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NEW YORK PHYSIOGRAPHY AND GLACIOLOGY WEST OF THE GENESEE VALLEY

BY

HERMAN L. FAIRCHILD

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CONTENTS

General Statement

This district, the extreme western portion of the State, includes a variety of singular and highly interesting features, physiographic and geologic, many of which have their first notice in this writing. In the paper number 5 of the attached list of writings Dr. Frank Leverett, in 1892, described the morainal belts; and a quarter of a century ago the writer mapped the inscriptions of the widespread glacial waters in a set of colored charts in paper 10. The features to be specially noted in the present writing include the remarkable Cattaraugus Valley and the series of parallel valleys on the north, with their romantic glacial lakes.

The unusual assemblege of striking features in this district, with their origin and glacial history, deserved detailed description long ago by the local scientific interests. In the lack of such publication the Rochester Academy of Science presents this outline of the physical characters of the neighboring province.

When the paper number 10 was published the topographic mapping by the United States Geological Survey had not covered all of the area and a number of the topographic sheets were lacking. Plate 4 in that Bulletin 106, covering a stretch from Gowanda north to Hamburg and Orchard Park, was based on imperfect county maps, and the glacial lake shores and the stream channels could not be precisely shown in either location or form, and the topography not at all. That district is now shown, in reduced scale, in the accompanying plate 29. However that former paper, State Museum Bulletin 106, is yet requisite for the general glacial history as introduction to the present paper. Unfortunately it has long been "out of print," but copies should be found in the libraries of the larger High Schools and certainly in the city libraries.

The geographic divisions of the district as based on the river systems or hydrographic areas are shown in plate 27. The present disposition of the drainage dates from the close of the Glacial Period. Previous to the "Ice Age" and the invasion of the Quebec glacier all of the major streams flowed northward, as indicated in figure 2.

The continental ice sheet in its relentless overriding of the land piled heavy fillings of rock rubbish, the glacial "drift," in many valleys, thereby interfering with the ancient stream flow. The present divide between the Allegheny River and Lake Erie was created by the drift blockade, and also the divides north and south of the

Cattaraugus Valley. This anomalous valley, which is out of harmony with the topography and stream flow of the large district, was developed at the front of the waning ice sheet by glacial and drift damming and the forced glacial drainage. This remarkable valley is entirely due to glacial interference, and will be briefly described, with the aid of the map, plate 28.

Plate 29, emphasizes the series of eight parallel north-leading valleys, with the forced, or ice-border, drainage during the recession of the ice front. The map, with its great reduction in scale, is mainly suggestive. The glacial stream channels are much exaggerated in width. Students, in and out of the schools, may find satisfaction and instruction in correcting possible errors and in the discovery of unmapped features and interesting details.

This writing does not attempt a complete, detailed description of the district, with its wealth of very instructive physiographic and glacial characters. Such treatment would require, and deserves, a large monograph. Its aim is to direct attention to the salient characters of the region as records of dramatic geologic activities; and also to encourage people with interest in nature to explore their home surroundings. The topographic maps should be utilized by the schools for recognition and study of their local features. Exploration in the field with intelligent study of the geologic phenomena is the highest intellectual exercise, and may well replace much study of books.

Map Illustrations

Plate 27 distinguishes the several drainage districts or stream system. Three of these are entire, the Cattaraugus, Erie-Niagara and the Ontario west of the Genesee Valley. For New York the Genesee Valley is also complete. The Allegheny headwaters is widely shown.

This map should be compared with figure 2. It will be seen that the Genesee River is the only large stream which has retained its general northward course across the State, in spite of the interference and opposition of the continental glacier.

Plates 28 and 29 have utilized as base maps the topographic sheets by the United State Geological Survey. Great reduction in size has been necessary. The sheets are easily available for study.

Plate 28 shows the central portion of the singular Cattaraugus Valley, using the Cattaraugus, Ellicottville and Franklinville sheets.

The three rock ravines may be located. On the southern divide the low passes which were the outlets of the high-upheld glacial waters are indicated, with some exaggeration. This map adjoins, with the same scale, the bottom of the map in plate 29. The two maps cover all of the Cattaraugus drainage except the few miles west of Versailles Village.

Plate 29 emphasizes the series of north-leading parallel valleys. Comparison of drainage should be made with figure 2. The many passes which provided outlets for the ice-impounded waters are interesting features and conspicuous in the mapping, but are not complete for the northern part of the area.

The moraines and the outwash plains, with their kettles and kettle lakes, are not specially designated. They may be recognized by the topography, and are noted in later chapters.

The shore lines and deltas of the widespread glacial lakes on the lower ground are heavily indicated. The Whittlesey features are incomplete, being mapped only where seen in the field. Some enterprising student should map them with refinement.

For areas north and south of plate 29 the lake features are mapped in paper 10.

The figures, 1, 2, 3, are described in the text.

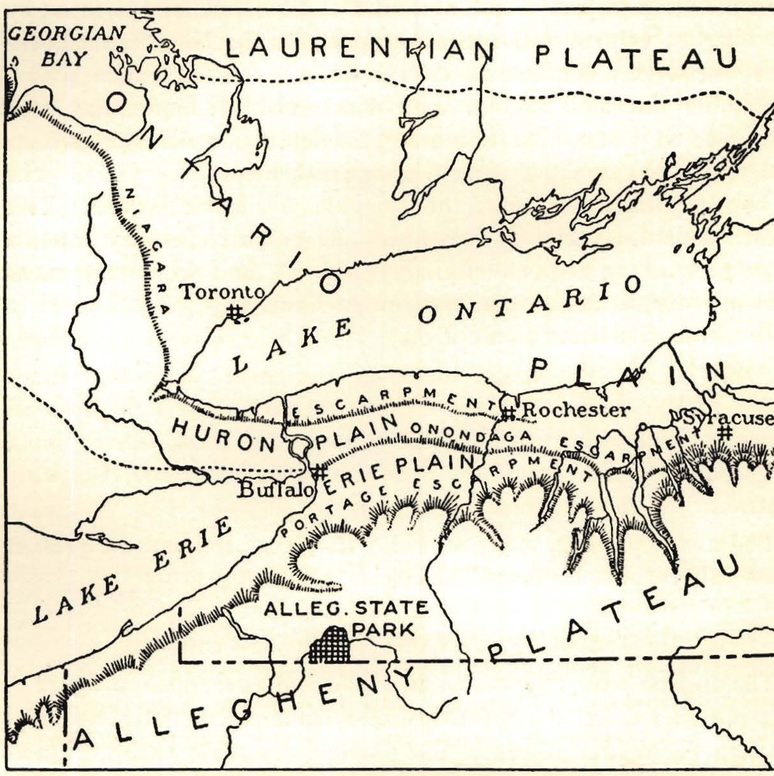
Physiography

One of the physical characters of which western New York may properly boast is its singular physiography. Its land surface is recognized as the type example of "Cuesta" topography, a titanic stairway with insloping treads.

The production of this singular structure required an unusual combination of geologic elements, and is the record of especially interesting history. When the area of western New York and Ontario was permanently raised out of oceanic waters, the interior or epicontinental sea, the newly created land, a vast coastal plain, had a general slope toward the south and southwest. But to-day the land surface rises southward, from the level of Lake Ontario, 246 feet above tide, and Lake Erie 573 feet, to much over 2,000 feet in the southern tier of counties.

During unnumbered millions of years exposure to the destructive agencies of the atmosphere, along with high uplifting and deep erosion of the rock strata, the land has been carved into a series of plains with sharp upslopes or escarpments. The three plains, Ontario Lowland, Huron and Erie, with three escarpments, Niagara, Onondaga and Portage, rise to the elevated Allegheny Plateau. These interesting physiographic elements are clearly shown in figure 1, reproduced from Professor A. K. Lobeck's figure 9 in his Handbook for the Allegany State Park, paper 21 of the appended list of writings.

The succession, rising southward, of plain and scarp, is an expression of three conditions; (1), the varying resistance of the different



Courtesy of the New York State Museum

Figure 1. **WESTERN NEW YORK PHYSIOGRAPHY**

rock strata to the atmospheric erosion; (2), the high-uplifted attitude permitting deep erosion; and (3), the northward upslant, or southward "dip" of the strata of perhaps fifty feet to the mile.

The extended succession of rocks, in all variety of the sedimentary class, may not be described here, being noted in all text-books and treatises on the New York stratigraphy, and given in detail in paper

16. The succession of less resistant rocks constitute the plains, the "treads" in the physiographic stairway; while the more resistant beds make the scarps or "risers." The wide outcrop of thick and weak Ordovician strata, the beds beneath the Medina sandstone, were eroded in Tertiary time to produce the deep and wide Ontario basin, with its eastern extension as the Mohawk Valley. This great depression reversed the direction of river flow, described below.

In the western part of the State the Ontario Lowland is faced by the Niagara escarpment, which is capped by the Niagara or Lockport limestone. The outcrop of the thick and weak Salina shales, containing the rock salt of New York and Michigan, has been excavated to produce the east and west depression through western and central New York, named in figure 1 the Huron plain. The Onondaga limestone forms the scarp at the south border. This Salina depression had gathered, by the end of Tertiary time, a large part of the regional drainage into east and west courses, as shown in figure 2; and that control of drainage is yet exercised in spite of the glacial interference.

Overlying the Onondaga limestone the thick shales and sandstones of the middle Devonian strata constitute the Erie plain of figure 1. The heavy strata of the Portage and the Chemung build the high scarp that forms the north-facing front of the Allegheny Plateau.

The minor physiography, especially the preglacial and the present river valleys, will be described below.

Tertiary, Preglacial, Stream Flow

The ancient river flow, as noted above and as mapped in figure 2, was northward or northwestward and tributary to the Mississippi through the master rivers in the Ontario and Erie basins. However, this northward drainage was not the earliest stream flow. Far back, in the Devonian Period of Paleozoic time, the earliest or primitive streams were created when the area was permanently raised out of the interior or continental sea, and their direction of flow was southward or southwestward. With further uplift of the continent the Ontario-Mohawk and Erie valleys were carved out of weak strata. And these east and west depressions captured the drainage and reversed the direction of flow. With the northeastern part of the continent standing perhaps several thousand feet higher than at present the north-flowing streams were vigorous and rapidly cut deep, steep-sided valleys. This drainage history is described in papers 14–16.

As noted in the preceding chapter the present land surface with its striking topography is the final effect of the removal of great thickness of rock strata, producing the deep valleys and the basins

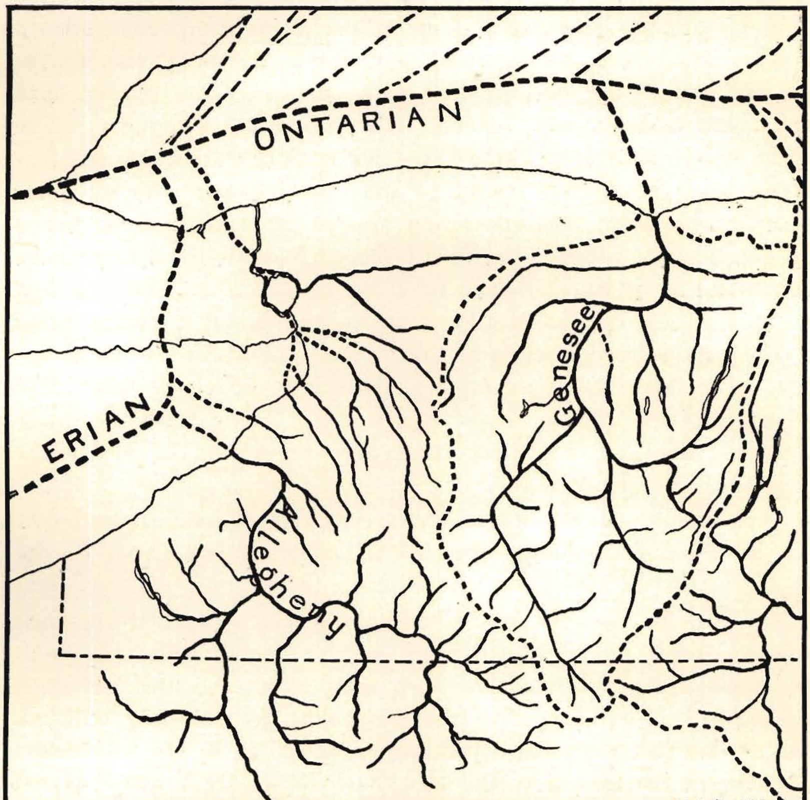


Figure 2. PRECLACIAL DRAINAGE IN WESTERN NEW YORK

now holding lakes Erie and Ontario. The strata which constitute the highland, the Allegheny Plateau, once extended far north into Canada. The detritus derived through millions of years of destructive processes has been largely contributed to the Mississippi River deposits in lower Louisiana.

In the lowering by erosion of the land surface, with the shifting of river flow, the paths or valleys of the primitive, south-flowing rivers are obliterated or quite obscured in all the area under description, and any doubtful relics are not here considered. North of the Cattaraugus Valley the many valleys declining northward (plate 29) are relics or survivors of the preglacial, Tertiary drainage. And an interesting fact which has not been recognized is that they are the western members of the remarkable series of parallel valleys lying eastward through central New York.

South of the Cattaraugus basin, where all of the present stream flow is southward, to the Allegheny River, the preglacial, north-leading valleys are deeply filled with detritus, from glacier, lake and river, and are now holding wide plains and swamps. These wide valleys with deep filling and slack drainage are abnormal features, being an indirect effect of the invading and overriding ice sheet. The deep, north-declining valleys were blocked in places by glacial drift fillings. South of the drift dams the valleys have been filled by detrital outwash from the ice sheet, and subsequently, in some cases, by glacial lake deposits and finally to the present level by the stream detritus of the reversed, or south-leading drainage. The conspicuous example is the wide, capacious valley now slowly drained by the Conewango Creek. Along with the lower stretch of the Cattaraugus the Conewango valley was the path of the preglacial Allegheny River.

Deep drillings in the line of the larger preglacial valleys go below sea level before reaching "bed rock," which is one proof of the high elevation of the region before glacial time.

The rock bottoms of these filled valleys were graded to the rock bottom of the Erie Valley. Drillings, for gas or water, down to bed rock will prove that the valley bottoms have a uniform slope northward. The amount of that slope has been slightly reduced, one or two feet per mile, depending on direction, by the northward uptilting of the land since the weight of the ice sheet was removed (papers 13, 14).

The diverting effect, direct and indirect, of the ice sheet invasion may be seen by comparison of the Tertiary drainage shown in figure 2 with the map of the present stream flow, plate 27.

The map of Tertiary drainage, figure 2, indicates by broken lines the stream flow which is chiefly hypothetic. Those north of the axis of Lake Ontario retain the primitive southerly direction of Paleozoic time. The drainage relation of the Erie basin to the

Ontario basin in preglacial time, with the ultimate outflow, is a difficult problem. In this map the Erian and Niagaran flow is tributary to the Ontarian. It must be understood that today the bottom of the shallow Lake Erie is over 600 feet above the bottom of Lake Ontario.

Glaciation

The high elevation of northeastern America in later Tertiary time was one cause, if not the principal cause, of the formation of an ice cap, or continental glacier, in Canada which expanded so as to cover most of New York. Students in the western states and in Europe find that the Glacial Period covered epochs of glaciation with intervening mild climate epochs of deglaciation. And the duration of the Glacial Period has been greatly extended, to cover 500,000 years, or more.

As applied to western New York our knowledge is limited to the closing stage of the Ice Age, the Wisconsin Epoch, and the operation and effects of the Quebec (Labradorian) ice sheet. The glacial phenomena are so well known that general description is here unnecessary, but some particular phases of the glacial behavior and interesting records will be considered in the following chapters.

The direction of movement of the overriding ice sheet, at least in the later phase, was southwestward from the Ontario basin, as shown by the orientation of the drumlins in Orleans and Genesee counties. The spreading flow from the Erie basin was to the southeast, as shown by the attitude of the drumlins in Chautauqua County and the trend of the terminal drift or moraines.

Ice-Front Recession

The geologic effects by the invasion (or invasions) of the ice sheet in western New York are a matter of conjecture or inference. The recessional records are conspicuous as the will and testament of the recently departed visitor.

The moraines in figure 3 mark the succession of ice-front positions as the glacier was reluctantly departing. South of Lake Ontario the trend of the ice margin was quite parallel to the lake shore. In the Erie basin the spreading movement of the ice body caused the ice front to lie slantingly or obliquely on the New York wall of the valley. And in consequence of this oblique relation the ice was not removed at once along the whole length of the wall or scarp, from State Line to Buffalo, but receded progressively from the southwest to northeast.

The glacial waters which produced the beaches mapped in plates 2–5, paper 10, and in plate 29, crept in from the west between the ice and the land slope, slowly extending northeastward. For example, the site of Dunkirk was yet beneath the ice sheet while Westfield was submerged in Lake Whittlesey.

The Lake Warren beaches were not formed until after the ice front had receded to the district of Marilla, fifteen miles east of Buffalo. At that time the far-west ice margin in the State of Michigan released an outlet lower than that of Whittlesey, and the imprisoned waters fell, some 45 to 50 feet, to the Warren level. The history is given in paper 10, pages 41–74, and in paper 17.

The moraines and outwash plains along the north side of the Cattaraugus Valley were under construction about the time, perhaps, when the Whittlesey waters were entering the State.

The glacier front in its recession over the areas mapped in plates 28, 29, probably had a general direction northeast by southwest. In its backward movement the drainage outlets for the glacial waters were probably opened sucessively westward.

Moraines and Valley Fillings

The slow melting of the ice sheet, with the backward recession (to northwestward) of the margin of the ice, left, normally, a thin mantle of ice-laid material, the "till," on the deserted land. But the waning of the glacier was far from steady or uniform. Climatic and other factors made the ice-front recession somewhat spasmodic. Along some stretches the ice margin hesitated and lingered, producing masses of the drift, as moraines. Occasionally the ice front readvanced after it had receded less or greater distance. Such pauses at readvanced positions produced the heavier moraines on the uplands and the massive blockades in the valleys.

These drift deposits are responsible for the changes in the drainage and for some of the anomalous features noted above with others to be described.

Figure 3 gives the location of the more extended and massive accumulations of frontal or morainal drift. The matter is discussed in paper 18.

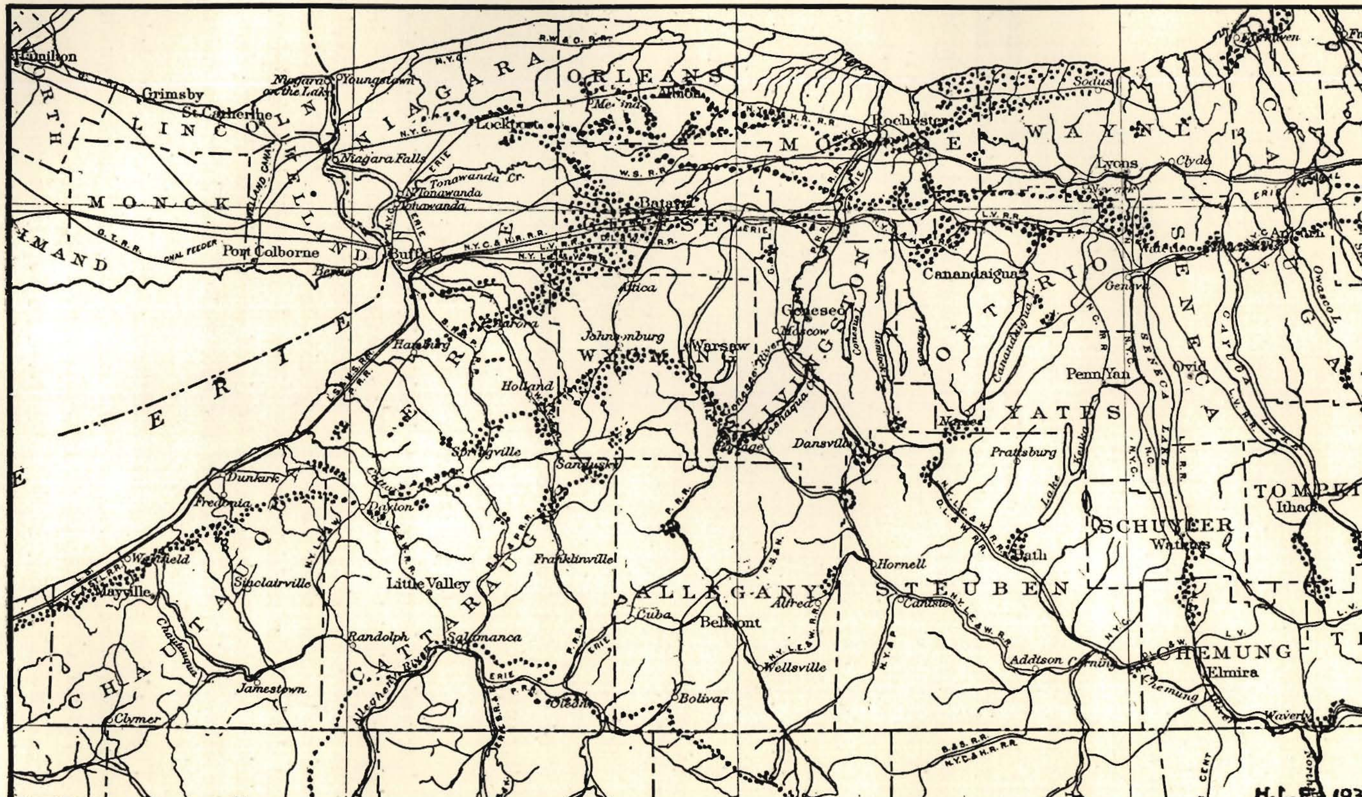


Figure 3. MORAINES IN WESTERN NEW YORK

The most continuous and extended moraine in the area is the one which forms the crest of the steep slope, or scarp, facing Lake Erie. This was described and mapped in paper 5, and named by Leverett the Lake Escarpment moraine. It appears on the Westfield and Dunkirk sheets of the topographic map, in plates 1–3 of paper 10, and in figure 1 of paper 18.

Distinct and definite moraine ridges, marking precise positions of an ice front, are rare and seldom will be found above the Terminal Moraine or on territory with high relief.

On plate 28 the irregular topography east of Dayton indicates a morainal tract. Also along the Cattaraugus Creek north and south of Zoar Bridge. A conspicuous moraine field lies south of Delevan and north of Machias; and another one at Sandusky, on Clear Creek in town of Freedom (Arcade and Franklinville sheets).

On plate 29 a series of heavy moraines and valley fillings are seen at the heads of all the north-leading valleys except that of Hunter Creek. They lie on the Eden, Springville and Arcade sheets. These fillings helped to produce the northern divide of the Cattaraugus basin, and they apparently correlate with the Escarpment moraine and its eastward continuation as the Valley Heads moraine in central New York. This moraine is mapped in papers 5, 10, 18.

The long standstill of the ice margin in the production of these fillings and the blockade of the ancient valleys forced the westward flow of the proglacial, or ice-border, drainage which developed the Cattaraugus Creek.

Outwash and Valley Plains

Interesting features connected with the valley moraines are the plains of "glacial outwash." These water-smoothed plains lie in front of the moraine fillings and were built of the detritus, gravel, sand and silt washed out of the glacier by the subglacial streams that drained the melting ice sheet. The detritus filled the incipient lakelets which were held in the heads of the valleys by the ice dam, the fillings being smoothed by the lake waters, and later channeled by the streams of the outflow.

These plains are recognized on the topographic sheets by their many basins, the "kettles," and the kettle lakes and lakelets, which features are characteristic of frontal moraine deposits.

The outwash plains in this area have no superiors, and lying on the north border of the high Allegheny Plateau they are remarkable for their altitude.

On plate 28 a good example is seen at Machias, which includes Lime Lake. Another is seen at and south of Freedom village, which includes Crystal Lake, with elevation 1,761 feet.

On plate 29 are the larger outwash plains. Extensive plains appear at East Concord and Springville, 1,400 feet elevation; at Chaffee-Yorkshire–Sardinia, 1,400 to 1,450 feet. The most elevated is at Eagle village (Arcade sheet), four miles southwest of Bliss, at the head of Wiscoy Creek in the Genesee drainage. Its altitude is 1,900 feet, which probably distinguishes it as the most elevated outwash plain in America if not in the entire world.

Valley Plains lead away, southward, from the heavy moraines on the divides, the detritus filling the valleys being derived at first from the glacier and supplied later by the lakes and the land drainage.

Good examples of these features are seen in the two valley plains which head in the moraine south of Dunkirk. One is the Bear Lake Valley, which holds the village of Stockton. The other is the upper part of the Cassadaga Valley, headed by the Cassadaga lakes. These two valleys unite to make the greater Cassadaga Valley, with a breadth at the junction of over three miles (Dunkirk sheet). The full display of the handsome valley is mapped on the Dunkirk, Chautauqua and Jamestown sheets.

Passing eastward we find definite outwash plains, connected with moraines, at Mud Lake, the head of the West Branch Conewango Creek; at East Mud Lake, the head of the North Branch Conewango; and at the village of Cottage on Slab City Creek. The plains of glacial outwash are shown on the Cherry Creek sheet.

Another excellent example, and with large kettle lakes similar to the Cassadaga lakes, is at Machias, at the head of the Ischua Valley, as shown on the Franklinvile sheet, and on plate 28.

The valley plains which are headed by the outwash deposits noted above are very conspicuous geographic features on the topographic sheets, and require particular notice.

The elevation of Bear Lake is a litle over 1,300 feet; and the upper Cassadaga Lake is 1,306 feet. In the distance of twenty miles to the junction of the Cassadaga Valley with the Conewango Valley the decline in elevation is only forty feet. This remarkable flatness is because the ancient valley declined northward and has been deeply filled by glacial, lake and stream detritus. Such peculiar valley forms are produced by morainal blockade and deep filling in valleys of reversed stream flow. These valley features are mapped in plate 2, paper 10, and also in paper 9, plate 38.

Twelve miles east of the Cassadaga Valley lies the very broad valley of the Conewango Creek. The creek heads in six branches, and their very interesting directions and relations are clearly shown on the Cherry Creek and Cattaraugus sheets. They all unite in the district of South Dayton and Markham villages. The recognized source of the creek is far east, by the hamlet of New Albion, three miles south of Cattaraugus village.

The Conewango Valley is remarkable in its size, form and history. It begins in a great basin at Markham, Dayton and Persia, four miles in width, and extends as a swamp, two or more miles in width, for twelve miles to the village of Conewango Valley. With similar width the ancient valley continues southeast fourteen miles, through Randolph and Steamburg, to the Allegheny River. It was the course of the preglacial Allegheny River.

In singular and unexpected manner the Conewango Creek deserts the broad ancient valley three miles northwest of Randolph and enters a narrow, steep-walled valley leading southwest, through Kennedy village, for six miles to Poland Center, where it joins the Cassadaga Creek in another very wide ancient valley, east of Jamestown. The geography is all mapped on the Cherry Creek, Cattaraugus, Jamestown and Randolph sheets.

These valley plains should be distinguished from the smooth areas filled and leveled by standing waters or lakes. Examples of the latter are seen on plate 28 in the towns of East Otto (Cattaraugus sheet); and Ashford (Ellicottville sheet). Also in the terraces along Ischua Creek (Franklinville sheet).

On plate 29 lake plains are seen in the town of Collins (Eden sheet), and north of Cattaraugus Creek in Sardinia (Springville sheet). As in the last example the lake plains may adjoin or blend into the outwash plains.

Recognizing water as the agent in eastern America producing fluid levels we must discriminate at least three classes of plains, according to their manner of origin or their genesis; the outwash plains, lake plains, and valley plains.

Existing Lakes

Lakes are ephemeral features and cannot occur in normal drainage. They are an effect of drainage blockade, and must be young, speaking geologically, as they face ultimate extinction. The myriads of lakes and lakelets in northern lands are an indirect effect of recent glaciation (paper 16, pages 185–194).

Lake Chautauqua is a "morainal" lake, due to drift damming, with elevation 1,308 feet. It occupies a shallow basin, a partially filled valley, which before glacial interference drained northward; as did all of the streams of the region. The glacial flow, forced southward from the escarpment moraine, produced the swampy tracts north of the present lake (Westfield and Dunkirk sheets).

Except Chautauqua the ponded waters are small in size and relatively few for the large area. Most, if not all, of them belong in the singular category of "kettle-basin" lakes. These basins were primarily occupied by blocks of ice, detached from the ragged front of the ice sheet, and were buried or enclosed in the gravel and sand swept out of the glacier. The eventual melting of the buried ice, and the consequent slumping of the detrital cover and enclosing walls, produced the "kettles." Multitudes of the kettles hold no water.

Kettles and kettle lakes are characteristic features of morainal tracts, occurring especially in outwash plains. They are well represented in the plains at Machias; between Yorkshire and Protection; and at Springville and East Concord.

The Cassadaga Lakes (Dunkirk sheet) are good examples of kettle lakes in wide outwash plains. Bear Lake has the same origin and character (paper 9, plate 38).

Eastward, on the Cherry Creek sheet, is Mud Lake, 1,380 feet elevation; and East Mud Lake, 1,330 feet, both in the headwaters of the western branches of Conewango Creek.

A group of lakes lie near Sandusky (Franklinville sheet), and Crystal Lake, three miles from the village, has elevation of 1,761 feet. Two lie in Elton Creek drainage. Lime Lake at Machias, probably the largest kettle lake in the area, has elevation 1,631 feet.

Java Lake, on the Arcade quadrangle, 1,651 feet altitude, is the head of Cattaraugus Creek. In the moraine, five miles southwest of Bliss, the Arcade sheet depicts a multitude of kettles, both dry and watered, having elevations up to 1,900 feet.

Lake Erie Plain

WIDESPREAD GLACIAL WATERS

The New York records of the extended glacial lakes which occupied the Erie and Huron basins were described in paper 10 (year 1907) and the beaches mapped in six colored sheets. It is deemed undesirable to rehearse the facts and data given in that publication, but a change is made in the interpretation of the lake records as regards their succession and history. The more detailed description and discussion is published in paper 17.

The succession of glacial lakes in the former paper was given as lakes Whittlesey, Warren and Dana. Further study through the years of the glacial records, with some change in their interpretation, make demand for two lakes at the Warren level, and between them a long stage of deglaciation and free drainage eastward to the Mohawk-Hudson valleys. The glacial features which are concerned in this reinterpretation lie in the Ontario drainage area, and are discussed in paper 17.

Under the new view the lake succession in the Erie basin is as follows:

1. Lake Whittlesey; with westward outflow.

2. Lake Warren, the first; with westward outflow.

3. Downdraining of Lake Warren, eastward, with the outflow control on the salient, the Onondaga scarp, north of Batavia, followed by a long stage with no ice-impounded waters in the Great Lakes area.

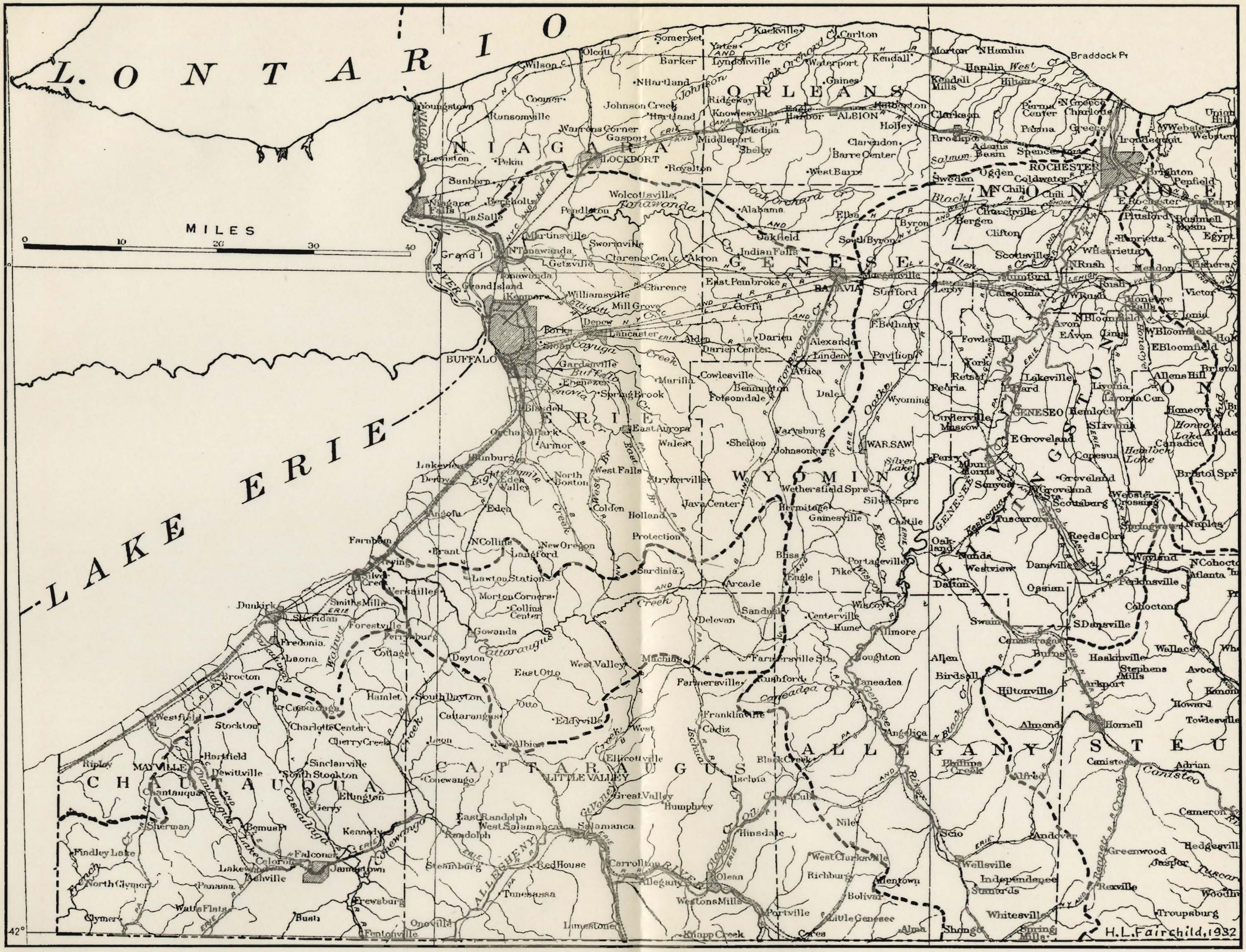
4. Lake Warren, the second. Readvance of the ice barrier in central New York slowly lifted the imprisoned waters until they rediscovered the western outlet across Michigan, at the Warren level.

5. The second downdraining, eastward, but with the outflow controlled on the high ground in the Syracuse-Utica district.

6. Lake Dana; due to a long pause in the downdraining, with outlet at Marcellus.

7. Lake Erie. The incipient lake was very small, but has been lengthened and deepened by the deformative land uplift.

The shore inscriptions of Lake Warren, with spacing of the bars in their northern reach had been recognized, and was discussed in paper 10, pages 64–79. The present theory appears to explain



RIVER SYSTEMS AND DRAINAGE DISTRICTS IN WESTERN NEW YORK

CATTARAUGUS VALLEY GLACIAL WATERS AND THEIR OUTFLOW CHANNELS the discrepancy in the water planes by attributing the lower wave work, at least in part, to the second Lake Warren.

STREAM CHANNELS AND DELTAS

The multitudinous stream channels, remarkable in their relations and succession, which carried the outflow of the glacial lakes described above, are depicted on plates 2, 3, paper 10. They were initiated at the edge of the ice sheet, but many of them became land streams as the ice front withdrew. Some of the later channels in the district are shown in plate 29.

As far northeast as the village of Marilla, six miles northeast of East Aurora, the stream channels carried the flow and detritus into Lake Whittlesey. But at and beyond Marilla the streams contributed to Lake Warren. A few of the larger delta tracts are indicated on plate 29.

The drainage into the second Lake Warren, and the succeeding Lake Dana, was derived wholly from the land. This later stream flow was not so heavily loaded with detritus, and the delta deposits are not readily discriminated from the earlier ones.

Lake Ontario Plain

This stretch of plain, bordering Lake Ontario for seventy miles, between the Genesee and Niagara rivers, and with a width of twenty or more miles, is in striking contrast with the Erie lowland; with which it merges in the area east of Buffalo.

This plain carries one conspicuous glacial lake feature, the strong embankment beach of Lake Iroquois, from Lewiston to Rochester. The plain rises from 246 feet, the Lake Ontario level, to 385 at Lewiston, 420 at Ridgeway and 435 at Rochester.

The beach of Lake Warren (papers 8, 11), with elevation of 880 feet, may be regarded as the southern limit of the Ontario plain.

During the downdraining of the first Lake Warren (paper 17) the plain was mostly buried under the glacier. A portion on the south and west was covered by the second Lake Warren; and a larger area by lakes Dana and Dawson. A few drumlins in the district north of Batavia rise high enough to carry the wave work of the Dana waters, at about 700 feet, as partly mapped on plate 2, paper 11. The northern belt was covered by the shortlived Lake Dawson, but the shore features are weak and have not been traced.

The Ontario plain is not traversed by any preglacial river channels. As shown in figure 2 the Tertiary drainage in this province was held to east and west directions in the depression caused by the thick and nonresistent Salina shales; the same as east of the Genesee Valley. Today this depression is occupied by the Tonawanda and Black creeks. The only trenching of the Niagara formation (Lockport limestone and Medina sandstone) is by the Irondequoit and Sodus valleys (figure 2).

This Ontario plain was smoothed by the friction of the ice sheet, with flow southwestward. In its latest flow it rubbed the till mantle into great ribs, or flutings, producing a drumlinized surface. This is described in two papers on drumlins, *N. Y. State Museum Bulletin* No. 127, and *Proceedings of the Rochester Academy of Science,* volume 7, 1929, pages 1–37.

Allegheny Drainage Area

The portion of this area which is included in the Allegany State Park is described in paper 21.

The southward stream flow of this area is due to glacial interference, which has wholly reversed the preglacial direction, as shown in figure 2. The rivers in Tertiary time were tributary to the Erie Valley. The new divides are morainal valley fillings.

The boundary of the area is roughly semicircular; the divide on the west lies over against Lake Erie; on the north against the Cattaraugus Valley; and on the east against the Genesee Valley.

When the ice front receded from the terminal moraine, figure 3, it was very deliberately, by pauses and readvances. The more effective standstills produced the valley fillings, thereby establishing the present water partings.

Three classes of the glacial features are conspicuous and important. These are, the existing lakes; the outwash plains and valley plains; and the records of the vanished lakes.

GLACIAL LAKES

The term "glacial lakes" denotes the water bodies, small or large, that were held up or impounded by the glacier, which served as a movable dam. Except the Marjelen See, in Switzerland, none are recognized today. The innumerable existing lakes and tarns due indirectly to the ice sheet are properly classed as morainal or drift-barrier, kettle and plunge-basin.

While the glacier was lingering in the Allegheny area the front of the ice sheet during its slow rescession, and especially in its standstills, held lakes in the valleys which declined northward, or toward the ice. The more definite and extended glacial waters were in the Conewango Valley; the South Branch of the Cattaraugus; and the valley of Ischua Creek.

Probably the earliest of the glacial valley lakes was in the Ischua Valley. The Franklinville sheet shows level areas, mostly the deltas of side streams, at Fitch, 1,680 feet; at Cadiz, 1,600; north of Franklinville, 1,620; at mouth of Johnson Creek, 1,680; at mouth of Bear Creek and north to Gulf Creek good terraces at 1,680 to 1,720. Similar levels occur about Machias village, at East Machias School, and in the Elton Valley.

The standing water which produced these level stretches may be named the Franklinville glacial lake. The blockade, either drift or rock, or both, or perhaps drift-buried ice, must have been in the very narrow valley at Ischua Village, with present elevation of about 1,530 feet; and also on the west in the constricted valleys at Devereaux and Ashford, some six miles northeast of Ellicottville.

The valley of Elton Creek, holding the villages of Elton and Farmersville Station, appears to have been flooded by the Franklinville lake through the valleys southwest of Elton Station.

Eventually the river flow across the barrier at Ischua Village eroded and lowered that outlet sufficiently to drain the Franklinville Lake. Evidence of this event in the history is found in a definite stream channel cut by glacial flow along the east side of the valley at Machias Junction. This channel is described by Mr. H. W. Clough,[1] in a letter, as heading at Lime Lake and extending along the east wall of the valley over three miles, and blending into the open valley a mile southeast of School No. 1. The Franklinville sheet gives the elevation of the channel on the divide, in a "swamp col," as 1,640 feet. The lake terraces on the west side of the valley below School No. 1 are 1,720 feet, and over, in elevation.

This Machias outlet channel implies a lake on the north. The geographic relations suggest that the upper portion of the Catta-

[1] The writer is indebted for valuable data relating to the Cattaraugus region to Mr. Clough, a student of the writer in far-gone days, with a life-work as meteorologist in the United States Weather Bureau, now retired, with summer residence at Arcade.

raugus Valley was, for a time, drained through the Machias outlet. In this view we may name the lake the Arcade glacial lake. It belongs in the glacial lake succession of the Cattaraugus Valley, recounted below.

The two swamp divides, five miles north and northeast of Ashford, on the Ellicottville sheet, and called "Beaver Meadows," indicate ponding of water in the valleys on the north.

Going west to the Conewango drainage area we find evidence of ice-impounded waters. When in the waning of the glacier the ice front had receded north of Randolph a lake was held in the valley of Little Conewango Creek, which we will call the Randolph lake. The barrier and outlet was at Steamburg, with the present elevation 1,420 feet. With further recession of the ice front the Randolph waters found lower escape through the narrow side valley in which rest the villages of Waterboro and Kennedy (Jamestown sheet).

As the ice front backed away the Randolph lake became the extended Conewango glacial lake. Eventually this lake received the overflow of the Cattaraugus glacial lake, by the outflow channel at Persia station on the Erie Railroad, three miles southeast of Dayton. This channel was described in paper 10, page 17.

The heavy outwash of rock-rubbish from the ice sheet, and the copious inflow of the many creeks draining large territory and sweeping in detritus for many thousands of years, accounts for the valley filling and the swampy condition. The creek is now a sluggish, serpentine flow, hundreds of feet above the bed of its preglacial ancestor. State drainage ditches now help to reduce the watery condition of the great valley.

The later glacial waters are described in the chapter on the Cattaraugus Valley.

The above account of the Allegheny area is only an outline. The varied and complex features have much of geologic and geographic interest and will well repay careful, detailed study.

Cattaraugus Valley

CREATION OF THE RIVER AND VALLEY

This valley is remarkable in its complex origin, its singular physiographic relations, its rock ravines and its glacial lake history. The area is covered by eight topographic sheets; Silver Creek, Eden, Springville, Arcade, Cherry Creek, Cattaraugus, Ellicottville and Franklinville. The features and relations which can be shown in black and white are seen on plates 27–29.

Plate 29 joins directly on plate 28 and the two cover all of the Cattaraugus drainage area except the seven miles below Versailles, which is shown on the Silver Creek sheet. The central and more critical part of the valley and river is shown on plate 28. The headwater part of the valley, from east of Springville to Java Lake, a stretch of twenty miles, is shown on plate 29. The lower stretch of the valley, below Gowanda, which was in the course of the preglacial Allegheny River, is partly displayed on the two plates.

The topography of the upper valley suggests that in preglacial time a water parting existed at East Arcade. North of this divide the flow was, probably, to the Tonawanda valley. Below East Arcade to Arcade and Yorkshire the tributaries appear to lie in their preglacial courses. But below Yorkshire the river is postglacial.

In its westward course the new river lies across the deep preglacial valleys that led northward, as shown in figure 2. During the removal of the ice sheet those ancient north-leading valleys were blocked, at first by the receding front of the ice sheet and then permanently by the morainal fillings. The escaping waters were forced to westward flow along the ice margin and took possession of some east and west valleys which had been tributary to the north-flowing rivers. In three stretches the glacial flow was compelled to cut across intervalley highlands, thus producing the deep rock canyons (plate 28).

The wider, more open, portions of the valley represent preglacial stream work, while the narrow, steep-walled rock ravines register the new, postglacial erosion by the newly-created river. The canyon section of the South Branch also represents diversion of stream flow. Careful study of deep borings may determine the old lines of drainage.

One of the two intersections of the preglacial, north-leading valleys is seen in the wide plain of water-leveled moraine and glacial outwash at Chaffee, Sardinia and Yorkshire (plate 29). This area is part of the great valley which headed at Ischua (plate 28) and passed northward as the East Branch Cazenovia. At Springville and Cascade Park is another great drift filling and pitted-plain, evidently related to the valleys of Buttermilk and Eighteen mile creeks. These extensive water-smoothed plains, with their kettles and lakelets, are the most unusual and interesting of the glacial features.

The courses in direct line of the Connoisarauley and Derby creeks with the South Branch Eighteenmile Creek is suggestive of a preglacial north-leading valley deserving of study. In this relation the valley of Spooner Creek must be considered.

The rock ravines will be described in a later chapter.

The quite direct course of the Cattaraugus Creek from East Arcade to the junction of the South Branch, a right-line distance of thirty miles, is a striking feature, but probably fortuitous.

The windings of the river in the rock ravines are "intrenched meanders" that were acquired when the stream was lazily swinging on detrital plains overlying the rock strata.

GLACIAL LAKES

The Cattaraugus Valley declines toward the southwest. The front of the waning ice sheet receded westward, and consequently the valley held ice-impounded waters, glacial lakes, in the main valley and its tributaries.

The lake history is complicated and not easily translated. In the production of the new valley the north boundary, created as described above by ice and stream deposition in the preglacial north-leading valleys, so blocked the valleys that even today there is no northward flow from the Cattaraugus basin. Except during the latest presence of the ice front all of the outflow was across the southern divide into Allegheny drainage (plate 28). That divide was uncovered by the ice removal from east to west, and the low passes permitting outflow of the ice dammed waters were opened successively westward. The height or elevation of the lakes and their extent were determined by the elevations of the points of outflow. The several outlets are indicated on plate 28.

Passing westward along the crooked line of water parting between north and south flow no pass with elevation lower than the Machias outlet, of 1,636 feet, is found until we travel fourteen miles in direct line and reach the head of Mansfield Creek, two miles northwest of Ellicottville. Here a pass leads southeast to Great Valley Creek, with elevation 1,620 feet and with form and relation indicating copious flow of water.

Further westward, seven miles in direct line, another pass ten feet lower is found two miles northwest of Little Valley (Cattaraugus sheet), but with the form less favorable. The Erie railroad found this pass available in passing from the Allegheny basin over to the Cattaraugus.

Five miles northwest of Little Valley, and three miles south of Cattaraugus village, a much lower pass occurs at the village of New Albion. This outlet has elevation of 1,440 feet and opens to the head of Conewango Creek. But the outflow by this pass was forced through the deep canyon west of Kendall Corners to the Mud Creek, tributary to the Conewango, until the ice front had moved away from the Wells Hill, six miles south of Dayton. The features are shown on the Cattaraugus sheet.

The westernmost and lowest pass is found at Persia flag station on the Erie railroad, with elevation 1,320 feet. This outlet, the latest across the southern divide, is three miles southeast of Dayton, leading to the wide Conewango Valley.

The next and the final escape for the Cattaraugus glacial waters was five miles west of Gowanda and northwest and north from Perrysburg, appearing on the Cherry Creek sheet and in plate 3 of paper 10. The outflow began at 1,300 feet, in the channel followed west of Perrysburg by the Erie railroad, while lower channels permitted outflow down to the level of Lake Whittlesey, 850 feet. Three interesting channels south of West Perysburg have elevation of 1,200 feet.

In review, these several outlets of the glacial waters are:

Machias,	elevation	1,640	feet.
Ellicottville,	"	1,620	"
Little Valley,	"	1,610	"
New Albion,	"	1,440	"
Persia,	"	1,320	"
Perrysburg,	"	1,300–850	feet.

The several outlets with the falling levels gives us the following theoretic lake succession, all of which, with exception of the last one, contributed their overflow to the Allegheny River.

1. Arcade-Yorkshire-Delevan lake. The outlet was at Machias village, with elevation about 1,640 feet, leading to Ischua Creek. The water in this stage filled the upper stretch of the valley nearly to the river's head in Java Lake, and the lower portions of the tributary creeks. The Arcade and Franklinville sheets depict the features.

2. Springville Lake. This occupied the middle stretch of the main valley, and the tributary Buttermilk and Connoisarauley creek valleys. Apparently the lake had outlets at Ellicottville, 1,620 feet, and at Little Valley, 1,610 feet.

3. South Branch Cattaraugus Lake. This three-branched water body had its central point at Cattaraugus Village. Perhaps its early outflow was at Little Valley but its chief outlet was at New Albion, elevation 1,440 feet, over to the Conewango Valley (Ellicottville and Cattaraugus sheets).

During this stage a pass at Brooklyn School, three miles north of East Otto Village and three miles southeast of Zoar Bridge, at 1,360 feet, appears to have given connection with the water in the main valley above Cascade Park. The intrenching of the rock canyon below Zoar Bridge had not begun in this stage of the history; but the lake deposits which completed the fillings in the intersections at Yorkshire and at Springville probably began during this stage.

4. Main Cattaraugus Lake. The outflow was by the Persia channel, elevation 1,320 feet, over to the wide Conewango Valley. This was probably the longest in life of the several lake stages, with larger area, and more copious outflow. The higher lake plains and the deltas by tributary streams were completed during this stage. Some of the features are described below.

5. Gowanda Lake. This was the closing stage of the glacial waters. It existed while the ice front weakened and slowly receded on the north-facing slope at Perrysburg and West Perrysburg, from elevation of 1,300 feet down to 850 feet, when the water blended with Lake Whittlesey.

This falling level did not occupy the Cattaraugus Valley above the district of Gowanda because the canyon above Gowanda had not been cut. But all the water of the basin passed through the Gowanda lake, reaching the latter by cascades or cataracts.

The first and highest of the Perrysburg scourways, produced by the escape of the Cattaraugus waters along the ice front, is followed by the railroad that used Persia channel, five miles on the southeast. The elevation should be less than the bottom of the Persia channel, and is shown by the Cherry Creek sheet as about 1,300 feet. Plate 3 in paper 10 shows the succession of downdraining channels from

1,300 feet down toward 900 feet, where the Cattaraugus waters blended with the great glacial Lake Whittlesey in the Erie basin. The wide plain of the Cattaraugus Indian Reservation and of the State Asylum are records of the lower lake waters, from 900 to 800 feet (plate 28).

6. Land-locked Cattaraugus Lake. When the glacial water in the Gowanda stage had lowered to about 1,200 feet, by the channels near Perrysburg, the water above Zoar Bridge was held in by the rock barrier. This lake was not, like its predecessors, a glacial or ice-barrier lake, but a rock-barrier lake.

This lake has long since been drained by the downcutting of the rock dam and the production of the great gorge or canyon above Gowanda. The lake was initiated while the ice margin lay on the ground northwest of Perrysburg, but its life, of tens of thousands of years, was mostly in postglacial time. Although the lake disappeared long ago the canyon erosion is yet in progress. The other rock gorges up stream, and the one in the South Branch, have similar and contemporaneous life history.

The curvatures or meanders in the rock sections were established before erosion of the rock began. They were formed on detrital plains when the new valley was filled with glacial and stream deposition to perhaps 1,300 feet elevation, at the close of the glacial history in the fourth stage, while the water was held up to the Persia outlet and the highest of the Perrysburg scourways.

ROCK RAVINES

The three ravines or canyons in the course of the Cattaraugus Creek (plate 28) mark the stretches where the stream was compelled to carve entirely new paths. In the intermediate open stretches of its course the stream, under control by the glacier front, discovered old valleys that had been tributary to the north-flowing rivers.

The surface of the ancient rock plain, of upper Devonian strata, appears to have been quite uniform in the district, as the ravines are similar in elevation and depth. The dimensions are approximately as follows:

Upper ravine, Cascade Park, two miles long.

Elevation of top of rock section	1,280 feet.
Elevation of the stream	1,080 feet.
Depth of ravine	200 feet.

Middle ravine, below Frye Bridge, four miles long.

Elevation of top of rock section	1,200 feet.
Elevation of stream	1,000 feet.
Depth of ravine	200 feet.

Lower ravine, below Zoar Bridge, five miles long.

Elevation of top of rock section	1,200 feet.
Elevation of stream	900 feet.
Depth of ravine	300 feet.

The carving of the ravines by stream erosion is in postglacial time, for the district, and is a measure of the uncounted years since the ice sheet melted from that locality. The cutting of the rock did not begin until the ice-impounded water in the Cattaraugus basin and the newly-created river valley had fallen to the level of the shale and sandstone. As that level is today about 1,200 feet while the Persia outlet (plate 28) is 1,320 feet it is apparent that the ravine cutting is subsequent to the lake outflow at Persia flag station. The lake water was lowered, and the river encountered the rock obstructions when the outflow was held against the north-facing slope west of Perrysburg. At that time, as noted above, the water held in the Cattaraugus Valley had become a land-locked lake.

A striking feature is the winding course of each ravine. They are excellent illustration of "intrenched meanders." The meanders antedate the initiation of the rock cutting, having been established on the detrital plains which overlay the rock surfaces. The drop in the lake surface with the desertion of the Persia outlet caused the river to rapidly deepen its winding channel. The curvatures in the rock ravines are an inheritance from the meanders in the superimposed detritus.

Of course the deepening of the middle and upper ravines was dependent on the downcutting in the lower ravine, above Gowanda. And the erosion is yet in slow progress.

LAKE PLAINS

Without much careful exploration and study, with precise measurements, the history and records of the earlier lake stages in the basin of the Cattaraugus cannot be described in detail. An interesting task for some enterprising geologist is the examination of the outlet passes on the southern divide, with determination of the correlating features and of the history in detail.

Beginning with stage 4, control by the Persia outlet, there is more of certainty and much of interest. The present elevation of the Persia outlet after its downcutting is 1,320 feet. The surface of the river in this channel determined the elevation of the impounded waters in the basin. The Cattaraugus topographic sheet shows extended smooth plains at 1,320 to 1,360 feet in the towns of Otto and East Otto. The valley plain at the village of Cattaraugus is 1,320 to 1,340 feet.

Examination of the topographic sheets will show that the plains, indicated by the white spaces, rise in elevation to the northeast, attaining 1,400 feet at Sardinia and Yorkshire. This increase in altitude is due in part to the postglacial uplift of the land, upslanting toward two feet per mile in the northeast direction. In the twenty-five miles of rightline distance from Persia to Sardinia the deformation may be toward fifty feet. If the outlet river at Persia had in its summer floods a depth of ten feet that alone carries the lake plane to 1,380 feet.

The wide plains at Sardinia-Yorkshire-Chaffee were built by the glacial outwash from the Cazenovia and Buffalo valleys into the Cattaraugus waters, and the abundant detritus was probably spread out, at Chaffee, above the lake level. At Arcade the delta filling, to 1,500 feet, was by the detritus of the upper stretch of the Cattaraugus Creek, and also by Clear Creek.

Another great outwash plain extends from Cascade Park through Springville to East Concord, first by glacial outwash and later by the outflow from the valleys of Cazenovia and the two Eighteenmile creeks. The elevations are 1,300 feet at Cascade Park, rising to 1,400 feet at East Concord (Ellicottville and Springville sheets).

The tributary valleys were also filled with detritus at the Persia level. A very handsome display is seen in Ashford Town (Ellicottville sheet) extending up the wide valley of Buttermilk Creek, and west to the Connoisarauley Creek, with elevations 1,300 to 1,360 feet.

During the thousands of years that the Cattaraugus river has been cutting the rock canyons detrital plains and deltas were forming in the land-locked lake by inwash by the tributaries, with slowly falling levels, from 1,200 feet down to the present creek.

The South Branch Valley has a similar history, produced by the rock barrier at Forty Bridge, with corresponding altitudes.

PARALLEL VALLEYS AND GLACIAL WATERS NORTH OF THE CATTARAUGUS VALLEY

In the slow deepening of the ravines the open-valley stretches above the ravines were always filled with stream detritus at the level of the rock channel downstream. With the deepening of each rock channel the stream was correspondingly lowered in the up-stream open-valley stretch, producing terraces and benches at various levels in the abandoned floodplains. These are abundant and conspicuous above Cascade Park in the fourteen miles to Arcade, with elevations from about 1,460 feet down to 1,100 feet, the present elevation of the river at the Park. An excellent example is found on the north side of the Creek, northwest of The Forks and south of Sardinia (southeast corner of the Springville sheet).

Below Gowanda, and beyond the control by the rock dam upstream, the wide old valley and adjacent land were yet under the glacial waters, controlled by the Perrysburg scourways. An excellent evidence of the slowly falling waters is seen in the drainage area of both branches of Clear Creek, in the town of Collins and North Collins (Cattaraugus and Eden sheets). Marshfield is on a plain at 1,320 feet. Westward, down stream, the beautiful plains and terraces decline to 850 feet, the level of Lake Whittlesey; while lower plains represent glacial Lake Warren, 780, and down to Lake Erie, 573 feet. The interesting succession of plains and terraces in the Gowanda region are described in paper 9, pages 137–139 and in paper 10, page 38.

North-Leading Parallel Valleys

ORIGIN AND CHARACTER

The remarkable series of parallel valleys in central New York, tributary to the Ontario Valley, have long been famous. The westward representatives of the great sisterhood of preglacial valleys, the ones leading to Lake Erie, have been given small attention, although of much physiographic and geologic interest. The neglect has been due partly to the absence of lakes, partly because the valleys are deep and narrow with less advantage for occupation and agriculture. Also the area has high relief and few important villages.

The Erie basin series include eight valleys with general decline northwestward. From west to east they are: the lower portion of the Cattaraugus, which was the course of the Tertiary Allegheny; South Branch Eighteenmile; main Eighteenmile; West Branch

Cazenovia; East Branch Cazenovia; Hunter; Buffalo; Cayuga. East of these the Tonawanda is a connecting link between the Erian and Ontarian groups, the creek having a course east of north and then west into Niagara River.

These open valleys are remnants and relics of much more extended valleys of Tertiary drainage. As with the valleys of central New York the former southern or headward portions and the northern, terminal portions of most of them have been obscured or even buried by the work of the ice sheet and the glacial lakes. West of the Cattaraugus the heavy moraine deposits on the scarp of the plateau have buried the channels of northward flow.

This group of valleys is an inheritance from Tertiary time, when all of the drainage of central and western New York, including the Allegheny River, passed northward (figure 2). The streams which carved these valleys performed the same function, and at the same time, as the Ontarian tributaries, namely, the removal of the precipitation from the northern scarp of the Allegheny Plateau. And, like the Ontarian group, they have been dissected or beheaded by moraine filling.

As these deep parallel valleys decline to the northwest, and as the blockading ice front lay across them transversely, the outflow from each valley was into the adjacent valley on the west. In the case of two valleys, Hunter and Cayuga, the water was held up to confluence with its neighboring lake, or lakes.

In the precise study of the elevations of the outflow channels and the planes of the lake surfaces it is necessary to take into account the postglacial land uplift, with the northward uptilt of about two feet per mile; and the lowering of outlets by the stream erosion.

MORAINES AND VALLEY BLOCKADE

The moraines in this area were mapped by Frank Leverett in paper 5, plates 19, 25, and described in pages 651–684. In a general way they are shown in figure 3, but require further study.

The ice front acting as a barrier, along with the moraine fillings which it piled in the valleys, produced the Cattaraugus Creek, which cuts across and has beheaded the longer preglacial valleys.

The outwash plains facing the valley fillings are extensive, and pitted with kettles and ornamented with lakelets. They are shown on the Eden, Springville and Arcade sheets. They are unequalled in New York; but kettled plains in comparison are the delta plains along the east side of the Black River Valley, described in the State Museum Bulletin 160.

The valley fillings along the north side of the Cattaraugus Valley are part of Leverett's "Escarpment Moraine System," described in pages 651–672 in paper 5, and partly mapped in the plate 19. It will be seen in the new moraine map, figure 3, that this moraine correlates with the "Valley Heads" moraine in the central part of the State, and has similar relations. In both areas the drift belt is poorly developed between the valleys, across the intervalley ridges.

The moraine deposits, the wide and smooth outwash plains blending with the Cattaraugus Lake plains, and the valley lakes and their outlets, described below, make a very interesting geographic and geologic complex.

BURIED VALLEYS

An interesting element in the study relates to the buried or obscured lines of the preglacial drainage, especially the southern or headward portions. With even the present limited data and information it is possible to locate and trace some of the drift-filled valleys, having in mind that the northern divide of the Cattaraugus basin is wholly of post-glacial origin, but that the southern divide mostly dates from preglacial time.

Excepting the valley of Hunter Creek it appears probable that all of the deep north-leading valleys north of the Cattaraugus had their original headings south of the present divide; and some of the old drainage lines may be confidently inferred.

It appears quite certain that the stretches of the Cattaraugus with wide fillings of lake deposits, as at Zoar, at Cascade Park and Springville and at Yorkshire-Sardinia are filled sections of ancient north-leading valleys. The directions and relations of the unfilled portions of valleys north and south of those filled areas clearly indicate the paths of some of the Tertiary rivers. Detaching, temporarily, from its binding the map, plate 28, and placing it in proper juxtaposition with that of plate 29 the above features appear in their true relationship.

Perhaps the clearest of the old valleys is that which had its head in the constricted notch or col at Ischua Village (Franklinville and Olean sheets). Its northward course is well marked past Franklinville, Machias, Delevan, Yorkshire, Chaffee, and the now-open stretch from Protection to East Aurora; a distance of forty miles. North of East Aurora the old valley is obliterated, as are all of the old drainage lines on the Erie lowland. As a name for the Tertiary valley we may favor that of the deep, open stretch and call the stream the Preglacial Cazenovia River.

Passing westward we find that Buttermilk Valley, heading near Ashford, is in line, through the valley filling at Springville, with, probably, the Eighteenmile Valley; a length to Hamburg of about thirty miles. The close relation of the West Branch Cazenovia requires study of the rock exposures and of any deep borings.

Apparently the valley of the east Beaver Meadows also headed near Ashford, and was tributary, at Machias, to the ancient Cazenovia.

The Connoisarauley Valley, heading near the hamlet of Plato, appears to connect with the South Branch Eighteenmile Creek. The length to Eden Valley is about twenty-five miles.

The Conewango Valley was long ago (paper 1) shown to connect with the lower Cattaraugus as the Tertiary path of the Allegheny.

The lines of the ancient, preglacial stream flow can be positively and fully determined only by systematic deep drilling, and study of the well records along with the observable rock outcrops. Perhaps there may now be considerable available data for the use of some enthusiastic student of the local geology.

On plate 28 the headings of some minor lines of the old drainage may be noted. The site of the outlet channel northwest of Ellicottville was originally a divide between a tributary of the Allegheny and the present valley of Mansfield Creek. This suggests continuation through the towns of Otto, crossing of the Cattaraugus at Zoar, with probable continuation northwestward to the old Allegheny.

The channel three miles northwest of Little Valley was the location of a col which headed the valley holding Cattaraugus Village. Apparently this drainage line passed northwest toward Gowanda as an Allegheny tributary.

On plate 29, an ancient col at East Arcade was doubtless the head of a north-leading valley which was tributary to the Tonawanda Creek, and was the actual head of that drainage system. Only the stretch at and south of Java Lake remains unfilled.

GLACIAL LAKES IN VALLEYS NORTH OF THE CATTARAUGUS

The territory including these valleys is mapped on the Buffalo, Depew, Attica, Eden, Springville and Arcade sheets. The first three of the sheets, in part, and the last three are combined to form plate 29, with reduction in size.

All of these valleys decline northwestward, and consequently were effectively dammed by the receding ice front. The earliest impounded waters, the primitive lakes, had outflow southward, across the moraine fillings, into the newly-created Cattaraugus Lake. Later outflow was westward, across the intervalley ridges, with the ultimate escape into lakes Whittlesey and First Warren. The abandoned, cross-ridge channels are evident on the topographic sheets and conspicuous and fascinating in the field. They are fairly indicated on plate 29. The latest and complex outflow channels were long ago mapped in plates 3, 5 of paper 10.

These glacial lakes will be described in order passing from west to east.

New Oregon-Clarksburg Lake

In the South Branch Eighteenmile Creek

The area is wholly shown on the Eden sheet, and in plate 29. The primitive outflow at the valley head was apparently across the outwash, at 1,420 feet, into the Cattaraugus waters by Derby Brook. The outwash plain lies between Concord and Morton Corners.

The earliest well-defined lateral outflow was a mile south of Langford corners, at 1,240 feet, over into the North Branch of Clear Creek. This flow contributed to the plains and terraces along Clear Creek.

Another main outlet of the lake was five miles farther north and only a mile from the present stream, at the head of Franklin Gulf, 1,120 feet. The canyon form of the channel attests a copious and erosional outflow, which contributed to the Whittlesey beach and delta at North Collins.

Close study on the ground in this district will doubtless locate several scourways across the divide at intermediate elevations between the three outlets here described. Some of the unmapped outlets may correlate with the fragmentary stream channels shown in plate 4, paper 10.

The final downdraining was east of Eden Village; first by a channel at 1,000 feet, and later on a north-facing slope into Lake Whittlesey. See plate 4, paper 10.

Boston Lake

In the West Branch Cazenovia Valley

The earliest waters were probably confluent with the highest Cattaraugus waters, producing the extensive kettle-pitted plain north of Springville and west of East Concord. This level, 1,400 feet, must have existed until the ice front receded on the western divide some nine miles. Southwest and west of Boston Center escape was found at 1,400 down to 1,300 feet. Below this the control was west of the Hampton Valley, at East Eden. Here a set of channels begin one half mile south of the corners, at 1,140 feet and continue north and northwest of the village down to 1,000 feet. At this lowest level control was also held a mile west of North Boston. These channels were mapped on plate 4, paper 10.

Two miles north of North Boston the lake waters blended with those of Lake Whittlesey at or just under 900 feet.

Glenwood-Colden Lake

In the Main Valley of Eighteenmile Creek

This is shown on the Springville sheet. The valley heads, like the former one, in the outwash plain at East Concord; and the primitive outflow appears to have been along the path followed by the Buffalo, Rochester & Pittsburg Railroad, at 1,420 feet.

The water in this valley was confluent with that of the Boston Lake, on the west, through the cross-valley pass two miles southwest of Colden, now occupied in part by Landon Brook. But when the Boston Lake was lowered about 200 feet this pass became the outflow channel. The swamp col has elevation of 1,170 feet.

This valley, like the others of the series, has walls too steep to hold large and conspicuous delta plains on its slopes. But some of the inflowing brooks should have built deltas that can be recognized in the field, and the altitudes definitely measured. Such small deltas are the very best criteria for determining the water planes and elevations.

The next lowest escape for the Colden waters was far northward, no pass below 1,080 feet being found until we reach Loveland, northwest of Jewettville and Griffins Mills. Here is a complex of channels, and one followed by the B. R. & P. RR. leading northwest curves around to southwest as a scourway opening to Lake Whittlesey.

The intake of the Loveland channel is 1,020 feet. Three miles north, and three miles west of East Aurora, a channel at 900 feet elevation leads west and joins the Loveland channel.

Holland Lake

In the East Branch Cazenovia Valley

The creek heads in several twigs in the moraine and outwash plain at Protection Station and Chaffee Village. The channel of primitive outflow is a capacious scourway across the divide, one half mile east of the Briggs School and two miles northwest of Chaffee, leading over to Hosmer Brook. The elevation is 1,440 feet. The features appear on the Springville and Arcade sheets.

The lake existed at the level of its early outflow until the ice dam had backed away on the high western ridge, a distance of eleven miles, to near the latitude of South Wales (Springville sheet). Two miles west by south from South Wales is a channel entered by the Darling Road and curving around to Pipe Creek. The elevation of the channel bottom at the intake on the divide is about 1,310 feet. The form of the pass and channel and the Pipe Creek canyon indicate a heavy stream flow. Indeed it appears that the channel carried not only the outflow of the Cazenovia Valley but also the later outflow of the Hunter and Buffalo valleys on the east.

On the dividing ridge, declining northward, scourways occur at successively lower levels, four of which are indicated on the map, plate 29, before this East Branch Valley joins the West Branch at East Aurora, at the level of Lake Whittlesey, about 900 feet.

Colegrove Lake

Hunter Creek Valley

This deep valley lies between the East Branch Cazenovia and Buffalo valleys, on the Springville and Arcade sheets. It does not head in a moraine and outwash plain like the other valleys. When the head of the valley was released from the ice sheet it was flooded by water from the Buffalo valley through a pass two miles north of Dutchtown, with elevation of 1,370 feet. During that phase the water in the Hunter Valley was a branch of the Wales Hollow Lake, described below.

The first outflow from the valley was southwest of Colegrove and two miles northeast of South Wales, by a channel at 1,300 feet.

This channel and the succeeding ones also served for the final escape of the Buffalo Valley waters.

West and northwest of Colegrove are three more passes which lowered the waters from 1,300 down to 1,200 feet. East and northeast of East Aurora the lower channels belong to the next lake, and are on the Depew quadrangle.

Wales Hollow-Java Village Lake

Buffalo Creek Valley

As shown on the Arcade sheet and on plate 29 the Buffalo Creek heads in many branches in the towns of Holland, Arcade and Java in an extensive moraine. The longest branch, through Dutchtown, heads close to the longest branch of the East Branch Cazenovia Creek.

Mr. H. W. Clough has drawn attention to an interesting path of glacial drainage which appears on the Arcade sheet but is not indicated on plate 29. This is a smooth and level stretch extending northeast from Chaffee past Punkshers Corners and Java to near Java Center, a distance of seven miles, which carried the earliest drainage of the Buffalo Creek basin.

This belt is quite level, with elevation 1,500–1,520 feet, and apparently was smoothed as a scourway of glacial flow along the margin of the waning ice sheet. It carried the overflow of the glacial waters on the northeast, especially those of the Tonawanda Valley. This ice-border drainage immediately preceded the flow through the Gallagher Swamp channel, three miles northeast of Java Village, and it carried the earlier contribution of detritus to the great outwash plain at Chaffee.

The early flow in the Java Center—Chaffee scourway was pressed against the northwest faces of two hills, one southeast of Curriers and the other northeast of Punkshers Corners, and produced undercutting and oversteepening of the eroded slopes. This is shown by the close-set contours, 1,540 up to 1,700 feet.

A later escape of the glacial waters appears to have been through the moraine by a pass across the divide a mile north of Chaffee, at 1,480 feet elevation, leading to the outwash plain at Chaffee and Sardinia. This pass exhibits no channel features. It is the north portion of the outwash plain and carries many and deep kettles (Arcade sheet). The kettles were produced by the melting of blocks of ice which had been buried in the drift, and the melting did not occur until the ground was exposed to the atmosphere and leaching rains.

The history, the succession of events and lake conditions, is not evident and positive. An important, and uncertain, factor is the position of the ice margin in this area in its time relation to the ice-front position on the southern divide of the Cattaraugus Valley having control of the glacial lake waters. The Chaffee-Sardinia outwash plain was built in the higher glacial Cattaraugus waters; and the question now arises, how long in time and how far in northward distance did the Cattaraugus waters occupy the Buffalo Creek basin.

Evidently the Buffalo Valley waters flooded the Tonawanda Valley, on the east, by the pass at Gallagher swamp, 1,420 feet elevation, some four miles east of Java Village. And the Tonawanda waters flooded the valley of Cayuga Creek through a pass one mile northeast of North Java Station. Thus it appears that one water body occupied portions of four distinct stream systems, the Buffalo, Hunter, Tonawanda and Cayuga; to which perhaps we may add the Cattaraugus as a fifth drainage area. The relations geographic are shown on plate 29.

Apparently the only ultimate escape for the Buffalo Valley and its confluent waters was by the Chaffee pass until the ice front had receded eleven miles so as to uncover the Hunter Valley outlet, one mile southwest of Colegrove, the outlet of the Colegrove Lake, at 1,300 feet. With the fall of the Colegrove Lake (Hunter Valley) the Buffalo Valley waters became tributary to the Hunter Valley, Colegrove Lake, by northward outflow through the pass two miles north of Dutchtown, described above as the strait which had been the connection of the earlier waters of the Hunter and Buffalo valleys.

The northward outflow of the Wales Hollow Lake persisted until the two lakes blended together south of Sales Center (plate 29). The final flow was by a network of channels northeast and north of East Aurora, from 1,000 down to 900 feet. This latest flow appears to have been forced by the ice front around to the Holland Lake, just before their lowering into Lake Whittlesey. The features lie on the Depew sheet, and are mapped on plate 5, paper 10, and plate 29 of this writing.

In Valley of Cayuga Creek

This is the most easterly of the larger valleys tributary to Lake Erie. The slender creek heads in a swamp with elevation 1,376 feet, one mile north of North Java Station on the Arcade & Attica Railroad; and very close to the west fork of the Tonawanda Creek. The glacial history is tied in with that of the Tonawanda, the waters of which flooded the valley through the swamp noted above. The early waters, also the earliest glacial water of the Tonawanda, had elevation of 1,420 feet.

The first lateral outflow of the combined waters was one mile southeast of Bennington Corners (Attica sheet), at what is now 1,400 feet. A remarkable network of channels carried the later outflow, covering seven miles northwest. These are mapped on plate 5, paper 10, and partially on plate 29.

Johnsonburg-Varysburg-Attica Lake

Tonawanda Valley

Here is the most easterly of the parallel valleys with the streams having escape to the Erie basin. Today it contributes to the Niagara River. The next important valley on the east, the Oatka, contributes to the Genesee River and Lake Ontario, and belongs with the central New York series, described in papers 11 and 17.

The Tonawanda Creek has two sprawling forks in the towns of Java and Weathersfield, shown on the Arcade sheet. The west fork lies close to the Java Lake branch of Cattaraugus Creek. It runs only one half mile south of the head of Cayuga Creek, as noted above. The single deep valley begins two miles south of Johnsonburg.

The primitive glacial lake appears to have had outlet through Gallagher swamp and a pass one mile southwest, with elevation 1,420 feet. This led to the Beaver Meadow Creek, a fork of the Buffalo Creek. This level carried 44 feet over the head of Cayuga Creek, described above, and consequently flooded the Cayuga Valley.

The first westward outflow of the Tonawanda glacial waters was on the northwest-facing hill slope, less than two miles south of Bennington Village. Allowing for the tilting land uplift the first flow between the ice front and the sloping ground was at elevation over 1,400 feet. The series of successive channels below about 1,380 feet are mapped on plate 5, paper 10.

That flow past the ice front, south of Bennington, acquired drift from the ice and constructed a very interesting set of deltas, along the east slope of French Brook. Their elevation of 1,240 feet determines the elevation of the water surface, at that time, in the Cayuga Valley; under control of the outlets near Bennington Corners.

The next lower escape of the Tonawanda Valley waters was by the Konawaugus Valley, Gillett Creek and French Brook, passing close to the corners at Bennington.

Eventually a lower outlet was found four miles north, at East Bennington, at elevation 1,300 and down to 1,240. And two miles yet further north a low pass northwest of Attica, at 1,080 feet, which is utilized by the Erie Railroad. Yet later escape was by channels two miles north of Alexander, at 1,040 and down to 940 feet.

All of this northern territory is covered with moraine, and the Attica glacial waters found a plexus of low channels which carried the flow westward into Lake Warren at Alden and Crittenden.

The mapping of the glacial stream channels on plate 29 is not intended to be complete, only some of the principal channels being indicated. A keen observer, with a trained eye, may find many other minor scourways; and perhaps some errors in this mapping. The topographic sheets are the "guide, counselor and friend" in the field study.

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