New York State Museum Bulletin

Published by The University of the State of New York

No. 299 ALBANY, N. Y. December 1934

CHARLES C. ADAMS, *Director*

GLACIAL GEOLOGY OF THE CATSKILLS

BY

JOHN LYON RICH

Temporary Geologist, New York State Museum

CONTENTS

ALBANY
THE UNIVERSITY OF THE STATE OF NEW YORK
1935

M298r—Je 32–3500

the bed of the channel. West and southwest of Liebhardt a large area of coarse stream gravel marks a place where the channel widened. Below this point it has not been traced. Before this channel was abandoned the stream near the head of the channel became concentrated on the southeast side of its bed, where it cut a deep, narrow gorge.

Further melting back of the ice opened a channel down Beaverdam creek, which appears to have been occupied for only a relatively short time. The delta north of Liebhardt was probably built at this stage.

Continued shrinkage of the ice lobe in the Hudson valley finally opened a pass at 780 feet at the foot of High Point (figure 58). A channel leading southward from this pass is well developed and appears to have been occupied for a long time. Its stream flowed past Liebhardt and emptied into the lake somewhere in the neighborhood of Mettacahonts.

The next lower possible col, that at 730 feet north of Kripplebush (Rosendale quadrangle), was not examined.

LOCAL DESCRIPTIONS—ESOPUS DRAINAGE

The portion of the Catskills drained by Esopus creek had a rather complex glacial history, and its glacial deposits are difficult to decipher. This complexity is due in part to the presence in many of the valleys of local glaciers, which in some places seem to have merged with the ice of the continental glacier. Continental ice pushed southward into the Esopus valley through gaps in the Central escarpment and also westward and even northwestward into the lower end of the valley from the Hudson Valley ice lobe.

Much further study is needed before the history of glaciation in the drainage basin of Esopus creek is thoroughly understood.

ESOPUS CREEK AND VALLEYS SOUTH OF IT (PHOENICIA AND SLIDE MOUNTAIN QUADRANGLES)

From High Point to the junction of Bush kill the plain at the base of the mountains has been strongly scoured by ice and has only a thin veneer of till over the rock. Striae indicate that the general ice movement was a little south of west.

In Watson hollow, striae indicate ice movement southwestward up the valley. At the head of the valley opposite the gap south of High Point is a series of prominent morainic ridges formed by a tongue of ice that pushed through the gap from the southeast.

Much of the thick drift in Watson hollow is stratified clay, sand and gravel with a veneer of till.

About a mile below the mouth of Mine hollow a small morainic loop appears to have been formed by a local glacier moving down Watson hollow. No other evidence of the presence of a local glacier in Mine or Watson hollows could be found.

Maltby hollow has a considerable filling of thick drift in the valley bottom. An esker and a small kame were found at the junction of its principal tributary, and a fragment of an eastward-sloping terrace or outwash train of coarse sand and gravel occurs about 60 feet above the stream near the mouth of the valley. The terrace may have been formed as outwash from a local glacier, but no positive evidence for local glaciation was found in Maltby hollow or its tributaries. A large alluvial plain of coarse boulders which may possibly be outwash from a local glacier (figure 59) stretches eastward from the mouth of the valley.

On the east side of Esopus creek about a mile below Boiceville, a railroad cut in thick drift exposes the following section:

	Feet
Loose red till at top	5
Red clay with iceberg boulders, locally crumpled	5 to 10
Red sand	5
Red till containing about 1% of foreign material	50+

The presence of stratified drift between beds of till suggests a local retreat and readvance of the ice, which here ended in a lake.

Traver hollow is floored by smooth thick drift. At the mouth of its southern tributary is a large pedestal that may have been formed by a local glacier, although the evidence is inconclusive.

The Esopus valley from Boiceville to Phoenicia holds extensive deposits of thick drift characterized by smooth surface and indefinite form. Much of it is stratified, largely clay, with a thin veneer of till. Above Longyear distinct morainic loops point northwestward up the valley. A short distance below Phoenicia indistinct loops suggest movement down the valley. Ice from opposite directions probably met at this locality.

The Woodland Creek valley was last occupied by a local glacier that moved northward, down the valley. At Woodland and on the hillslope southeast of it are distinct morainic loops which prove movement down the valley. Farther down, at the junction of Panther kill, are less distinct loops indicating movement in the same direction.

At the mouth of the valley a distinct morainic ridge lies on the west hillslope at 1120 feet, trending S. 60° E. Its situation suggests that it might have been built by a glacier descending Woodland valley and strongly deflected toward the west at its lower end by the curve of the valley wall to the east. It could not have been deposited in this situation by a glacier pushing westward past Phoenicia. The only other alternative is deposition by ice moving southeastward down the Esopus valley. Such movement seems unlikely because the morainic terrace on the opposite hill, north of the Esopus, descends toward the northwest, as if built from the southeast.

The head of the Woodland valley is relatively free of moraine, but has considerable outwash gravel. In the tributary valley that rises on the northeastern slope of Wittenberg mountain is a large pedestal bearing strong evidence of having been formed by a local glacier. Below it the valley bottom is composed of outwash gravel.

The valley of Panther kill has several morainic loops on the north side that point eastward as if built by a local glacier.

In the Esopus valley at Phoenicia is a large morainic terrace south of the stream whose relation is not clear.

In the vicinity of Allaben and Shandaken are morainic loops that obviously were built by glaciers descending Forest valley and Bushnellsville creek and spreading out as bulbs in the Esopus valley.

Moraines and thick drift in Fox hollow are noncommittal in direction. A small delta at 1440 feet at the head of the hollow was probably built into a local lake held in the valley by the ice that built the moraines at Allaben.

Between Shandaken and Big Indian faint morainic loops appear to point westward. They are thought to have been built at the western end of a bulb of ice pushing westward up the valley from the glacial tongue that descended Bushnellsville creek.

Big Indian hollow has very little drift in its lower part. A short distance below Oliverea faint traces of moraine point northward, down the valley. Above Oliverea numerous morainic loops pointing northward prove the presence of a local glacier of considerable size. A small local glacier appears to have descended the north slope of Balsam mountain to a level of about 1500 feet. Its moraines are small, but moderately distinct.

BIRCH CREEK

At the head of Birch creek, north of Rose mountain, is a group of massive moraines formed at the end of a tongue of ice that pushed from the east over the pass leading from Bushnellsville

valley. Other moraines in this valley are mainly of the thick drift type and yield uncertain testimony as to the ice movements.

The pass at Grand Hotel, at 1890 feet, was occupied, probably only for a short time, by a stream flowing westward from a lake in the upper Esopus watershed. The channel at the divide is shallow and only 50 to 100 feet wide, and the amount of cutting across the divide has been small. On the west side, however, where the stream cascaded down a steep slope into Emory brook, it cut a considerable gorge in which distinct fossil waterfalls are found.

No certain evidences of local glaciers were discovered in the valleys on the north slopes of Belle Ayr mountain.

BUSHNELLSVILLE VALLEY

The glacial features of the Bushnellsville valley are especially interesting because it heads in one of the three low passes or "notches" that cut the Central escarpment, and was therefore a path of relatively free ice movement.

Sharp morainic loops at Allaben and morainic loops extending northward into Peck hollow prove that a tongue of ice from the Bushnellsville valley spread out in the form of a bulb in the Esopus valley. The moraines near Big Indian formed at the western end of the west lobe of this bulb have already been mentioned. There is no direct evidence that the bulb extended eastward farther than the moraines at Allaben, for the indistinct morainic loops below the mouth of Forest valley may have been built by a glacier from that valley.

At Shandaken is a large delta. The shape of its front shows that it was built into open water to the south by a stream descending Bushnellsville valley. Upstream it grades into an outwash plain that rises gradually toward a mass of moraines below Bushnellsville. These probably mark the position of the end of the ice at the time the earlier parts of the delta were forming. The elevation of the top of the delta—about 1320 feet—corresponds so closely with the level of the lake outlet at Wagon Wheel gap that doubtless the delta was built at the time the lake had its outlet there. From this prominent delta the lake is named Shandaken lake.

On the evidence from the delta and that of the stream channels southeast of High Point, we may conclude that when the ice ended at Bushnellsville its margin lay against High Point at Wagon Wheel gap, passed near Liebhardt and thence into the Rondout valley somewhere in the neighborhood of Kerhonkson or Wawarsing.

Above Bushnellsville, on the hillslope north of the junction of Angle creek, is a small kame or delta with a flat top at about 1820 feet, and an ice-contact slope on the west side. On the top, which stands out a little from the hill to the east, one can readily make out the point where the delta-building stream left the ice. It is uncertain whether this delta was built into a small lake impounded in Angle creek or into the larger water body (Peekamoose lake) whose outlet was at Peekamoose gorge.

Between Angle creek and Deep notch, on the east side of Bushnellsville creek, massive lateral moraines are found. Some of the ridges and embankments are sharp and distinct. Others contain considerable gravel.

DEEP NOTCH

Deep notch is the middle one of the three remarkably narrow and deep defiles that cut the Central escarpment (figure 60). The upper two-thirds of the profile of the notch has a slope of moderate steepness and is believed to be part of a preglacial gap in the range formed by the headward erosion of two streams from opposite sides. The lower third of the notch is essentially a rock gorge that is believed to have been formed mainly by glacial streams, which, as in the case of Peekamoose gorge, were diverted across the notch as a result of glacial interference with normal drainage.

The walls of this lower third of the notch are nearly vertical except where they have been broken down by weathering or are obscured by talus. At the divide the notch is so filled with boulders and talus that it is impossible to determine the elevation of its rock bottom, but it was almost certainly below 1880 feet and may have been considerably lower. It would be convenient to know the original depth of the gorge for it probably was the outlet of a lake in the Schoharie valley at some stage of the glacial retreat, although apparently not at the latest stage, for the gorge appears to have been partly filled with drift since it was abandoned by its stream.

South of the divide, below the two ponds shown on the map, is a steep-walled rock gorge such as only a powerful stream could have cut, but it is partly buried under glacial drift. Its walls are revealed here and there along the valley side where the drift has been removed. On the west side of the valley, for instance, near the junction of the secondary road that enters from the west, and about 250 feet west of the main road, a tributary stream has uncovered the buried rock wall of the gorge. At this point the bottom of Bushnellsville Creek valley is narrow and shows no evidence of the former presence of a larger stream. About a quarter of a mile downstream, however, the valley widens out and the glacial stream channel emerges, so to speak, from its drift cover. It has a flat bottom, steep sides and every appearance of having at one time carried a large stream. The elevation of the channel bottom here must be less than 1700 feet.

Whether the partly buried rock gorge through the notch was cut during earlier glacial epochs—including the advancing stages of the latest epoch—and for some reason was not reoccupied by a stream at the close of that epoch, or whether the channel was cut near the close of the latest glacial epoch and later partly buried by a readvance of the ice over its northern end or by local glaciers after the continental ice had receded, is an unsolved problem.

Whichever of these may be the correct explanation, it remains clear that the "notch" was not an important lake outlet after the final retreat of the ice from it.

PECK HOLLOW

Peck hollow is one of the shorter valleys heading on the south side of the Central escarpment. Its western branch heads in a gap in the range at about 2850 feet; its eastern branch starts on North Dome (3593 feet), one of the higher peaks. The moraines in the valley indicate ice movement southward everywhere except in the lower three-quarters of a mile, where two prominent morainic loops are convex up the valley and show clearly by their form that they were built by ice pushing up the valley from the south. On their western side they grade upward into a terrace that leads around the hill toward Bushnellsville valley, showing that they were built at the end of a bulb of ice that spread down the Esopus from that valley, at least as far as Allaben.

At the lower end of the massive moraine that is crossed by the county line is a small body of sand and gravel whose flat top at about 1330 feet suggests that it is a delta built into Shandaken lake, whose outlet was at Wagon Wheel gap.

Farther upstream the west branch of the valley contains considerable thick drift, which toward the head of the valley, has the form of indistinct pedestals. The absence of distinct moraines in this branch of the valley is conspicuous. Not so, however, with the east branch. At its junction with the west branch a remarkably sharp and distinct, though small, morainic ridge swings down out of the west side of the east branch and out across the west branch as shown on the map (plate 1). It was unmistakably formed at the western edge of ice that descended the east branch and spread out as a bulb where the two branches join—seemingly a local glacier heading on North Dome.

FOREST VALLEY

Forest valley has two principal tributaries joining about two miles above its mouth. One, Broadstreet hollow, heads in a broad, relatively low gap in the Central Escarpment (2460 feet); and the other on the southwest side of West Kill mountain, one of the highest peaks in the range.

That the pass at the head of Broadstreet hollow was an important channel of ice movement is suggested by its broad U-shape, indicating strong scouring by ice, and by a large mass of morainic material that chokes the upper two and one-half miles of the valley south of the pass. The top of the moraine is nearly flat, except that gravelly ridges descending southward from either side have formed a bowl-shaped depression that has been converted into a lake by a small dam. At the south end the moraine is flat-topped and gravelly at about 1835 feet, and at its outer edge is probably a delta built into a lake that stood at that level while the moraine was being built. The front of the delta, about 400 feet high, slopes very steeply to the south. Below the moraine and delta, at the mouth of Broadstreet hollow, are exposures of lake clay veneered with till, indicating considerable fluctuation of the ice margin while the lake waters were present. From this point to the Esopus, the bottom of Forest valley is filled with thick drift and moraine in which the presence of considerable lake clay is suggested by slumping and land-sliding.

In the small tributary valley west of Broadstreet hollow are two pedestals of thick drift or moraine having steep fronts facing the south. The hillside to the west of them has been strongly scoured.

The eastern tributary of Forest valley contains considerable thick drift and indistinct moraine in the lower two miles of its course. The remainder of the valley is floored with smooth thick drift through which the stream flows in a trench 10 to 75 feet deep. The tributary valley heading on West Kill mountain was not ascended, but from the opposite hillside it was seen to be a V-shaped valley with overlapping spurs showing no evidences of glacial erosion. No glacial accumulations other than the ever-present veneer of till were noted.

STONY CLOVE VALLEY (PHOENICIA AND KAATERSKILL QUADRANGLES)

The Stony Clove valley is one of the most interesting in the Catskills on account of the great number and variety of glacial phenomena that it displays. It heads in a remarkable defile, called Stony clove, cut to a depth of about 1400 feet through one of the highest

parts of the Central escarpment (figure 61). Its headwater tributaries drain the southern slopes of three of the highest peaks in the Catskills—West Kill mountain, 3777 feet; Hunter mountain, 4025 feet; and Plateau mountain, 3855 feet. Combined in the valley are the effects of the continental glacier pushing through the low pass at Stony clove and of strong local glaciers that appear to have descended the slopes of Hunter and neighboring mountains.

Upstream from a point half a mile above Phoenicia, the Stony Clove valley is choked for about three miles with moraines comprising a remarkable series of ridgelike loops convex down the valley, some of them as sharp and steep as high railway embankments. The steep hillsides near Chichester are plastered with moraine which has been conspicuously exposed by landsliding and stream undercutting.

The lower half of the Ox Clove valley, a tributary entering at Chichester, is choked with moraine deposited by a lobe of ice that pushed up from the Stony Clove valley.

In the neighborhood of Lanesville the most conspicuous glacial feature is a terraced outwash plain, or valley train, the upper terrace of which may be traced from about half a mile below Lanesville upstream to the junction of Stony Clove and Hollow Tree Brook valleys, whence one branch extends for a mile up the latter valley, while another extends for a mile and a half up the Stony Clove valley to the moraine at the mouth of the first large valley leading down from Hunter mountain. From this point to Edgewood the bottom of the Stony Clove valley is partly filled by a series of deltas and a large kame, over 200 feet high, which blocks the valley opposite two morainic ridges descending toward it from the hillside to the south.

The kame is believed to have been formed where an ice tongue ended in a lake, building the moraines above lake level and the kame below and up to lake level. Later, as the ice tongue retreated eastward up the valley the deltas appear to have been built into the same body of water. The top of the kame and the flat top of the delta on the hill northeast of it lie at about 1800 feet elevation. The deltas between the kame and Edgewood lie at two levels, approximately 1810 and 1830 feet. Their south fronts are straight and steep, as if built against a body of ice lying south of them in the valley. Bordering the deltas on the north is a mass of kame-moraine with numerous large and small kettle holes.

The deltas above described reveal the former presence of a lake in the Stony Clove valley, the level of which fluctuated between about 1800 feet and 1830 feet. It may be recalled that the deltalike front

of the moraine in Broadstreet hollow, the delta in the Bushnellsville valley at Angle creek, and a delta in the Warner Creek valley, all lie at about the same level. These deltas were probably formed in Peekamoose lake, whose outlet was at Peekamoose gorge. It is possible, however, that those in Stony Clove valley were built at a later stage in a local lake impounded by one of the local glaciers descending from Hunter mountain.

About half a mile north of Edgewood a mass of moraine has distinct loops and ridges convex toward the south. North of this body of moraine, and leading into it, is a strip of hummocky kame-moraine bordering the west side of the valley for about three-quarters of a mile, which probably represents a marginal gravel terrace thrown into knob and kettle form by the melting out of its ice support on the east side.

Stony clove is a deep, narrow pass through the range (figure 61, also figures 19 and 20). No evidences of glacial scouring or vigorous ice movement through the pass were noted. Neither is there any sign of the pass having been occupied by a glacial stream after the ice melted out of it. It is evident, therefore, that Stony clove is not a postglacial phenomenon. It may have been cut by glacial streams during the advance of the Wisconsin glaciers or during the advance or retreat of glaciers of an earlier epoch.

The valleys heading on Plateau, Hunter and West Kill mountains present features which, in any region known to have been occupied by mountain glaciers, would be pointed out as the clearest evidence of glacial erosion. U-shaped valleys with oversteepened sides (figure 62) are especially conspicuous on the south side of Hunter mountain. Cirquelike forms are also conspicuous at the heads of several of the valleys, notably those heading on Hunter mountain and the one heading on the southeast side of West Kill mountain. The extensive areas of rock talus masking the steeper slopes of Hunter and Plateau mountains are believed to be due mainly to the oversteepening of the slopes of the valley sides and cirque heads by glacial erosion, thereby exposing the much-jointed rocks to intensive frost action, which led to their rapid disintegration. The valley sides and cirque heads have lost some of their characteristic glacial form as a result of this disintegration.

Further discussion of the evidences of strong erosion by local glaciers in this locality, together with a suggested explanation of the phenomenon, will be presented in the section on local glaciation.

The outwash valley train along Hollow Tree brook, which joins a similar train at an accordant level at Lanesville, has already been

described. The Hollow Tree Brook branch heads in a series of moraines that appear to have been formed by glaciers descending the southeast slopes of West Kill mountain. A mile above Lanesville a large valley heading on the south side of West Kill mountain enters the valley of Hollow Tree brook. The lower half of the valley has a distinct V-shape and appears to be free from moraine; but where it joins that of Hollow Tree brook, a narrow, bouldery morainic ridge, 75 to 100 feet high, detaches itself from the southwest spur of the valley and swings down the middle of the valley of Hollow Tree brook for more than a quarter of a mile. The ridge appears to have been built by a local glacier descending the valley under discussion. About three-quarters of a mile farther up Hollow Tree brook a large, hummocky drift mass blocks the east side of the valley. Its top is gravelly and lies at about 1800 feet.

Diamond notch, at the head of Hollow Tree brook, is a sharp stream-cut notch, 200 feet or more in depth, partly choked by talus fallen from its eastern wall. The source and the direction of the stream that cut the notch are not known. No evidences of glacial scouring in or near the notch could be found.

WARNER CREEK

The lower four miles of the valley of Warner creek are comparatively open and free of drift except for indefinitely shaped accumulations of smooth thick drift in the valley bottom. Three-quarters of a mile above the mouth of the valley this thick drift filling makes a distinct "step" in the valley bottom. At the low gap in the south side of the valley at the Greene-Ulster county line a tongue of ice pushed into the Warner valley from the south, building three distinct morainic loops in the gap and a large mass of gravelly moraine and kame-moraine in Warner valley adjacent to the morainic loops. Behind the highest morainic loop on the east side of the gap is a marginal stream channel 50 feet in width leading down into the gravelly moraine in the Warner valley already mentioned.

At a somewhat later stage, a glacial stream of considerable size flowed through the west side of the gap and cascaded down into the Warner valley, where, at a level of about 1740 feet, it built a large delta into a lake (probably Peekamoose lake) which occupied the valley at that time. The delta has a steep, lobate front 160 feet high facing down the valley. The fossil waterfall and plunge basin at the head of the delta are as distinct as if they had only recently been abandoned by their stream.

In the Warner Creek valley, slightly more than half a mile above the gap, is a massive accumulation of stony moraine that appears to have been built by ice moving down the valley from the northeast, although this direction could not be certainly established. This moraine has ponded the stream, causing it to build a wide alluvial flat on its upstream side.

The upper part of the valley, as seen from a distance but not examined in detail, appeared to be floored entirely by smooth thick drift.

BEAVER KILL (PHOENICIA AND KAATERSKILL QUADRANGLES)

Beaver kill is a beheaded stream which at one time rose on the south side of the Central escarpment at its eastern end and entered Esopus creek at Mount Pleasant. The stream in the upper part of the valley, from Shady to Echo lake, has been captured by a stream called Saw kill draining more directly to the Hudson past Bearsville and Woodstock.

Glaciation in the valley of Beaver kill was dominated by ice from the Hudson Valley lobe that pushed westward and northwestward into the valley and against the southern flanks of the Central escarpment.

In the lower three miles of its course, the Beaver Kill valley is filled with smooth thick drift having the appearance of having been overridden by ice since its deposition. Farther upstream, opposite the mouth of Silver hollow, a huge mass of smooth moraine blocks the valley. It has effectively ponded the stream and caused the formation of a wide, smooth alluvial plain stretching upstream for three miles to Cooper lake. Along the north side of the valley between this moraine and the stream from Mink hollow, extensive marginal gravel terraces and kame-moraines were formed along the north side of the ice tongue which here traversed the valley from east to west.

At a later stage of the ice retreat a lobe of ice pushed into the valley through the gap south of Cooper lake and built a series of beautiful morainic loops that now inclose the lake. Outwash from these moraines was spread westward and probably contributed largely to the silting up of the ponded portion of the valley already described. A similar ice tongue undoubtedly pushed up Saw kill past Shady. In the area between these two ice tongues extensive kame-moraines were formed.

An ice tongue also pushed northward through the gap at Meads and built a pedestal moraine opposite the gap.

The valley of Saw kill from Shady to Echo lake has its bottom covered with thick drift and indefinite moraine. Echo lake is held in by a low bar of smooth thick drift without morainic form. At Shady a gravel terrace appears to lead downstream to a large delta, fragments of which are preserved on both sides of the stream half way between Shady and Bearsville. The top of the delta lies at about 880 feet, which corresponds closely with the level of a fossil stream channel leading into the head of the Little Beaver Kill valley. The lake in which the delta was built was evidently held in the valley over Woodstock and Bearsville by the Hudson Valley ice lobe.

A series of remarkably distinct morainic loops in the gap three miles north of Shady as well as those in the gap leading to Warner creek, testify to the westward and northwestward movement of ice from the Hudson Valley lobe around the end of the high Central escarpment.

LITTLE BEAVER KILL (PHOENICIA AND KAATERSKILL QUADRANGLES)

The valley of Little Beaver kill, like that of Beaver kill, was occupied, at least during all the later stages of the ice retreat, by ice moving westward from the Hudson Valley lobe.

In the lower two miles of its course the valley is deeply filled with thick drift, mostly of smooth indefinite form, although moderately distinct morainic loops are found on both sides of the valley near its mouth. A small drumlin rises from the thick drift a mile above the mouth of the valley, and another larger one at Yankeetown. In the stretch above and below Yankeetown, several distinct morainic loops swing down from the hillsides and partly across the valley. The tongue of ice that built these moraines ended in a lake, as is shown by the presence of a distinct delta, whose top lies between 860 and 880 feet, close inside the westernmost morainic loop, and by masses of kames and kame-moraines farther up the valley.

The entire upper end of the valley has been strongly scoured by ice. The soil is very thin, and smooth, bare, striated rock surfaces are common. Little glacial débris of any kind is present.

LOCAL DESCRIPTIONS—SCHOHARIE DRAINAGE

The Schoharie drainage is made up of a number of streams flowing westward between the Central escarpment and the Northeastern escarpment of the Catskills, and joining to form the main Schoharie creek, which flows northward across the Central New York plateau.