	220

It should be remembered that in the Herkimer-Ilion section and the Rome-Oneida section these figures may not represent maximum depths in the middle of the valley.

It thus appears that between Harbor and Little Falls a true rock basin exists, 18 miles long and having an ascertained depth of nearly 150 feet below its lowest or western rim. It is excavated in soft Utica shales, and if, as appears, the work was done by the eastward-moving glacier of the upper Mohawk valley, it affords a close and interesting parallel to the rock basin part of the Finger Lake basins of western New York.*

PREGLACIAL COURSE OF THE WEST CANADA CREEK

Only a tentative statement is here offered. Reference to the map (page 183) shows that West Canada creek turns abruptly from the southwest to the southeast about Trenton Falls and enters the Mohawk at Herkimer. It is held as possible that before Glacial time its course may have continued to the southwest, past Holland Patent, along the Nine Mile Creek valley to the Mohawk, near Oriskany. The evidences are a broad open valley, adequate to the Ohio or Susquehanna, at Holland Patent and Stittville, now occupied by a minor stream; the more normal arrangement of drainage thus postulated; massive barriers of glacial debris north and east of Holland Patent; superior altitude of West Canada valley bottom below Trenton Falls as compared with Holland Patent; a very level stretch of some five miles of the West Canada creek about Poland, and the constriction of the valley about Middleville.

The supposition is that morainic obstruction blocked the old channel and sent the creek across a col not far from Middleville.

DIVERSION OF HEADWATERS OF "ROME" RIVER

The explanation is clear. Glacial erosion at Little Falls and the later, eastward, eroding flow of glacial waters would in considerable measure cut down the rocky col, while an immense mass of glacial debris was discharged into the valley, aggrading its bottom from Rome eastward. This discharge was mainly from two sources, the upper Mohawk, debouching above Rome, and West Canada creek, which, whatever its early course was, certainly formed a great outlet by Holland Patent during the recession of the glacier and while its present lower course was filled with glacial ice. This is shown by the extensive deposits of gravel and sand about Remsen, Trenton Falls, Holland Patent, and for a few miles eastward, while below Newport massive tills clog the valley to

* See A. P. Brigham: Finger lakes of New York. Bull. Am. Geog. Soc., vol. xxv, no. 2, 1893; also R. S. Tarr: Lake Cayuga a rock basin. Bull. Geol. Soc. Am., vol. 5, 1893, p. 339.

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Herkimer. Once discharged into the Mohawk valley at Rome and Oriskany, the gravels were spread eastward by the great currents flowing out by the Mohawk valley.

MATURING OF THE LOWER MOHAWK VALLEY

As described by Vanuxem, and in greater detail by Darton,* a series of faults crosses the river between Little Falls and Hoffmans. The uplift in each case is on the west, and to a greater or less degree the gneiss, the Calciferous, and Trenton are brought up within the reach of the valley-making agencies. It would be difficult to find a more instructive example of the effect of hard rocks in retarding the maturing of a valley. But for the faults the lower Mohawk should be as broad and well developed as the upper valley, unless indeed the western Mohawk glacier was more effective in excavation.

Three of the dislocations have especially influenced the topography. At Hoffmans no gneiss exposed is to be seen, but the Calciferous and Trenton appear for several miles, with noteworthy bluffs of Calciferous, and the valley bottom is but a scant fourth of a mile in width. The valley is still more immature at the Noses, both because it is farther upstream and because a greater thickness of hard rocks is encountered. The whole thickness of the Calciferous is exposed, and of the gneiss, according to Darton, 40 feet on the south side and 70 feet on the north. Strong bluffs run for several miles, attaining a height of 500 feet toward the fault, and facing the river with many slopes of 40 to 60 degrees, rising in places to the vertical. The cliff runs northward for some miles, and to the east the valley becomes at once broad and well matured. The topographic effects at Little Falls are sufficiently well known, and in general it may be said that but for the series of faults the Hudson's advantage should have anciently given it the country as far west as Syracuse. Part of the area which it lost for structural reasons it has gained by means of glaciation. It should be added that from Little Falls to Hoffmans the river flows approximately on a rock bottom. The hard rock barriers have not been breached to any extent below the level of the stream, though it is possible that minor rock basins lie between them. Rock is exposed in the bed of the river at the state dam, 5 miles below Little Falls; also on the edge of the floodplain at Indian Castle. At Saint Johnsville rock lies at a depth of 14 feet by the edge of the river. From Saint Johnsville to Palatine Bridge on the north side drift is scanty, exposures of rock being frequent and often continuous along the lower slopes. At Canajoharie and the Noses rock appears at the edge of the

* N. H. Darton : A preliminary description of the faulted region of Herkimer, Fulton, Montgomery, and Saratoga counties. State Museum Report, vol. 2, no. 48, 1896.

stream on either bank ; also on the north side at Tribes Hill and Amsterdam. Accepting the current view, which dates the faults back to the Appalachian revolution, no sign of them probably appeared upon the Cretaceous peneplain, for only by later erosion have the hard rocks been encountered.

GLACIAL MOVEMENTS

The facts are not so fully in hand as would be desired. The only constructive account is by Chamberlin, in the terminal moraine report already cited.* He briefly describes the deposits of the western Mohawk glacier, gives a number of observations of striæ, including references to Vanuxem and Dana, and says :

"I hesitate, at this stage of the inquiry, to encourage any confident opinion in regard to the exact history of glacial movements in the Mohawk valley, further than the general presumption that massive currents having their ulterior channels in the Champlain valley on the one hand and the Saint Lawrence on the other, swept around the Adirondacks and entered the Mohawk valley at either extremity, while a feebler current, at the height of glaciation, probably passed over the Adirondacks and gave to the whole a southerly trend. It should not be overlooked that this valley lies sufficiently back from the average limit of glaciation to afford the presumption that the earlier and later movements may have been quite different."

Gilbert, from later observations, appears to be in accord with Chamberlin's view.† The writer's studies have not been directed especially to this point, but a few pertinent observations have been incidentally made. The linear east-and-west arrangement of topographic forms noted by Chamberlin is strongly confirmed by field observation and by the recently issued Amsterdam and Fonda atlas sheets. Some observations of striæ were made. On the south side, between Saint Johnsville and Fort Plain, on a surface of Utica shale inclined 12 to 21 degrees south-east, are well defined groovings running north 53° to 60° west, and a minor set north 75° west. The direction of the main set coincides with that of the valley at this point. At the quarry of A. E. and D. C. Shafer, Canajoharie, on a flat surface of limestone, the direction is north 75° west. At Palatine Bridge, on a cellar bottom at the residence of S. L. Frey, the direction is north 73° west. All readings are magnetic. At Amsterdam, on the north side, above East Main street, a case was found which appears to be demonstrative of westward flow. The accompanying diagram perhaps needs little explanation. The striæ run westward on a flat limestone surface. A flake somewhat larger than one's hand

* Pages 561-565.

† Letter to the writer, February, 1897.

and from three-eighths to half an inch thick has been plucked, leaving a ragged rim to the east, north, and south, while the westward edge of

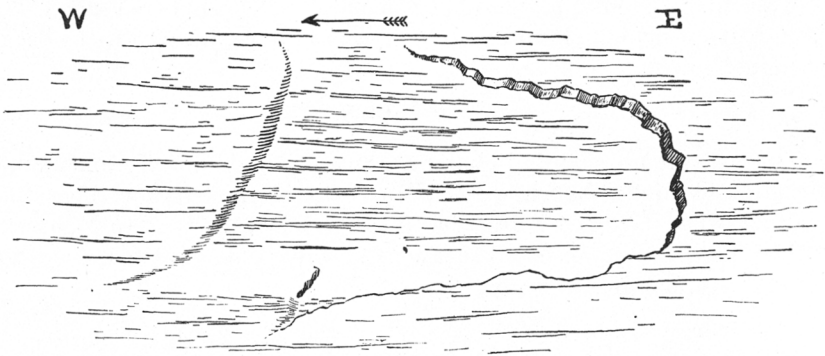


FIGURE 1.—*Striated Surface of Limestone at Amsterdam.*

The diagram is about one-half natural size. The arrow indicates the westward direction of striae.

the depression is, with one slight exception, well subdued. The inclosed space is as perfectly polished as the surrounding area, and on the west the general surface drops by a narrow bevel to a slightly lower plane.

DRIFT DEPOSITS

PREVIOUS INVESTIGATIONS

Considering that the Mohawk valley has long been known to geologists as an important channel, published observations concerning it are surprisingly few. Vanuxem alludes to a "determinate order of alluvial deposits," namely, blue clay, covered with sand and sometimes with rolled stones. He mentions a few of the large bodies of drift.* Dana, in his paper on the Mohawk Valley glacier, thus refers to the character and importance of the terraces:

"The subject of river terraces, or stratified post-Tertiary deposits, on the Mohawk and its tributaries is also one of great interest in this connection and merits a thorough examination. The deposits have some relation to the drift, as they belong to the epoch immediately following—the Champlain epoch—and consist in part, at least, of material that had been transported by the ice. They are of unusual extent on the East and West Canada creeks and other northern tributaries of the Mohawk."

Chamberlin, as already noted, gives a general description of the drift shoulders between Utica and Little Falls, and Merrill alludes to them in

* L. Vanuxem: *Geology of the Third District*, p. 212.

discussing the clays and sands of the Hudson valley,* and cites the views of Gilbert and Spencer as to their nature.

Taylor gives a short account of these accumulations and notes that they are deltas rather than true river terraces.†

The drift of the Mohawk, as might be expected from difference of position and greater complexity of relations, contrasts with the drift of the Chenango valley. The former has massive tills, few kames or kame terraces, and affords lacustrine clays above the level of the floodplain. The latter has numerous masses of kame with frontal terraces, many kame terraces, no massive tills, and all its lacustrine clays are buried beneath the floodplain.‡

The subsidence of glacial waters from the Warren to the Iroquois plane is as yet imperfectly understood. Gilbert refers to 'a baselevel higher than the Iroquois plane, "probably determined by an ice-dam in the lower Mohawk valley."§ Fairchild has made known one important stage in this subsidence by his discovery of the Geneva beach, which he has described in detail and of which he gives this summarized account :

"A well defined beach lying at an elevation of about 700 feet has been traced for 30 miles along the western side of Seneca Lake valley and westward to Shortsville, while evidences of the same static water have been noted farther west. It is supposed that these phenomena belong to a long pause in the irregular fall of the Laurentian glacial waters from the Warren level to the Iroquois level." ||

It is believed that the studies which follow throw light upon one additional stage of this subsidence. The bodies of drift lying between Westerville and Little Falls will be taken up in order.

UPPER MOHAWK VALLEY

Upper Mohawk delta.—This is the deposit made by the upper Mohawk at its entrance into the Iroquois basin. Only the southern portion, about Rome, has been mapped, and the study has been but partial. The slightly generalized map (plate 15, page 183) shows the principal relations at the head of the delta. At Westerville, 8 miles northward from Rome, the river leaves its deep trench in the northern plateau and makes a broad swing to the west past the village of Delta, returns to the east, bends sharply to the south, and passes through a gorge in the shales 80 feet

* F. J. H. Merrill : On the postglacial history of the Hudson River valley. *Am. Jour. Sci.*, vol. xli, 1891, p. 460.

† See communications by F. B. Taylor and Warren Upham in the *American Geologist*, May and June, 1892.

‡ A. P. Brigham : Glacial flood deposits in Chenango valley. *Bull. Geol. Soc. Am.*, vol. 8.

§ G. K. Gilbert : Old tracks of Erian drainage in western New York. *Bull. Geol. Soc. Am.*, vol. 8, p. 286.

|| H. L. Fairchild : Glacial geology of western New York. *Geological Magazine*, December, 1897, pp. 529-537. See also *Bull. Geol. Soc. Am.*, vol. 8, p. 271.

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deep and locally known as the "Palisades." Westernville lies upon a terrace 36 feet above the river and about 575 feet above the sea. This terrace continues southward toward the Palisades, but less simply than the figure suggests. On the west the terrace level swings, like the river, past Delta village around to the Palisades, capping a steep eroded bluff of sand and gravel 75 feet high and bordering a tract of slightly rolling drift to the west and south. The bowl-shaped depression is about 2 miles in diameter, and may have been kept open by stagnant ice, though its borders have been rimmed out by the broad meander of the stream. There can be little doubt that the preglacial river flowed past the site of Delta village into the "Rome" river; that the passage was blocked by a widespread apron of drift and the river forced to cut a new passage at the Palisades, maintaining for a time a lake in the bowl to the north. The rock surface at the top of the Palisades bluff on the east was well swept by the stream before the gorge was begun.

Rome-Floyd stagnant ice area.—Extending from near Rome and the Palisades east and southeast to Floyd is a broad and broken terrace which seems to have been formed in the presence of lacustrine waters and of stagnant ice. It is 4 to 5 miles long and varies in width from 1 to 2½ miles. Its higher surfaces rise from 520 feet above sea on the riverward side to 600 feet, where it abuts upon the hill slope at the north. Its margin is much broken with some isolated tabular masses, and resembles the kame terrace. Its top surfaces as they appear on the atlas sheet, drawn to the 20-foot contour line, are much too uniform. The sections all show sand and gravel, with inclined and discordant stratification.

Nine Mile Creek delta.—Here is one of the most interesting bodies of drift in the valley. This is not due to good structure sections, but to its relations and surface expression. There can be no doubt that the aqueo-glacial discharge from the basin of West Canada creek was chiefly at this point. The head of the delta is approximately at Holland Patent, at an altitude of 600 feet. Thence the delta extends 5½ miles to the Mohawk floodplain, where its altitude is 520 feet and its height above the floodplain 100 feet. It is narrow at Holland Patent, but widens symmetrically to 3 miles at its frontal edge, or if, as is probable, a massive bench of drift to the southeast is genetically connected with it, the width should be put at 5 miles. Its surfaces are exceedingly smooth and the mass is beautifully dissected to the bottom. The materials are coarser toward the head, and at the front consist exclusively, so far as seen, of fine sand, which at two points is kept bare by the action of the wind. The drift mantles a floor of Trenton limestone and Utica shale, and is of no great thickness, except toward the front. To the south and east runs the very massive shelf of drift to which reference has been made. It is two miles long and half a

mile wide. Its height is uniform with that of the rest of the delta, from which it has been cut off by a postglacial ravine. Like many of the drift banks of the valley, it has suffered erosion on its riverward side.

Oriskany-Whitestown sandplain.—This is a noteworthy accumulation stretching between the towns named on the southwest border of the valley. Its origin and relations are not clear. The main mass or "Oriskany bluffs" has an altitude of 540 feet. At Whitestown the altitude is 500 feet. On the valley side the slope is chiefly a product of erosion; on the west and southwest is a kame area, whose surfaces in part fall below and in part rise above the terrace, ranging between 480 and 600 feet. The mass lies at the mouth of the Oriskany creek, but both the surface expression and the internal structure appear to forbid the supposition that it is a delta related to that stream. Toward Oriskany an extensive opening at the base of the bluffs gives a section of 30 feet. At the bottom are 15 feet of very coarse, much indurated gravel, with a profusion of cobblestones and small boulders. Above the gravel, a fine, sandy silt is exposed to a thickness of 15 feet. This silt is seen in fresh excavations along the way to Utica continuously for nearly a mile. About midway of the mass is a nearly complete section from the base to the top. At the base is an exposure of 30 feet of fine sand alternating with beds of very fine silt, which holds moisture and "cuts like cheese." Except at the top there is absolute freedom from gravelly material or even coarse sand. The beds incline slightly, but uniformly away from the valley. Above an unseen interval of 20 feet or more is a 45-foot section, showing 15 feet of tumultuous coarse and bouldery gravel at the top, and below alternating sand and gravel with some cross-bedding. Its general inclination, however, as well as that of the silts below, is from 1 to 3 degrees southwest. A generalized section for the whole deposit, therefore, gives us a great body of fine silts intercalated between two massive bodies of glacial gravels. At Whitestown the coarse gravels are absent so far as seen. There is a slightly pebbly layer at the top, underlain by nearly 70 feet of very fine sand. Alternating thin layers are seen of finer or at least more coherent material, and with such regularity as to suggest a seasonal variation in deposition. The slopes here show evidence of ice contact and the water currents seem to have come from the north side of the beds. This fact and the inclination of the beds in the Oriskany bluff suggest a connection with the Nine Mile Creek delta, whose precise nature is, however, in doubt. The Oriskany beds are 20 feet higher than the edge of the delta. But for this fact it would be reasonable to suppose that the delta deposits extended across the valley and have been breached by the river. Perhaps the two masses mark different stages of recession.

Frankfort-Ilion drift benches.—A noncommittal term is here used for aggregations which may in part have the nature of deltas. The valley about Utica is quite free from marginal drift. As indicated by Chamberlin, drift shoulders appear a few miles to the east, becoming strong about Frankfort and Ilion. Three miles west of Frankfort a section of 60 feet, obscured by slip at the base, displays 30 feet of horizontal beds of yellowish silt, with blue clayey layers above, still overlain by 10 feet of tough unstratified till containing many small scratched pebbles. Thence the surface rises by a concave curve to the steep upper hillside without any line of demarkation between the deeper drift of the valley and the thin mantle of the higher slopes. This is a common phase of the valley topography from this point to Little Falls. The valleyward edge presents an erosion escarpment gashed by numerous small ravines. Eastward the bench fades to a gentle slope, reappearing near Frankfort as a considerable feature. It is a mile and a half long and a mile wide, having an altitude of 480 feet on the river side and 540 to 560 feet at the base of the valley slope on the southwest. The surface is a gently sloping plane, rather stony. Toward the river, sections of 6 to 8 feet show sand, and in one case open gravel inclined toward the valley. Farther back coarse gravel with boulders is found, and under this sometimes fine clay. Structure and contours suggest the delta, but the stream from the southwest is local, and the drift mass lies wholly on one side of it. Possibly the mass is related to a yet unstudied channel passing south of Frankfort hill, which may have acted as a spillway before the main valley was open.*

A similar terrace lies on the west of Ilion, having the same altitude in front, but rising to 600 feet, a mile and a quarter south, in the valley of Steeles creek. Near the front a 16-foot excavation penetrated coarse gravel above and fine gravel below. Farther south, in a sand pit at the upper edge of the terrace, several feet of coarse gravel were found to be underlain by 25 feet of fine, horizontally bedded sand. At the 600-foot level farther south the section afforded by Mr Warner's well is—

	<i>Feet.</i>
Sand	10
Fine, blue clay; no pebbles.....	60
Gravel.....	1
	<hr/> 71

A small shoulder appears on the east side of the creek, from the Remington residence south toward the cemetery. Here a well was drilled to a

*See forthcoming Utica atlas sheet, a preliminary proof of which is in hand, through the courtesy of the U. S. Geological Survey.

depth of 80 or more feet, mainly in solid blue clay. The Ilion mass also has many characters of the delta, though the massive clays are anomalous in position, on this hypothesis.

On the north side, from Frankfort to Ilion, is a shoulder of moderate width, in which several sections show undisturbed sand and gravel below and 10 to 12 feet of till with scratched pebbles at the top. In one section a bedded layer lies midway in the till. At Coppernoll's sandbank, near Ilion station, fine waterlaid clay with scratched pebbles and thick overlying sands have been much disturbed and folded, thereby incorporating with the sands boulders of the clay with slickensides.

Ilion-Mohawk kames.—From Ilion station a belt of kames extends a mile or more eastward to, but not including, the Herkimer cemetery. On the south side massive kames rise above Ilion village on the east and extend to the eastern limit of Mohawk village, south of Herkimer. It is the only noteworthy illustration of these forms in the Mohawk valley. Altitudes of 580 feet above tide are attained. The sections are not altogether typical for kame, and we may have here an aggregate largely due to lacustrine deposition and subject to subsequent erosion. In some measure, however, the contours appear to be constructional. The dominant material, save at the base, is a fine yellowish sand, verging sometimes into loam or clay. The valley of a local stream in Mohawk divides the mass into two parts. A section by this stream gives 12 feet of very fine, black, horizontal, waterlaid beds of clay with scratched pebbles, overlain by nearly 50 feet of alternating, thin, horizontal beds of gravel and loamy sand. A section in the eastern part of Mohawk gives 50 feet, passing from good building sand at the base through loam and clay to fine yellow sand above. At the West Shore station, Mohawk, 6 feet of gravel are overlain by fine waterlaid clays with glaciated pebbles, and these in turn by the yellow sands. A few rods eastward by the railway the same clays rise 36 feet above the track, surmounted by 20 feet of the sands.

West Canada Creek delta.—This delta has a meager development. Its valley was apparently occupied by an active glacier to a late stage, as appears from the massive blue tills rising to a height of about 200 feet, constricting the valley for several miles. A short distance above Herkimer a sharp, crested, crescentic moraine nearly blockades the valley. Much of the original delta must also have been swept away both by the river and its tributary. A gravel shoulder runs westward past the Warner Miller residence to the Herkimer cemetery. On the east a broad shoulder, with an uneven surface, swings around toward Little Falls. It consists of till to the north, thinly mantled with waterlaid material, but passes into clay and gravel in the main valley. Faintly inscribed on the top of this shoulder a series of water levels appears from the

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Mohawk valley northward for a mile or more. These levels range from 490 feet to slightly above 600 feet. South of Herkimer, across the valley, lies the frontal portion of the delta. It may have been built at the front of an ice lobe pushing across the main valley, or may have been largely cut away by river erosion. At its north edge by the canal 10 feet of fine, black, tough, lacustrine clay are overlain by 15 feet of very coarse gravel. The apron terminates short of the south side of the valley, leaving a depression through which the West Shore railway passes. The gravels have been extensively excavated for ballast, and are rather fine and in beds inclining southward. Position, contours, and structure are demonstrative of their origin.

Deposits about Little Falls.—A massive shoulder of drift continues on the south side to a point near Little Falls, going east. The clays and fine sands give way to ordinary kame gravels and contours. At the northwest of Little Falls a very strong embankment of drift appears, consisting of till below and sands and gravels above. The mass is kame-like above the town, but a solid shoulder to the west, where its altitude is 808 feet above tide by the aneroid. The escarpment on the south border of the shoulder is steep and gashed by deep erosion gorges alternating with sharp spurs.

It will have been seen from the detailed account of beds between Utica and Little Falls that a generalized section of the marginal drift from the top downwards will stand as follows:

Till, overlying undisturbed beds of sand and gravel.	10-12 feet.
Fine to coarse sands and gravels.	A variable thickness.
Waterlaid, fine clays with glaciated pebbles.	A few to 36 feet.

No till appears west of Utica and no fine clays, except below the valley bottom, though the sands and silts are very fine.

Discussion of levels and succession of events.—The altitudes of the several deposits thus far described fall into fair accord.

	<i>Feet.</i>
Head of Rome-Westernville delta, about.	575
Nine Mile Creek delta.	600 to 520
Oriskany-Whitestown terrace.	540
Frankfort (delta).	560 to 480
Ilion (delta).	600 to 480
West Canada Creek delta.	600 to 490

These figures indicate a waterlevel at about 600 feet.* The lower limits of height represent offshore delta deposits. If the accordance of

* Professor Davis has called the attention of the writer to a sandplain at Oneida castle whose altitude requires a controlling barrier at not far from 600 feet. See also D. F. Lincoln: *Geology of Seneca county, New York*. State Museum Report, vol. 2, no. 48, 1894, p. 77.

level appears inadequate, it is to be remembered that the conditions did not favor uniformity in deposition or stability of waterlevel. The barrier which held the waters at this stage was doubtless of a somewhat transient nature. A straggling water body received contributions from fluctuating glacial drainage streams on its border, and perhaps suffered invasion from glacial ice itself. A progressive reduction of the baselevel may have exposed the heads of the deltas to dissection while their frontal portions were still receiving accessions of material. We are thus led to inquire as to the location and nature of the barrier. Gilbert suggests an ice dam in the lower Mohawk valley. This would be entirely adequate, but from his present knowledge of the facts the writer inclines to place the obstruction at Little Falls and to view it as composite in character. It is to be noted that the gorge is long, narrow, and sinuous. At the time in question the gneiss barrier would have stood at an altitude of at least 440 feet if the relation to the sealevel had been the same as at present, but the country was lower by whatever share this locality had in the Champlain depression. This diminished the rate of flow and may have made ice-gorging a most effective agent. Dana thus urges the importance of this means of blockade:

"The obstructions in particular cases might have existed for a very long era, instead of for a few weeks, such as happens after a modern winter. Again, the slackened or suspended flow of the water, caused by such ice obstructions, would have favored the deposition and accumulation about them of drift, and some may have thus been converted into complete dams."*

Chamberlin and Salisbury admit blockade by ice-gorging to the extent of considerable flooding of the Driftless area.†

At Little Falls we have the most favorable conditions—a narrow gorge, toward which abundant waters moved—waters which in turn were bordered by glacial ice. It is as if Glacier bay, Alaska, were to be raised above sealevel and given a long, devious outlet a fraction of a mile in width. There is, however, an added consideration. The drift shoulder on the northwest of Little Falls has suffered severe erosion. The Calciferous cliffs on the south side have also been sapped to an unknown amount. The valley is now barely wide enough for the river and the various lines of travel. This passage was not unlikely completely blocked to near the present altitude of the shoulder or 808 feet. The barrier would then have been cut down like the blockade north of lake Bonneville, but probably much more slowly, being protected by grounded ice

* J. D. Dana: On the damming of streams by drift ice during the melting of the great glacier. *Am. Jour. Sci.*, vol. xi, March 1876.

† Chamberlin and Salisbury: Driftless area of the upper Mississippi valley. *Sixth An. Rep. U. S. Geol. Survey*, p. 290.

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above. If the barrier were below Little Falls, the corresponding water levels should be found below that place. Such have not been noted, though it has not been possible to make a careful study of the higher slopes. It would seem that powerful rapids led down to a lower water-plane, yet to be described, on the east. The gradual withdrawal of a tongue of ice from the upper Mohawk valley, as described by Chamberlin, would have left a local lake, in whose quiet waters the fine clays, with glaciated pebbles, between Utica and Little Falls, were deposited. Later the Mohawk channel opened to the drainage from the west and a vast body of fine sands, with varying gravels, were laid down in the great lake-like river which swept eastward. The sediments from the main flow were commingled with delta and terrace material from local sources. Any earlier or higher outflows to the east were probably temporary, leaving little record, until the 600-foot horizon is reached. Gradually the barrier was breached and the waters came down to the Iroquois level. Lake waters still extended eastward to Little Falls, owing to the presence of the gneissic barrier, and probably were maintained at that level through the lower valley for a considerable period.

LOWER MOHAWK VALLEY

East Creek delta.—This is a triangular area whose parts are symmetrically disposed on either side of the creek above its entrance upon the Mohawk. It has not been mapped, and was but partially studied. It extends northward about a mile and a half. Westward it is prolonged into a narrow, somewhat morainic shoulder toward Little Falls. Eastward it breaks into a decidedly morainic belt which extends to Saint Johnsville. The height at the front is 110 feet above the Mohawk floodplain, or 440 feet above the sea. It is bounded along the valley by a steep erosion bluff.

Saint Johnsville bench.—At this village on either side of a local stream from the north is a somewhat morainic bench sloping toward the river and rising about 110 feet above the floodplain, or 430 feet above tide. A good section by the creek offers an exposure of 60 feet.

	<i>Feet.</i>
Fine, horizontally bedded sand, top.....	27
Fine, thinly laminated black clay, without pebbles..	8
Very stony blue till	25

Fort Plain bench.—This extends, with uneven top, in a fairly continuous manner, nearly to Saint Johnsville on the west and eastward toward Canajoharie. It is bisected by the valley of Otsquago creek, but is only slightly related to it in origin. The Clinton Liberal Institute stands con-

spicuously on it, and the higher parts of the town both east and west. The height may be averaged at 125 feet, or 431 feet above sealevel. The chief and basal constituent of the mass is very stony till. This is usually overlain by a moderate though variable thickness of sands and gravels. Many exposures are afforded by the cuts of the West Shore railway. The high bluff facing the creek on the east side gives the following section :

	<i>Feet.</i>
Till, moderately stony, oxidized, scratches obscure, contains sandy layer....	10-15
Waterlaid material, light sands below, sandy clay above.....	15-20
Base, very tough, stony blue clay, stones freshly scratched.....	25-30

Cayadutta (Fonda) delta.—The term is used with qualification. In and about Fonda are massive stony tills, extending up the creek one and a half miles, the edges of the till showing ice contact rather than erosion. Rising out of the creek valley to the west a level tract stretches westward toward Yosts and the Noses fault scarp at an altitude of 440 feet. This area is well shown upon the Fonda sheet. The surface is sandy, free from stone, smooth as a floor, and rises gently to the lower slopes northward. The general section, as learned from a resident, is sand, 6 to 15 or 20 feet, then often gravel, followed sometimes by fine clay without stones. At a greater depth the till would doubtless be entered.

The deposits represent a lacustrine expansion of the river, when held at this level, aggrading to a uniform surface above the till. Some stone fences were seen, but it was learned that all the material was brought from the hills to the northwest.

Schoharie Creek delta.—The conditions are similar to those at Fonda, with massive till at the mouth of the valley, a slight bench on the east, and a large triangular area stretching westward, extending by Auriesville to near Fultonville, at altitudes ranging from 420 to 440 feet. The proportion of true delta material is not well determined, nor were good structure sections found. The Mohawk floodplain is very broad where the creek enters, and no doubt extensive deposits have been swept away. At the top of the drift bluff about Auriesville lacustrine clays and sands were found, apparently in the same relations as at Saint Johnsville and near Fonda,

Amsterdam benches.—At Aiken, 3 miles to the west, boulder-clay is overlain by highly inclined beds of sand and gravel. North of Spring street, in Amsterdam, and at the cemetery and "Cork hill" a very tumultuous assemblage of sands, gravels, and clays is found. The sections were somewhat obscured, but, without much doubt, till is overlain by stratified beds. The altitude is 420 to 440 feet. At the top of a similar shoulder on the south side 5 feet of pebbly loam are underlain by lacustrine clay

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of considerable thickness. Another section at Yankee hill cut on the West Shore railroad is as follows:

	<i>Feet.</i>
Pebbly loam.....	3
Waterlaid clays.....	5-10
Blue till.....	60

The clays near this point are used for making brick. They are very fine and absolutely free from pebbles. Eastward from Amsterdam no noteworthy marginal drift is found until Schenectady is reached.

Correlation of deposits in lower valley—440-foot level.—The dominant constituent is a massive basal till. The abundance of such material appears to be largely due to the free exposure of rocks by faulting. Overlying the till at several points we have found the fine clays, whose freedom from pebbles suggests that no glacier ice floated in the waters of the lake while the clays were laid down. The surface beds on all the marginal accumulations are sands and gravels. There is a striking accordance of levels thus:

	<i>Feet.</i>
East Creek.....	440
Saint Johnsville.....	430
Fort Plain.....	431
Fonda.....	440
Schoharie creek.....	420 to 440
Amsterdam.....	420 to 440

This corresponds well with the Iroquois plane, though not believed to be genetically related to it. The waters may or may not have fallen below this level before the barrier was cut to the gneiss at Little Falls. Whenever it took place a waterfall of 100 feet or more was inaugurated at that point, and the postglacial breaching of the gneiss was actively begun. The dam that held the lower Mohawk lake in place is unknown. Most naturally it would be the retreating ice of the Hudson valley, perhaps extending up our valley toward Amsterdam. Stagnant ice may have filled much of the valley during the aggrading of the marginal drift, though the ice contacts have largely been cut away by later erosion. The benches, it is evident, are not kame terraces, nor are they in any true sense river terraces. The lake may not have originated and grown by uniform extension eastward, but may have begun at several points, as at the confluence of lateral valleys, these local lakes gradually merging as the ice melted out. The lake may have come more or less fully into existence before the drainage of the great lakes found an eastward outlet.

Aqueduct barrier—340-foot level.—The next stage was the subsidence of the lower Mohawk waters to the plain of 340 feet. This is the altitude of the great mass of sands which girt the south and east of the broad basin in which Schenectady lies. A reference to the Schenectady sheet will render detailed description unnecessary. It was here, as has long been held, that the Mohawk was jostled from its more southerly preglacial course and sent toward Cohoes. For the most part rock lies at no great depth at Schenectady. The old channel is probably westward from the city, where at the city waterworks the following section was revealed by well boring.* The mouth of the well is 34 feet above the river.

	<i>Feet.</i>
Red clay and loam.....	12
Gravel.....	68

Rock was not reached. Across the river from Schenectady westward a broad ridge of sand (so far as seen) about 60 feet high extends 3 miles up the valley between the river and the Central railway. It is perhaps a bar or shoal built into the lake at the mouth of the valley while the waters held the 340-foot level. This must have been maintained for some time, for the lowest point was found at Aqueduct, 4 miles northeast of Schenectady, where the river has cut a postglacial gorge 135 feet deep into rocks of Hudson River age. Traces of this level have been discerned up the valley, near Fort Plain and at other points. The Aqueduct barrier ponded the waters westward to the base of the gneiss at Little Falls. The valley of Alplaus kill, which joins the Mohawk valley above Aqueduct, offers a passage slightly lower than 340 feet. Whether this continues northward and eastward to the Hudson is not known. In any case the receding ice-front in the Hudson valley would have served as a dam for a time, until erosion at Aqueduct provided at that place the lowest point of overflow.

Considering the amount of postglacial work at Aqueduct, it is quite possible that a lake, contracting in depth and in westward extension, persisted until the end of the Iroquois stage, or even later.

A striking similarity of conditions appears at the head of the upper and lower Mohawk deltas (see figure 2). In both cases the river emerges from the plateau by a narrow valley, swings broadly around through a bowl bordered by a steep escarpment of drift, and passes through a postglacial rock gorge. In both cases the river seems to have been driven from a more westerly course by a blockade of drift and a lake has been maintained during the erosion of the gorge, except so far as the bowls

* Obtained by the courtesy of Superintendent George T. Ingersoll.

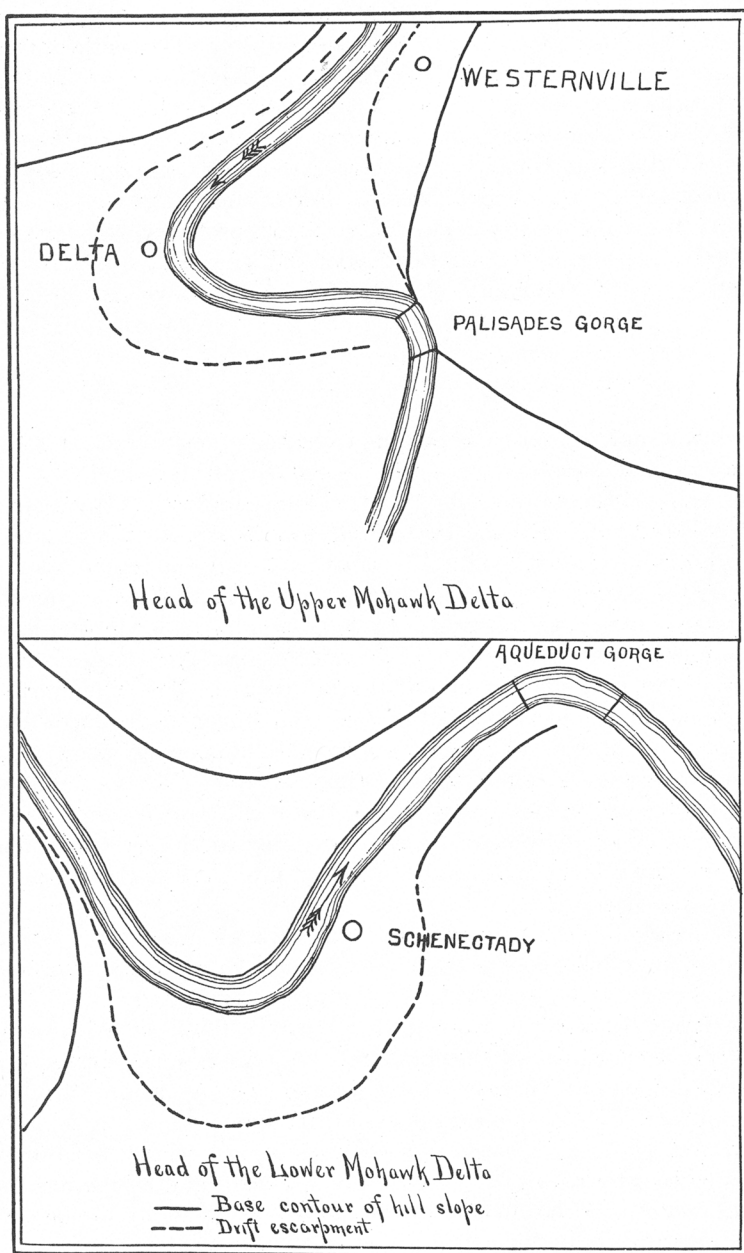


FIGURE 2.—Heads of the upper and lower Mohawk Deltas.

may have been filled, but later opened and their edges rimmed out by the stream.

It is not in the plan of this paper to discuss the delta of the lower Mohawk. The character and extension of the deposits which belong to it and their relations to the other Pleistocene materials of the Hudson valley offer an adequate field for a separate investigation.

Various flood gravels.—Various gravels along the valley receive brief reference. East of the Little Falls gorge is the small moraine described by Chamberlin and south of it along the valley side a somewhat morainic accumulation, not sufficiently observed to warrant a detailed notice. Large boulders of gneiss are associated with coarse gravels, a natural product of the vigorous glacial and aqueous erosion of the gneissic barrier to the west.

From East creek to near Saint Johnsville there extends for two miles a somewhat uneven terrace of coarse, indurated, horizontally bedded gravels, from 40 to 60 feet high. Its origin is not clear. It may be a remnant of a much more extensive sheet of gravel, as there are indications of terracing upon the erosion cliff along its southern border. It may be derived from the East Creek valley. The plentiful exposures of limestone in that valley, taken with the extensive induration of the gravel seen where the Central railway has excavated for ballast, emphasizes this suggestion.

A very interesting gravel bed runs from the big Nose on the north side past Yosts station. It is three-quarters of a mile long and has been opened for nearly its entire length for the railway and to the depths of from 5 to 20 feet. The valley bottom abruptly widens from a quarter of a mile at the Noses to nearly three-quarters of a mile here, though the Calceiferous cliffs still rise on the north. The railway runs between the gravel bed and the river, whose flood waters never now quite reach the track. Except at the west end, where it is a few feet higher, the gravel rises about 8 feet above the present floodplain. The material is fine, very uniform, with a sandy matrix, and pebbles rarely exceeding an inch in diameter. The gravel is so clean to the top as to support only a spare growth of weeds. Along the north border the surface slopes gently toward the base of the cliff. Fresh exposures by the steam shovel show the same inclination of the strata. A long and very fine exposure near the middle of the mass shows the beds inclining down the river from 3 to 4 degrees, with elaborate displays of cross-bedding. The whole appears to be an alluvial apron made by the flooded Mohawk. As the pent up stream emerged from the narrow channel between the shores it dropped its well worn burden into the more quiet waters below, waters which

were perhaps lacustrine, held up by the still persisting rock barrier at Aqueduct.

Fluvial stage.—North of the above gravel bed, midway, in a triangular recess between it and the cliffs, are some kame heaps rising 60 to 70 feet from the top of the gravel. Their sides are not abraded, and the lateral slope of the gravel plain toward their base also suggests that the river flood could not have risen, unless for short intervals, much above the present surface of the gravels. In a similar recess on the north side, west of the Nose and west of a creek entering from the north, are similar mounds, of which the highest rises to an estimated height of 80 feet. Their position in a kind of recess may have been a partial protection, but repeated observation confirms the impression that a swift and powerful current could not have left their slopes unharmed had it risen upon them for any length of time after lacustrine conditions ceased.

MASSIVE LACUSTRINE CLAYS

No reference, except by way of record, has thus far been made in this paper to a few deposits of massive clay, indicating long intervals of quiet deposition. Well records have not disclosed the presence of such deposits in the valley to such a degree as had been anticipated from studies in the region to the southward. Such clays appear at Sylvan beach, Rome, Herkimer, and in some of the wells at Ilion and Frankfort. Of the wells disclosing thick masses of lacustrine clay, not one is midway of the valley, but all are either on the edge of the floodplain or beyond. The well at the Ilion Typewriter works was sunk 195 feet to rock without encountering clay. Either, therefore, the clay was never a continuous deposit or it has suffered erosion. If the former, it was laid down in local, marginal lakes, but the thickness, especially at Herkimer, is not favorable to this supposition. The hypothesis of erosion is favored by the conditions at Ilion. At the south edge of the floodplain is the well at the typewriter works. Within a mile and a half southward massive clays occupy almost all altitudes, from 70 feet below the river floodplain to 200 feet above it. It is also significant that at Herkimer 100 feet of clay are underlain by 30 feet of gravel, including a boulder 7½ feet in diameter. At one of the Rome wells, also, 65 feet of clay and quicksand are underlain by 31 feet of hardpan. These facts look toward an early period of low altitude and slack drainage preceded by active glaciation and followed by erosion and glacial deposition. If an erosion of the clays took place in the Mohawk valley, it was in part glacial, as is shown by the presence of the rock basin in the valley east of Utica.

In an earlier paper the writer has reported a series of well records from

Chenango valley.* Little of inference was there drawn from the presence of massive beds of fine clays underlying the gravels throughout the valley. They are of such depth and apparent continuity as to suggest a single and contemporaneous origin. The gravels, on the other hand, overlie the clays abruptly, show a high gradient, and kames and kame terraces at short intervals from Deansville to Binghamton were made in the presence of glacial ice. The case is similar for the Unadilla valley, though little study has been given to it. The writer has information of a bed of more than 300 feet of clay at Leonardsville, in the Unadilla valley, 10 miles south of the col at Richfield Junction. At the col, rock is reported at a depth of 30 feet. These facts, compared with the rapid ascent of the rock bottom to the surface in the Chenango-Susquehanna confluence at Binghamton, suggest that there may be long and shallow rock basins in these valleys similar to that east of Utica. Much additional study would be needful to prove this, but in any case the clays point to a depression much earlier than the Champlain, so fully described by Chamberlin and Leverett for the west and indicated by Shaler and Woodworth for southern New England.†

SUMMARY

The lower Mohawk and a corresponding valley to the westward are considered as subsequent in character, having been initiated by headward cutting from the ancient Hudson and Saint Lawrence valleys, along the strike of soft beds to the col located by Chamberlin at Little Falls. The Adirondack streams consequent on Paleozoic topography were thus diverted and the Susquehanna streams were beheaded. West of Little Falls the rock floor descends toward lake Ontario, but not uniformly, a buried rock basin nearly 150 feet in depth lying east of Utica. The present arrangement is due to glacial and aqueo-glacial erosion at Little Falls, and to aggrading from Rome eastward by glacial materials. The westward flow of the lower Mohawk glacier is confirmed by striation at Amsterdam.

The drift deposits west of Little Falls are largely composed of deltas and benches whose altitudes indicate approximately a waterlevel of 600 feet. This is believed to represent a lacustrine stage in which the waters had fallen below the Warren level and below Fairchild's Geneva beach, but had not yet subsided to the Iroquois plane. The dam is thought to have been at Little Falls, and of a composite nature, the sill of gneiss

* Glacial flood deposits in Chenango valley. Bull. Geol. Soc. Am., vol. 8, pp. 27-29.

† N. S. Shaler, J. B. Woodworth, and C. F. Marbut: The glacial brick clays of Rhode Island and southeastern Massachusetts. Seventeenth Ann. Rep. U. S. Geol. Surv., pp. 951-1004.

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then standing at about 440 feet, with drift and ice blockade in the long, sinuous, narrow gorge. Below Little Falls marginal bodies of massive till, aggraded by water-laid material, show a fluvio-lacustrine level of 430 to 440 feet, the barrier being unknown. The next stage in the lower valley was also fluvio-lacustrine at 340 feet. The gneiss then caused a great waterfall at Little Falls, and the lacustrine stage persisted to the eastward, while a rock gorge more than 100 feet deep was cut at Aqueduct near Schenectady. Certain beds of massive water-laid clay west of Little Falls, taken with similar deposits in the Chenango and Unadilla valleys, are thought to show long and quiet deposition, with perhaps considerable later erosion before the last advance of the ice across central and southern New York.

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Topography and glacial deposits of Mohawk valley

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Notes

