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C.N
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OLIN
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WYOMING COUNTY.

G[6]

EXPLANATION OF COLORS.

Pocono Sandstone X

Catskill Sandstone IX

Chemung Shale and Sandstone VIII

C. Clay.
B.C. Brickclay.
≡Q. Quarry.
= Stone Ledges
↓ Direction of Dip

BRADFORD COUNTY

SUSQUEHANNA COUNTY

WYOMING COUNTY

SULLIVAN COUNTY

LUZERNE COUNTY

WILMOT ANTICLINAL

BERNICE SYNCLINAL

SHORT MT.

MUNCY CREEK ANTICLINAL

BRAINTRIM

WINDHAM

MESHOPPEN

MEHOOPANY

BRANCH

NORTH MOUNTAIN

FORK

NORTH MOUNTAIN

Wire Ferry

LACEYVILLE

NORTH FLAT

SKINNER'S EDDY

GOLDEN HILL

SCRANTON CORNERS

MESHOPPEN

B.C.

JAYNE BEND

KEISERVILLE

SCOTTSVILLE

JENNINGSVILLE

Little Mehoopany Creek

RUSSELL HILL

MEHOOPANY

MAYNARD HILL

LOVELTON

North Branch of Mehoopany Cr.

THE NECK

SUSQUEHANNA RIVER

NORTH BRANCH

FORKSTON

Coal Creek

EATON

BOWMANS KNOB

Bowman's Creek

Stony Brook

Mehoopany

BELLA SYLVIA

VERNON

Bowman's Creek

South Run

MONROE

MILL CITY

CENTRE MO

JULIUS BIEN PHOTOLITH. NEW YORK.

SUSQUEHANNA COUNTY

BERRICE SYNCLINAL

TUNKHANNOCK ANTICLINAL

SCRANTON CORNERS

HOPPEN

MESHOPPEN

JAYNE BEND

MESSERVILLE

LEMON

LEMON

WEST NICHOLSON

NICHOLSON

PIERCEVILLE

MARCY POND

RUSSELL HILL

MEHOOPANY

OPANY

THE NECK

SUSQUEHANNA RIVER NORTH BRANCH

TUNKHANNOCK

DIXON

FACTORYVILLE

EATON

BOWMANS KNOB

OVERFIELD

CROOKED LAKE

MILL CITY

SOUTH EATON

FALLS

VERNON

KEELERSBURGH

NORTH MORELAND

CENTRE MORELAND

MONROE

MILL CITY

WYOMING COUNTY

WHITE DEER MOUNTAIN ANTICLINAL

SECOND GEOLOGICAL SURVEY
OF PENNSYLVANIA
J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP
OF
WYOMING COUNTY

ANDREW SHERWOOD, ASS'T. GEOLOGIST

1876.

Scale: 2 Miles to 1 Inch

LANE S. HART, STATE PRINTER

QE
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ENVIRONS OF LEHIGH GAP.

G.[6]

C

A

E

F

D

FROM MAUCH CHUNK

BOWMANSVILLE

CHURCH

FROM PARRYVILLE

CHURCH

SCHOOL HOUSE

ROOFING SLATE

MILLPORT

CEMENT

PAINT

LIMESTONE

CHURCH

LIZARD CREEK

HAZARDVILLE

CRAIG'S ISLAND

LEHIGH GAP

PAINT WORKS

AQUANCHICOLA CREEK

Edge of Slates

LEHIGH RIVER

366'+1160'=1526' A.T.

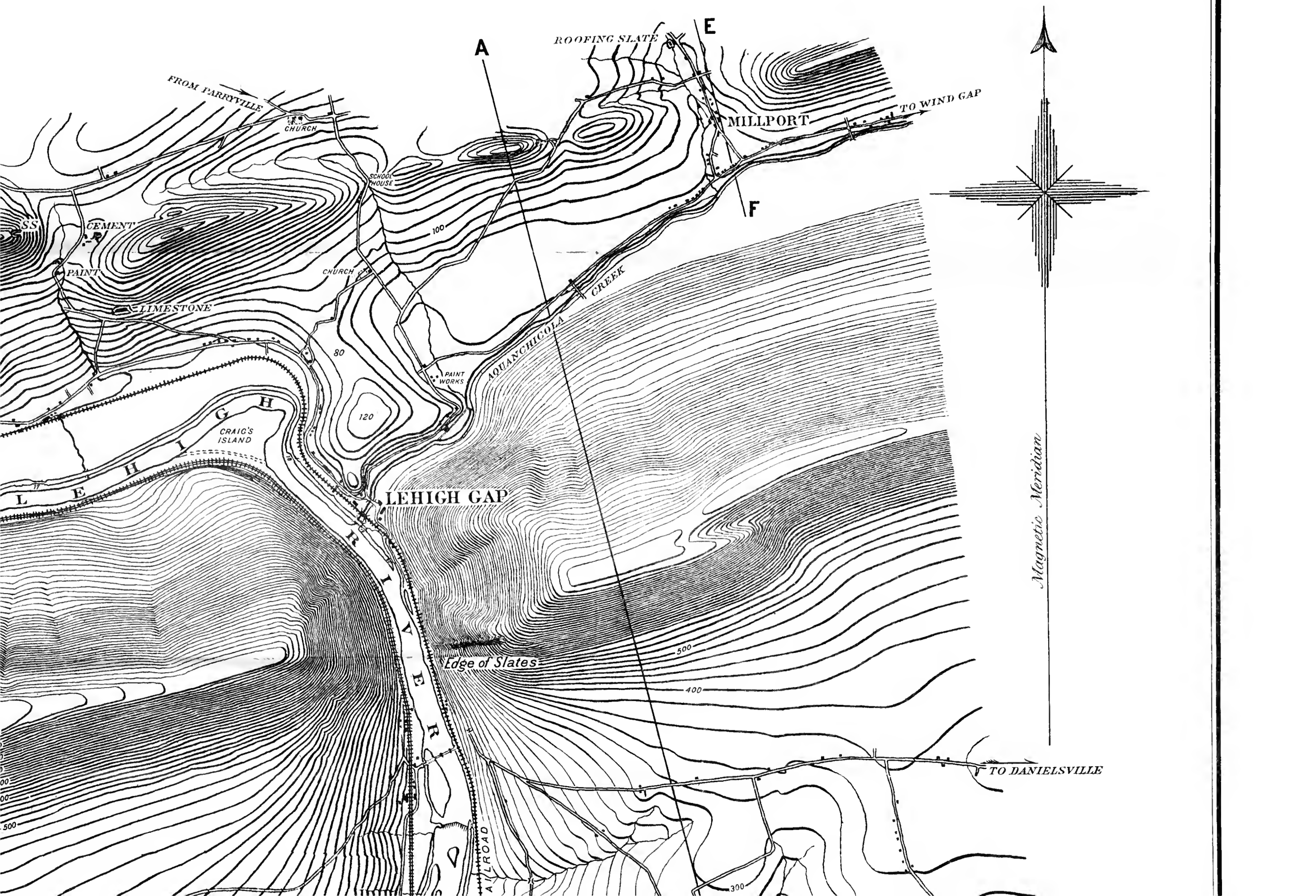
460 400 300 200 100

200 300 400 500 600 700 800 900 1000 1100

1100 1000 900 800 700 600 500

100 80 120 500 400 200

RAILROAD


A
E
F
ROOFING SLATE
FROM PARRYVILLE
CHURCH
SCHOOL HOUSE
MILLPORT
TO WIND GAP
SS
CEMENT
PAINT
LIMESTONE
CHURCH
100
80
120
PAINT WORKS
AQUANCHICOLA CREEK
CRAIG'S ISLAND
L E H I G H
LEHIGH GAP
R I V E R
Edge of Slates
500
400
300
TO DANIELSVILLE
RAILROAD
Magnetic Meridian

KEY TO SLATE QUARRIES.

1 *Franklin Quarries.*
2 *Girard, No1.*
3 *Girard, No2*
4 *Trout Creek*
5 *Columbia.*
6 *American, No1.*
7 *Williamstown*
8 *American, No2.*
9 *Eagle.*
10 *Blue Vein.*
11 *Washington.*
12 *Owned by Lehigh Slate Co.*
13 *Old Quarry (Bangor)*
14 *Owned by Heimbach Co.*
15 *David Jones.*
16 *Owned by Lehigh Slate Co.*
17 *Knauss.*
18 *Mantle.*
19 *Wiltstown.*
20 *Keystone*
21 *David Williams, No3.*
22 *David Williams, No2.*
23 *David Williams, No1.*
24 *Walnutport.*
25 *Heimbach.*

Note: Add 366 feet to elevations for elevation above mean Ocean level.

366'+1160'=1526' A.T.

1100 1000 900 800 700 600 500 400 300 200 100

LEHIGH VALLEY R.R.

LEHIGH & SUSQUEHANNA RAILROAD

B

SYNCLINAL

WILLIAMS

ANTICLINAL

WASHINGTON

AMERICAN

SYNCLINAL

FROM READING

FRANKLIN

SLATINGTON

WALNUTPORT

TO ALLENTOWN

TO EASTON

SECO

J.P.

A TO

IN TWENTY

ENVIRON

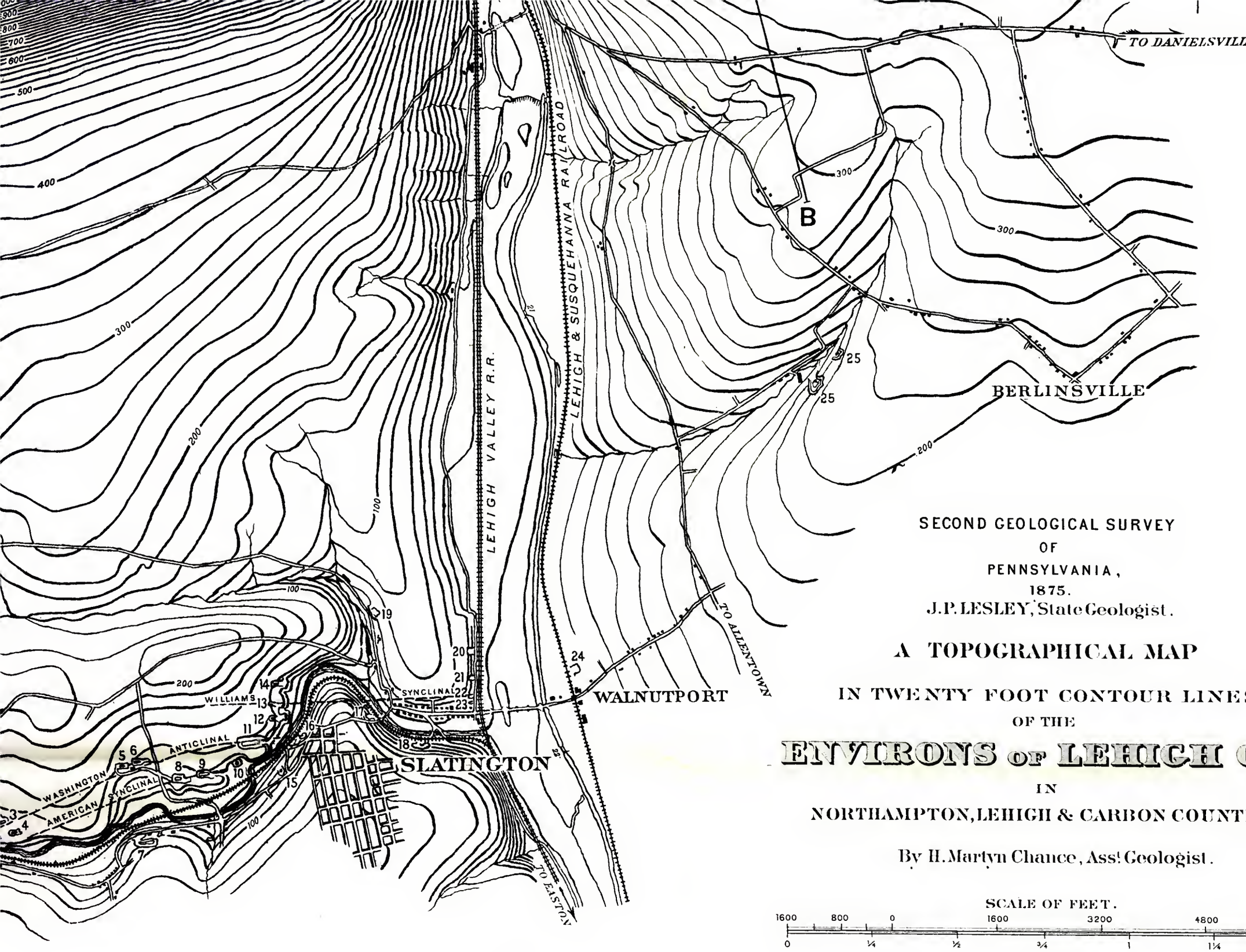
NORTHAMPTO

By H.M

1600 800 0

0 ¼

LANE S. HART, STATE PRINTER.



SECOND GEOLOGICAL SURVEY
OF
PENNSYLVANIA,
1875.
J.P. LESLEY, State Geologist.

A TOPOGRAPHICAL MAP

IN TWENTY FOOT CONTOUR LINES
OF THE

ENVIRONS OF LEHIGH GAP

IN
NORTHAMPTON, LEHIGH & CARBON COUNTIES,

By H. Martyn Chance, Ass't Geologist.

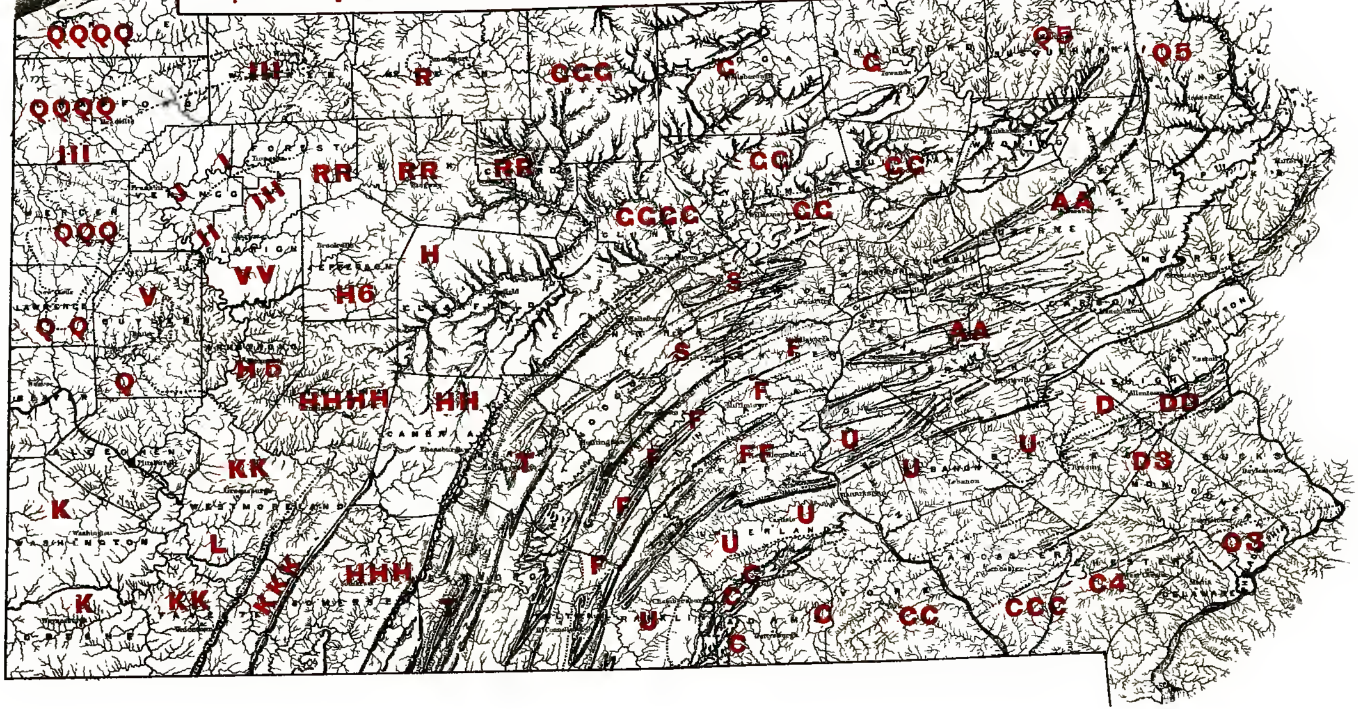
SCALE OF FEET.

1600 800 0 1600 3200 4800 6400

0 ¼ ½ ¾ 1 1¼ 1½

MILES.

Map of Pennsylvania, Showing the Areas Surveyed in 1874, 1875, 1876, 1877, 1878, 1879 & 1880.



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA:
REPORT OF PROGRESS G⁶.
1881.

THE GEOLOGY OF

PIKE AND MONROE COUNTIES.

By I. C. White.

With colored geological county maps;
a map of glacial scratches;
and seven small sections.

SPECIAL SURVEYS

OF THE

DELAWARE AND LEHIGH WATER GAPS.

By H. M. Chance.

With two contoured maps of the Water Gaps;
and six detailed sections.

HARRISBURG:
PUBLISHED BY THE BOARD OF COMMISSIONERS
FOR THE SECOND GEOLOGICAL SURVEY.
1882.

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TABLE OF CONTENTS.

CHAPTER 6.—*Descriptive Geology.*

PREFATORY LETTER.

To His Excellency, HENRY M. HOYT, *Chairman, ex officio, of the Board of Commissioners of the Second Geological Survey of Pennsylvania:*

SIR: I have the satisfaction to present for your favorable consideration Prof. I. C. White's sixth report of progress, namely, G^6, on Pike and Monroe counties.

This report embodies his work of 1881, and is a southward continuation of his study of Susquehanna and Wayne counties, G^5, in 1880.

During the current field season of 1882, Prof. White will complete the survey of the Devonian and Silurian measures in Wyoming, Lackawanna, Luzerne, Montour, Columbia, and Northumberland counties, along the northern border of the Third Anthracite coal field, and as far west as the West Branch Susquehanna river.

The country described in this report, G^6, is as interesting in a geological sense as it is uninteresting mineralogically.

Its outcrops of limestone, cement rock, and flag-stone are of great value; but it contains neither ores of the precious metals,* nor coal beds,† nor iron ore deposits.‡ A large part of it is a wilderness of forest, swamp, and lake, elevated 1500 to 2000 feet above sea level, affording bark for tanneries and timber in abundance, and so strewn with bowlders of rock, gravel, and sand, of glacial age, as to be hardly susceptible of cultivation.

Its topographical and geological resemblance to the Catskill Mountain region of New York is evident.

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* Local traditions respecting Indian silver and lead mines are delusions.

† Why the search for coal in Monroe and Pike counties has always been and must be futile, is explained in various parts of the report. See pp. — —

‡ For some brown hematite outcrop beds, however, see pp. — —

Those who travel on the Hudson river see, on the western horizon, a wall of mountains about 3000 feet high, back of which spreads a table-land, gashed with deep valleys, draining westward into the Delaware.

The plateau widens westward; its northern edge trending west, and facing central New York; its southern edge trending south-west, and overlooking the Wallkill valley, through which passes the Delaware and Hudson canal.

The edges of the table-land and the ribs which separate its valleys are set with peaks, rising a thousand feet higher than its general plane of elevation above tide. Those ranged along its southern edge are the highest.

Professor Arnold Guyot reports one summit 4179′ A. T.; Hunter mountain, 4052′; Black-head, 3965′; Monk mountain, 3880′; Stony mountain, 3856′; Round-top, (once thought to be 3800′,) 3670′; Overlook mountain, facing the Hudson, 3500′ to 3600′; the Schoharie peaks, on the northern edge, 3600′.

The body of the Catskill plateau is composed of the *Upper Devonian*, *Old red sandstone*, or *Catskill formation*, (*No. IX* of the First Geological Survey of Pennsylvania,) which is at least 5,000′ thick. The upper layers (3,000′,) slightly inclined, project their edges from its southern wall; the lower 2,000′, more inclined, crop out in the foot hills in the valley.

The peaks are what remain of the overlying grey *Subcarboniferous*, *Pocono formation* (No. X,) which formerly spread continuously over the red *Catskill.** These frag-

*Above *No. X*, the *Mauch Chunk red shale* formation *No. XI*, the *Pottsville conglomerate* No. XII, and the *Coal measures No. XIII*, once lay. So that the original height of the Catskill mountain massif must have been at least 11,000′, if not 12,000′.

Mather's description of the Catskill in N. Y. Geol., 1843, pp. 299+, is based upon the supposition that the highest summits contain the *Pottsville conglomerate* No. XII. He says, (p. 310:) "On the road from Pleasant Valley to Windham and Plattsville the base of the mountain is observed principally composed of grey grits; in the middle, reddish and chocolate-colored rocks predominate; toward the head of the valley the thick-bedded grey grits abound, and red shales for the higher hills, capped in some places on the high peaks by *conglomerate of the coal formation*. This distribution of the red and grey rocks is general in the Catskill division, and corresponds with Nos. IX, X, XI, XII of Prof. Rogers' Reports of Pennsylvania." The mis-

ments have been preserved by *grey* conglomerate beds in X, which appear at their tops. The table-land itself has been preserved by *red* conglomerate beds. The southern edge of the table-land is higher than its northern edge, because both formations—the upper grey X and the lower red IX—increase both in aggregate thickness and in the number and coarseness of their sand and gravel beds in a southerly or southeasterly direction.*

This law of thickening and coarsening southward, or southeastward, governs the palæozoic *noncalcareous* deposits—*Subcarboniferous, Devonian, Silurian, and Siluro-Cambrian*—along the whole Appalachian belt, from the State of New York to the State of Alabama; and points to if it does not prove the derivation of the palæozoic sediments from the archæan highlands of New England, Southern New York, Northern New Jersey, the South mountains of Pennsylvania, the Blue Ridge ranges of Virginia, and the Black mountains of North Carolina; or, in lieu of some of these, which were early covered with palæozoic sediments, to archæan alps still further off, now buried beneath the shore deposits, or beneath the deep waters of the Atlantic.

The thickening and coarsening of the sub-carboniferous (X) and Catskill (IX) beds from the New York State line southeastward, through Susquehanna and Wayne counties, was described by Prof. White in his report of 1880 (G⁵.) In the present report of 1881 (G⁶) he shows how it continues through Pike and Monroe counties, towards the New Jersey State line.

The Catskill mountain table-land, as above described widening westward, declines in height as it approaches the Delaware river. The cause of this is to be found in a grad-

take arose from the fact that there is a considerable thickness of red shales *beneath* the conglomerate sandstone mass of No. X (*Pocono; Mt. Pleasant,*) which was confounded by Prof. Mather with the great red shale of XI *overlying* No. X.

* The northerly dip of the southern side of the table-land, instead of increasing its relative height, would have diminished it; for the maximum resistance of a rock to erosion is reached when the rock becomes perfectly horizontal. This is the real reason why the highest mountains of any given region range along its synclinal axis.

ual sinking of the geological planes southwestward; or, in other words, an exceedingly gentle, but positive, universal dip of the rocks *from* the Hudson *towards* the Delaware. And this is a sufficient reason why the drainage of the table-land is not eastward into the Hudson, but westward into the Delaware. In fact, the Catskill table-land has its northeastern end lifted along the Hudson river valley.*

It is 75 miles, in a straight line, from the Catskill mountain overlooking the Hudson, southwest, to the Delaware river; and 50 miles more, west-southwest, to the Lehigh river. The Catskill table-land is therefore at least 125 miles long; half in New York and half in Pennsylvania; that part of it which spreads through Pike and Monroe counties being called the *Pocono plateau;* extending westward across the Lehigh in Carbon county as the Nesquehoning mountain; and northward, as Moosic mountain, into Lackawanna, Wayne, and Susquehanna counties. It is thence continued westward, by the Elk mountains, across the Susquehanna river and becomes the North or Allegheny mountain uplands.

The Catskill plateau as a whole must be regarded as one broad synclinal, rising towards the northeast. Through this synclinal run lengthwise (N. E. and S. W.) gentle anticlinal undulations, which are not of sufficient moment to destroy the synclinal unity of the whole plateau. But west of the Delaware river these or similar undulations become so momentous that the unity of the grand synclinal is lost, and its place is occupied by deep parallel basins containing coal measures, separated by high anticlinals bringing up belts of Devonian formations.

The Delaware river makes a clean cut across the Catskill

*Sharp foldings between the foot of the mountain and the banks of the Hudson, at the village of Catskill, repeat the story of a downward slide or slip of the Palæozoic mass (in this instance westward) which is told by the plications (in the same rocks, VI) at the Delaware, Lehigh, and Schuylkill water gaps in Pennsylvania. See Mather's report of 1843, New York Geology, Plate 46, Fig. 1; and Chance's sections in the Appendix to this volume, G⁶.

A beautiful little memoir on this structure has been lately published in the Appalachia, Vol. III, No. 1. It was read May 12, 1882, by William Morris Davis, of Harvard College, and is entitled, "The Little Mountains east of the Catskills." Charmingly drawn maps and sections illustrate it.

plateau from northwest to southeast, through a narrow tortuous gorge, between horizontally bedded cliff walls from 400′ to 600′ high. The river bed now stands at 980′+ A. T. at Deposit where the cut commences at the north and falls in 78 miles (60 miles in a straight line) to 540′ A. T. at Pond Eddy (11 miles above Port Jervis) where it issues from the Catskill rocks.

Something in the structure of the table-land must have determined the river to take this course.

That something is explained further west, in the Lehigh river country, where we see the general horizontality give place to high anticlinal and deep synclinal waves, producing an original irregular elevation of the plateau in that direction quite as extraordinary as the original regular elevation of the plateau towards the Hudson river. It was in a sort of general depression between the two elevated northeast and southwest ends of the plateau that the drainage found a vent. The result was, 1. the present Delaware river gorge, and 2. the erosion of the grey (X) and red (IX) conglomerate beds which characterize the high Catskill plateau towards the Hudson and the lower Pocono plateau towards the Lehigh.

To find the remains of the red (IX) conglomerate beds one must go back from the river to the knobs on the west line of Pike county, and to the front crest of the Pocono mountain in Monroe and Carbon counties.

To find the still more meager relics of the gray (X) conglomerate beds, one must go to the ridges in the center of plateau on the north line of Monroe county, at the head waters of the Lehigh river.

All this is copiously explained in Prof. White's report; but it is necessary here to state and explain a consequence which imperils part of the geological nomenclature adopted by me in the earlier years of the Second Geological Survey of the State, and habitually used in the volumes of its reports. This I proceed to indicate.

The front edge or south wall of the plateau in Carbon and Monroe counties has always been called the *Pocono mount-*

ain; ending eastward in the *Pocono Knob*, back of Stroudsburg; but spreading northward and northeastward, around the heads of Brodhead's creek, as far as the High Knobs in Pike county.

On the geological map of Pennsylvania which I made in 1841 (published by Prof. Rogers in 1858) it will be noticed that I spread the color of No. X over most of the plateau from the front edge of the wall of the Pocono mountain northward far into Pike and Wayne counties, and confined the color of No. IX to the steep face of the mountain (southwards) and its foot hills. But the principal valleys of the plateau are represented as cutting down into X; and the country bordering the Delaware gorge is capped with X between the streams.

In naming Nos. IX, X, XI and XII geographically (from east to west) *Catskill, Pocono, Mauch Chunk and Pottsville*, I took for granted that, as the Catskill mountains were characterized by the great red formation IX, so the Pocono plateau was characterized by the great grey formation X.*

But in point of fact, of the conglomerates which form the two crests of the Second mountain west of the Lehigh, colored the one IX and the other X, only the lower (IX) appears in the Pocono mountain; the other (1,500′ above it) has been eroded from the plateau. Half way between them (on the Lehigh) runs the edge of a thinner conglomerate, where the First Survey placed the dividing line between IX and X, splitting the Second mountain midway between its two crests.

This middle conglomerate is the *Mt. Pleasant conglomerate* of Mr. White's reports, and is the rock which he adopted in Wayne county in 1880 as the basal rock of X.

The conglomerate in IX which makes the south crest of the Second mountain at Mauch Chunk he recognizes as his *Cherry Ridge conglomerate*, 700′ down from the top of the *Catskill formation*. Now, it is precisely this conglom-

*The red shales of XI being best developed in the valley at Mauch Chunk; and the conglomerate XII in the Sharp mountain, at Pottsville.

erate which makes the cornice or top edge of the Pocono plateau.

Therefore, to find any *Pocono* on the Pocono plateau, one must go a number of miles to the north of the front edge of the plateau, where ridges of the *lowest Pocono* rock, the Mt. Pleasant conglomerate, remain uneroded.

The real reasons why the Pocono (X) color was spread over the whole plateau on my map of 1841 (1858) were 1. the impossibility at that time of determining any special limit between IX and X in the wilderness country of "the Shades of Death," or "the Great Beech Woods;" and 2. the desirability of distinguishing the plateau from the low lands, topographically and geologically. This could only be done by using the strongly contrasted grey and red colors assigned to X and IX.

With this explanation, I trust that the reader who compares the map in this report with my State map of 1841 (1858) will not have his ideas confused.

To meet the special difficulty I have intercalated a tint between the two colors for X and IX; and this separate tint will be understood as expressing the 700′± of Catskill rocks which overlie the *Cherry Ridge conglomerate* in IX, and underlie the *Mt. Pleasant conglomerate base of X.*

The whole of Pike and a large part of Monroe counties have been and generally still are covered with glacial bowlders, drift heaps, clay beds, ponds, dams, buried valleys, and scratches on the outcropping rocks. The glacialist will find in this report ample materials for study.

A preliminary local *glacial map* is published with this report, showing where *striæ* have been more particularly noticed; their magnetic direction at each spot;* and the curves across the field which the semi-fluid ice seems to have made in its general onward course from north to south.

The great *Terminal moraine* is also shown; but the reader must be referred to a special report, by Mr. H. C. Lewis,†

*The magnetic deviation from true north is so slight in Pennsylvania (0° to 5° W.) that it is seldom mentioned. In Pike and Monroe it is about 5° west.

† To be published in the autumn of 1882.

in which its character and trend for 350 miles through Pennsylvania and western New York are described in detail.

This moraine crosses the Delaware river at Belvidere; curves through Northampton county to the end of Offset mountain; crosses Offset creek and ascends Blue mountain to its crest (1600′ A. T.) It then creeps westward gradually down the north side of the Blue mountain, to Saylorsburg in Ross township, and turns north between Saylorsburg and Lake Popanoming. At Brodheadville, in the southern part of Chestnut Hill township, it makes a sharp point, and then runs due north, west of Mineola lake, up the west side of McMichael's creek, to the notch west of the Pocono Knob in Northern Jackson township. Here, instead of going up through the notch, it slides up the south slope of the Knob, and around its east and north slopes, within 300′ or 400′ of the summit, and so reaches the table land of Tobyhanna township behind (north of) Long Pond, at an elevation of 1835′ A. T.

The great moraine on this Pocono plateau is a ridge of drift 100′ feet high of so remarkable an aspect that it has been named by the inhabitants the "long ridge," and its course is now nearly straight S. 80° W. to where it descends into the deep valley of the Lehigh river at the mouth of Hickory run.

Hence it has been followed by Mr. Lewis across all the mountains to Berwick on the Susquehanna, Ralston on the Lycoming, Pike mills on Pine creek, and Rose lake in Potter county.

Here it is on the very highest land in northern Pennsylvania (2,200′ A. T.)

Thence it proceeds to the Allegheny river south of Olean and to Little Valley north of Salamanca in Cattaraugus county, New York.

Thus far its course for 220 miles has been in general about N. 60° west. It now turns and takes a pretty straight course S. 40° to 45° west, a little west of Titusville and Franklin, to Darlington in Beaver county, 130 miles. Here it crosses the Ohio State line and proceeds west-south-westward towards Cincinnati.

Its course across the highlands and the plains of New Jersey to the Atlantic coast at Amboy is closely described in Prof. Cook's annual reports of the survey of that State. Thence eastward it has been followed across Staten island, along the axis of Long island, by Block island and Naushon to the southeastern point of New England, where it descends into the Atlantic ocean.

The whole country *behind* the moraine, *i. e.* to the northward of it, is covered with *Drift deposits.** But Prof. White, in this report, often speaks also of *Drift* in parts of his district which lie *in front* or to the south of the great moraine. Prof. Prime has even found an abundance of *Drift* in the valleys of his district south of Allentown and Bethlehem. But it is getting to be more and more probable that these deposits as well as the *Drift* of Philadelphia are secondary results of the working over of the terminal moraine and of the Drift behind it by the Delaware and its affluents. For in this way alone can the absence of secondary *Drift* in the valley of the Schuylkill be explained; for, none of the head waters of the Schuylkill extend far enough northward to receive deposits from the Moraine. The Lehigh, on the contrary, not only cuts through the moraine itself, but drains the thickly Drift-covored Pocono plateau behind it.

It must be kept in mind however, that the existence of ice striæ on the crest of the Locust mountain west of Ashland, 25 miles south-southwest of the nearest part of the great moraine (Berwick,) suffices to show that much is left uncomprehended. Where are the moraines corresponding to these striæ? Was the ice-flow which made them of an earlier or a later date? How far south did it reach toward Harrisburg, in the direction of which the striæ point?

Similar questions are pertinent in regard to things observed in front of the moraine, such as the origin of the

* The reader will find in the detailed description of Barrett township, that Mr. White found the *Drift* covering the Pocono *summits* to a height of 2,050′ A. T., and in Coolbaugh township *glacial scratches* on the highest summit 2,150′ A. T. There is a large bowlder perched on the summit of High Knob, in Pike county, about 2,010′ A. T.

Wind gap, and of the hollow beneath the Bake Oven in Carbon county. If the great moraine was *terminal* for the ice sheet at its maximum development, evidently it does not suffice to explain everything that happened in the Ice age.

The *Glacial map* referred to above expresses the main topographical features of the region, the highest mountains and knobs, and the water courses. Curves, in blue color, have been drawn across it, varying in direction from *magnetic south* to *magnetic* S. 70° W. to conform to the direction of the glacial scratches at each point of observation. This not only exhibits the universal former outspread of the ice over the whole country back of the great moraine, but suggests the variability of its flow according to the obstacles in its path presented by the inequalities of the surface. A multitude of curves in its course are not shown for want of data. Probably when a thousand points of observation shall have been obtained, it will be seen that every part of the mass of ice moved sinuously.

But the few data obtained are quite sufficient to demonstrate: 1. the general south, south-southwest, and southwest movement of the ice sheet. 2. the different directions which its deeper parts and its surface layers took in their forward movement.

It is perfectly evident that while the ice at 2,000′ A. T. was moving nearly due south, the ice at 1,500′ to 1,000′ A. T. was moving S. 20° to 40° W., and the ice at 500′ to 800′ A. T. was moving S. 50° to 70° W. along the deep troughs of the preglacial topography.

On the Pocono plateau the striæ point nearly south. At the east end of Pike county they point parallel to the flow of the Delaware river. But it is evident that the mountain barrier south of the river only affected the deeper layers of ice, for the striæ on the mountain flank at the Delaware water gap point diagonally up and over the crest of the mountain. Great blocks from the limestone of VI in the valley lie now on the mountain and are tumbled down over the crest upon its southern slope.

Why Pocono Knob was not covered by the ice is plainly

shown by the east and west line of the terminal moraine back of Long pond (1,835′ A. T. ;) for when this is projected eastward it falls into the lower country of Pocono and Brodhead creeks, which the ice filled deeply and then flowed round the Knob fan-wise toward the west and southwest.

The *Geological Map* published with this report was compiled from the wall and atlas maps of six adjoining counties, and the geological State map of New Jersey.

Nothing can be worse than the county maps of Pike and Monroe. The uncertainty and confusion which characterize all the township and county maps of Pennsylvania, with hardly an exception, reach their acme in the wilderness region lying between the Delaware and Lehigh rivers. A comparison of the course of the Lehigh river as shown on the Monroe, on the Carbon, and on the Luzerne county maps would strike the reader with astonishment. They can hardly be recognized as drawings of the one and the same important water course. That of Luzerne county, however, is so superior to the others that it has been adopted and the others rejected. The reader who consults the map may do so with confidence that—not a single stream in Monroe and Pike counties is properly portrayed. Even the Delaware river had to be forced over southward more than a mile, to agree with the carefully-prepared State map of New Jersey.

Nothing but a trigonometrical survey of Pennsylvania can remedy this shameful state of things.

What is a geological map worth without topography? But how can topography be executed on paper without accurate instrumental surveying?

People who consult a map wish to see the direction, width, height, and shape of the ridges which traverse its area. The geologist, especially, needs these features of the surface to guide his own researches and to assist him afterwards in locating the outcrops of the rocks on the map which is to explain his report.

The more exact the topography the more useful will be

the geology. The two things go together in nature and mutually depend upon each other in science.

The reader will notice, in the description of Hamilton, Ross, and Eldred townships, the use of the terms: "No. VII ridge," and simply "the ridge." These terms are used for want of a common name to the broken range of narrow, rocky hills of which Dodendorf mountain in Ross, Saylorsburg ridge in Hamilton, Godfrey's ridge in Stroud, and Walpack ridge in Smithfield and Middle Smithfield are continuations. Its western prolongation through Carbon county is called the Steinberg, or Rocky ridge, or the Devil's wall opposite the Lehigh water gap. They all mark the continuous outcrop of the *Oriskany sandstone* (No. VII) and *Lower Helderberg limestones* (No. VI) across the county.*

The *Offset anticlinal* is omitted in the enumeration of Chapter IV; it should come in after the *Kammererville anticlinal*, on page 70. But it is described on page 277, in the special account of Hamilton township.

There is another anticlinal roll at Tot's gap, shown in the Northampton county slates; but on the Monroe county side, it seems to make merely a bend in the mountain.

The steep plunge (northward) of the Lehighton anticlinal is an interesting fact, which however hardly appertains to a report on Monroe county, because its maximum development takes place in Carbon county; but I wish to direct attention to it in its connection with the flatness of the rocks of the Pocono-Catskill plateau.

The remarkably straight southern border of the First anthracite coal field across Carbon, Schuylkill and Dauphin counties, that is, from the Lehigh to the Susquehanna river, is due to the vertical plunge of the whole Devonian and Lower Carboniferous mass northwards from the Lehighton

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* For the figures in this report, I am responsible. Figs. 3 to 7, I drew in 1842 to illustrate my report on the Orwigsburg-Stroudsburg valley, embodied by Prof. Rogers in the Geol. Penn. 1858, from Vol. 1 of which I have borrowed them. Fig. 1 I have constructed from Prof. White's data published in this report.

anticlinal in Carbon county and from the corresponding Orwigsburg anticlinal in Schuylkill county; an overturn nearly a hundred miles long.

Now the very same thing happens in front of the great bituminous coal field of the northern and western counties. The Silurian and Lower Devonian measures plunge vertically northward and north-westward, along the whole course of the Bald Eagle mountain through Lycoming, Clinton, Centre, Huntingdon, Blair and Bedford counties; and in that case also the eastern end of the disturbance vanishes in the great horizontal region of Wyoming, Susquehanna and Wayne counties.

The Delaware Water gap, the Lehigh Water gap, and the Schuylkill Water gap were surveyed, contour maps and transverse sections of them drawn, and descriptions written by Mr. H. Martyn Chance in 1874–5. My intention was to continue this work until a sufficient number of the Appalachian water-gates could be collated and compared to afford materials for the study of their origin; while the comparison of their measured sections would enable us to comprehend better the local variations of our sand and gravel deposits of Silurian and Devonian age. But the exigencies of the survey have prevented the completion of the project; therefore the data obtained at two of the three gaps are now published, and the reader will find Mr. Chance's maps, sections and descriptions of these two gaps appended to this volume. A small map of the Schuylkill gap will also be found on page 334.

The non-conformability of *Oneida conglomerate* (No. IV) upon *Hudson river shales* (No. III) is referred to in this report several times. I have annotated these references to raise a doubt of the reality of the fact, and to suggest a different explanation of the appearance. A discussion of this question will come more in place in the Report on Northampton and Lehigh counties now in press.

The *Honesdale Bore-hole* described by Prof. White in his

Report on Wayne county (G^6,) was only 1505′ deep when that report was published. It has been recently sunk to 2165′, and the additional record just received may be found at the end of that volume, with Mr. White's remarks upon its important bearing on the question of how the formations thicken southwards.

It is proper to state that the proof reading of this report was not done by the author. I am responsible myself therefore for whatever mistakes occur in the text. Some personal and geographical names are doubtful, and their various readings will be found in the Index No. 1. Such mistakes are due to two causes: first, the great number of initials to private names, some of which are perhaps errors on the county maps; secondly, to the native pronunciation of names, especially in the Penusylvania-deutsch patois; Berryer and Barger for Berger; Triechler and Treichler for Treuchler &c. Schwangunk mountain, and other Indian names are variously spelled.

With great respect,

Your obedient servant,

J. P. LESLEY.

PHILADELPHIA, *July 1, 1882.*

LETTER OF TRANSMITTAL.

Prof. J. P. LESLEY, *State Geologist:*

DEAR SIR: I herewith transmit my report on Pike and Monroe counties.

Work was commenced in this district on the 10th of June, and continued until the 24th of November.

For valuable information and other acts of kindness, I am especially indebted to Dr. Barrett, of Port Jervis, N. Y.; M. M. Van Etten, of Milford, and E. F. Torrey, of Honesdale. To the engineers of the N. Y., S. and W. R. R. the survey is greatly indebted for many valuable elevations made during the final and preliminary survey of their route through the district. Mr. J. J. Wood, resident engineer of this R. R., also gave me many elevations on the old Lehigh and Eastern R. R. survey, a line projected down the Delaware valley between Port Jervis and Stroudsburg, and he connected the N. Y., S. and W. levels in Stroudsburg with the track of the D., L. and W. R. R., at East Stroudsburg depot, at my request, to determine the error in elevation of the latter as given in Survey tables (N). Using 316′ A. T. as the elevation of Delaware Water Gap station on the D., L. & W. R. R., he found that the E. Stroudsburg depot of this R. R. should have an elevation of 435′ A. T. instead of 403′ as given at page 88 Report N. This determination was especially important since my net-work of barometric elevations in Monroe was largely based on the elevation of the East Stroudsburg depot, and in them I have used 435′ A. T. instead of the 403′ given in Allen's report N. Much confidence can be placed in this elevation (435′) of E. Stroudsburg, from the fact that 316′ A. T. for the Delaware Water Gap station checks within one or two feet with the elevation

of Walker's ferry (298′) near by, obtained through the Philadelphia and Trenton R. R. levels. (See report N, table 84.)

Mr. J. P. Schermerhorn gave me the levels on the N. Y., S. and W. R. R. north from Canadensis, including special determinations of Goose and Eich's ponds. Mr. G. W. Atkinson gave me levels from Stroudsburg to the Delaware river; and Mr. Trusdell determined the elevation of the Delaware river at low water opposite "Indian ladder," in the water gap, making it 291′ 8″ A. T., and the depth of the river there 51′.

For season passes the survey is indebted to Hon. Samuel Sloan, of the D., L. and W. R. R.; E. S. Bowen, of the Erie; C. F. Young, of the D. and H. C. Co., and Charles Latimer, of the N. Y., P. and O. R. R.

Very respectfully,

Your obedient servant,

I. C. WHITE.

W. VA. UNIVERSITY, MORGANTOWN, *April 21, 1882.*

REPORT OF PROGRESS

IN

PIKE AND MONROE COUNTIES.

CHAPTER I.

Area; population; towns.

PIKE COUNTY occupies the most eastern projection of the State, formed by a great bend in the Delaware river, where after flowing south-eastwards between this county and New York it suddenly veers around at a right angle and passes off to the south-west, separating the county and State from New Jersey. Wayne county borders it on the north-west, and Monroe on the south-west.

Its boundaries are approximately as follows, beginning at the most northern point of the county on the Delaware river and passing around it to the right: From Big Eddy to the Tri-State corner (N. Y., Pa., and N. J.,) along the northern border, by the meanders of the Delaware river, 37 miles; thence by the meanders of the same stream along the eastern line to the mouth of Big Bushkill at the Monroe county line, 26 miles; thence along Big Bushkill westward to the mouth of Middle Bushkill, 3½ miles; thence N. 20° W., 4 miles; thence N. 80° W. 4⅓ miles; thence N. 10° E. 6½ miles; thence due west to the South Br. of Wallenpaupack creek at the crossing of the North and South Turnpike, 11½ miles; thence northward by the meanders of Wallenpaupack between (Wayne and Pike) to its mouth at the Lackawaxen,

near Hawley, 30 miles;* thence N. 31° ¾ E. 10 miles, 23 poles to the Delaware, and our starting point at Big Eddy just below Narrowsburg.

Its general shape is that of a rude square so placed that one of the diagonals runs almost due north and south, its length in this direction being 35 miles, while the side of the square varies from 20 to 25 miles.

Its *area* is 631 square miles, or 403,840 acres.†

The county is subdivided into 11 townships, arranged in the following order:—

Lackawaxen.
Palmyra. Shohola.
Blooming Grove. Westfall.
Greene. Milford.
Dingman.
Porter. Delaware.
Lehman.

Its *population* for the last three decades according to the census reports is as follows:

In 1860, ...	
In 1870, ...	8, 436
In 1880, ...	9, 664

Its *principal towns* are:

Milford, the connty seat, situated in the township of the same name, on the Delaware river, at the mouth of the Sawkill creek, 7 miles below Port Jervis, N. Y. The site of the town is on a beautiful terrace of *Drift*, 110′ above the Delaware river, and 490′–500′ A. T. The town has long been celebrated as a summer resort, its beautiful scenery pure air, and water, together with its general healthfulness, rendering it peculiarly attractive during the heated term. Among its scenic attractions may be mentioned the Delaware valley bordered on the north by almost vertical walls of rock 500′–600′ high, with the blue mountains bounding the horizon to the south in New Jersey; Sawkill Falls, a great cataract, 75′ high in a deep gorge one mile north from the

*In the description of Wayne county G⁵, page 4, this distance is erroneously stated as 40 miles.

†According to the report of the Secretary of Internal Affairs of Pa., 1880.

town; Raymondskill Falls, another wild waterfall 100′ high, and a most delightful sylvan retreat within easy reach (4 miles.) The chief employment of the inhabitants is the entertainment of summer visitors for which purpose there are several large hotels besides many private establishments. Its population in 1870 was 746, and in 1880 .

Lackawaxen, situated on the Delaware river at the mouth of Lackawaxen creek, an important shipping point on the Erie R. R., being the junction of the main R. R. with the Honesdale and Hawley Branch over which come immense quantities of anthracite coal shipped from the Scranton and Carbondale regions. The Delaware and Hudson canal crosses both the Lackawaxen and Delaware rivers at this locality on noble aquaducts, high above water level. The Delaware House, just across the Lackawaxen river is a noted summer resort. Elevation above tide of R. R. station 650′; Delaware river, level of the canal dam, 600′.

Matamoras is situated on a beautiful terrace plain just across the Delaware from Port Jervis N. Y. It has a magnificent site for a large city and has been growing rapidly of late years; elevation A. T. 440′–445′.

Dingman's and *Bushkill* are villages on the Delaware celebrated as summer resorts, the former 15 miles below Matamoras and 405′ A. T. the latter at the southern extremity of the county and 360′ A. T.

Other villages in Pike county with approximate air line distances from Milford and elevation above tide, by barometer or otherwise, are as follows:

Villages in Pike county.		*Miles.*	*A. T.*
Blooming Grove,	Blooming G. township,	18.5, N.	1420′ (B)
Delaware P. O.,	Lehman township,	12.8, W.	390′ (B)
Egypt Mills P. O.,	" "	16.2, S. W.	380′ (B)
Fulmerville,	Delaware township,	8 7, S. W.	950′ (B)
Greentown,	Greene township,	27.0, W.	1195′ (B)
Hawesville,	" "	21.8, W.	1750′ (B)
Lackawaxen,	Lackawaxen township,	14.0, N. W.	650′
Lord's Valley P. O.,	Blooming Grove,	13.8, W.	1275′ (B)
Laureldale,	Greene township,	21.0, W.	1725′ (B)
Millville,	Lackawaxen township,	17.0, N. W.	780′
Mast Hope,	" "	18.6, N. W.	668′
Narrows,	" "	19.2, N. W.	849′
Portersville,	Porter township,	14.7, W. S. W.	1305′ (B)

Pond Eddy,	Shohola township,	7.6, N	571′
Paupack Falls,	Palmyra township,	21.5, N. W.	—
Paupack P. O.,	" "	23.4, W. N. W.	1290′ (B)
Rowland's,	Lackawaxen township,	16.0. N. W.	700′
Shohola,	Shohola township,	11.8, N. N. W.	648′
Saw Mill Rift,	Westfall township,	6.7, N. N. E.	465′ (B)
Taylortown,	Lackawaxen township,	12.1, N. W.	1065′ (B)
Wilsonville,	Palmyra township,	21.9, W. N. W.	1150′ (B)

MONROE COUNTY adjoins Pike, and lies in a south-west direction from the latter, which forms its entire eastern boundary, and about half of its northern.

The Delaware river separates it from New Jersey on the south between the mouth of Big Bushkill and the Delaware Water Gap, a distance of about fifteen miles by the meanders of that stream.* From the Water Gap westward, the Blue (Kittatinny) Mountain makes the southern limit of Monroe, separating it from Northampton county, the exact boundary between which, is an irregular line along the crest of the mountain, the distance in an air line from the Water Gap to the western border of Monroe being approximately 20 miles (about S. 60° W.); so that the whole south boundary is a practically straight line 31 miles long.

Its western line along Carbon county is quite irregular, and not far from 30 miles in length including the offsets, and meanders of Tunkhannock and Tobyhanna creeks, which streams separate the northern portion of Carbon county from Monroe.

On the north-west it is separated from Lackawanna county by the Lehigh river whose sinuous course between the mouth of Tobyhanna creek, and the south-west corner of Wayne county, is not far from 12 miles in length.

The northern boundary runs due east from Lehigh river with Wayne county on the north for a distance of 7 miles and 92 rods to the waters of South Wallenpaupack at the crossing of the North and South Turnpike. From this last point on around to the mouth of the Big Bushkill it is bordered on the north and east by Pike county, the several

*But only 11 miles in a straight line on a line N. E.—S. W. 45°.

distances and directions being the same as those given for Pike county along the same line on a preceding page. The whole north boundary is practically a straight east and west line 22 miles long.

The *area* thus enclosed is 585 square miles or 374,400 acres. (Report Sec. Inter. Affairs 1880.)

Its 16 townships are arranged in the following manner:

Coolbaugh. Barrett.
Price.
Tobyhanna. Paradise.
M. Smithfield.
Tunkhannock. Pocono.
Jackson.
Chestnut Hill. Stroud. Smithfield.
Polk. Hamilton.
Ross.
Eldred.

Its population according to the census reports has been

In 1860,	——
In 1870,	18,362
In 1880,	20,175

Its principal towns are:

Stroudsburg, the county seat, situated on a broad plain of *alluvium* and *drift* at the confluence of Broadhead, McMichael's and Pocono creeks. It has business connection both north and south over the Delaware, Lackawanna and Western R. R. which passes by it one mile east from the center of the town. The N. Y. S. &. W. R. R. now nearly completed runs directly through the borough. Its chief manufactories are: a woolen-mill, emery-wheel works, sash and blind factory, a machine shop, foundry, and tannery. It is well patronized as a summer resort, there being several large hotels and private boarding houses in the borough and the immediate vicinity, devoted to the entertainment of such visitors. Its population in 1870 was 1,793, and in 1880 ; level above tide 435′, on the upper level at the Burnett House.

East Stroudsburg is separated from Stroudsburg by Broadhead creek. It is quite a thriving town, having two bottle-glass factories, a very extensive tannery, machine-

shop, foundery and match factory. The D. L. &. W.R. R. passes directly through it giving amply business connection with neighboring cities; level above tide at Station R. R. grade 435°.

Delaware Water Gap, a village just above the famous Gap through the Blue Mountains has long been celebrated as a summer retreat. The grandeur and wildness of the scenery, its pure mountain air and water, have rendered it a very attractive retreat during the Summer. It has hotel accommodations for over two thousand guests, the largest houses being the Kittatinny and Water Gap. The D. L. & W. R. R. passes through the village giving connection with either Philadelphia, or New York in a three hours' ride.

The N. Y. S. & W. R R. is to cross the Delaware river a short distance above the village, on a magnificent bridge now (April, 1882) building. Elevation of Water Gap Station above tide 316′; elevation of low water (1881) in Delaware river at the N. Y. S. & W. R. R. bridge, 394′ A. T. on the basis of 316′ for Water Gap Station.

Villages in Monroe county, with distances from Stroudsburg and elevations above tide (by aneroid barometer or otherwise) are as follows:

Villages in Monroe county.		*Miles.*	*A. T.*
Bartonsville,	Pocono township,	4.4, N. W.	785′ (B)
Bossardville,	Hamilton township,	5.4, S. W.	670′ (B)
Brodheadsville,	Chestnut Hill township,	11.1, W.	695′ (B)
Bushkill,	Middle Smithfield twp.,	12.0, E. N. E.	360′ (B)
Canadensis,	Barrett township,	14.3, N.	995′
Coolbaugh,	M. Smithfield township,	8.1, N. E.	515′ (B)
Effort,	Chestnut Hill township,	12.9, W.	720′ (B)
East Stroudsburg,	Smithfield township,	1.0, E.	435′
Experiment Mills,	" "	2.4, E.	330′ (B)
Forks P. O.,	Coolbaugh township,	12.7, N. W.	1665′ (B)
Henryville,	Paradise township,	7.9, N. N. W.	800′ (B)
Jackson Corners,	Jackson township,	8.0, W. N. W.	925′ (B)
Kellersville,	Hamilton township,	5.8, W.	500′ (B)
Kemmererville,	" "	4.2, S. W.	450′ (B)
Kresgeville,	Polk township,	16.6, W.	660′ (B)
Kunkletown,	Eldred township,	16.2, S. W.	495′ (B)
Marshall's Creek P. O.,	Smithfield township;	5.1, N. E.	380′ (B)
McMichael's P. O.,	Chestnut Hill township,	10.6, W.	1010′ (B)
Merwinsburg,	" " "	14.2, W.	940′ (B)
Oakland,	Barrett township,	13.2, N.	1225′ (B)

Paradise Valley,	Paradise township,	10.3, N. N. W.	965 (B)
Rossland,	Ross township,	11.4, S. W.	635′ (B)
Roscommon,	" "	10.0, S. W.	835′ (B)
Saylorsburg,	Hamilton township,	8.8, S. W.	745′ (B)
Shawnee P. O.,	Smithfield township,	4.7, E.	360′ (B)
Spragueville,	Stroud township,	4.7, N.	525′ (B)
Snydersville,	Hamilton township,	5.2, W.	—
Stoddartsville,	Tobyhanna township,	23.8, N. W.	—
Stormville,	Hamilton township,	3.3, W.	430′ (B)
Tannersville,	Pocono township,	6.8, W. N. W.	845′
Tobyhanna Mills,	Coolbaugh township,	16.7, N. W.	1932
Tompkinsville,	Tobyhanna township,	16.3, N. W.	1725′ (B)

Chapter II.

Mountains; *Rivers*; *Railway levels*; *Lakes.*

Pike and Monroe counties are among the wildest and roughest parts of Pennyslvania. Five sixths of their general surface is a mountain wilderness elevated between 1,200′ and 2,000′ above sea level. The remaining sixth consists of a long narrow belt of parallel hills and valleys, bounded on the south by the Blue or Kittatinny mountain, the sharp level crest of which varies in elevation above tide between 1400′ and 1600′.

The front edge of the great upland is an irregularly continuous mountain wall, a thousand feet high, very bluff and precipitous, and only broken by short ravines in the western part of its course, and by the deep gorges through which, further east, break out the waters of Broadhead creek in Mercer county and the three branches of the Bushhill in Pike county.

This mountain wall is called *Pohopoco* in Carbon and western Monroe counties; but *Pocono mountain* further east. At Tannersville, on Pocono creek (six miles N. W. of Stroudsburg) the Carbon-Monroe section of the wall abruptly terminates in a spur pointing east, called *Pocono Knob.**

* This Knob is a remarkable object as seen from the east and south, and possesses a peculiar geological interest, because it stood as a small island in the edge of the great ice sheet; the terminal moraine encircling its sides, at about two thirds of its hight. The elevation of the notch which separates the summit of the knob from the plateau behind it to the west is 1681′ A. T.

Behind the Pocono Knob is a recess, or cove, and then the mountain wall runs on as before into Pike county; but there breaks up into knobs, two or three of which are 2000′ A. T. Here the Pocono mountain wall may be said to end; for the whole country to the north and east of these knobs lies at a level from 400′ to 800′ lower.*

The Pocono mountain wall is merely the eroded edge of the great plateau behind it; and the horizontal stratification is everywhere apparent; the mountain front being in fact a huge staircase of red sandstone strata, one a little behind the other, ascending from the bottom to the top.

The *Pocono Plateau* stretching back (northward) from the top of the Pocono mountain wall, has a general elevation of between 1800′ and 2000′ A. T. the valleys being sunk 100′ to 200′, and the highest knobs, (made by patches of massive sandstone and conglomerate, left from erosion) rising 100′ to 200′ above the rest.†

This *Pocono plateau* is a perfect wilderness covered with a dense forest growth, and variously known as the "Beech woods country," "Shades of Death," etc. It includes the northern portions of Jackson and Barrett townships, all of Tunkhannock, Tobyhanna, and Coolbaugh, and extends northward into Wayne and Lackawanna counties, its northwestern escarpment being known as the Moosic or Wyoming mountain. The breadth of the intermediate plateau is 12 to 15 miles. There is no doubt that this plateau once extended over all of northern Pike, and all of Wayne county, for isolated peaks like Big Hickory Knob in the latter and High Knob in the former, attest not only its former existence, but also the sweeping erosion to which all this region has been subjected; for in Wayne the plateau is eroded quite up to the Moosic escarpment, while in Pike, it has

* In New York, beyond the Delaware river, the wall assumes much grander proportions and becomes at length the Catskill mountains, its highest summits exceeding 4000′ A. T. according to the surveys of Professor Guyot of Princeton.

† West of Pocono Knob the direction of the wall is straighter (because there is a more decided northern dip to the rocks) and its height is also greater. Three miles west of Tannersville a knob rises to 2225′ A. T. and appears to be the highest point of land in the two counties.

been everywhere lowered 500′ to 1000′ except in the western portion.*

South from the Pocono escarpment in Monroe county, the surface falls off precipitously to 1200′ or 1300′ A. T. when there comes an undulating plain which descends southward to about 900′ A. T. where the *Catskill rocks* end in a ridge separated from the *Chemung ridge* to the south usually by an intervening shallow valley worn down 100′–200′ through the softer portion of the *Upper Chemung.*

Then, south from the *Chemung ridge* which rises 800′–1000′ A. T. there generally occurs another narrow valley (*Genesee slate*) separating the *Chemung* from the *Hamilton sandstone ridge*, which coming next south at 700′–800′ A. T. rapidly descends to the broad, low, and usually level valley made by the *Marcellus Shales* throughout Pike and Monroe.

So far, through the central portion of Monroe county, the surface has continually declined by successive stages until in the highest portion of the *Marcellus shale* valley it only reaches to about 550′ A. T.; but on continuing southward from this the hard rocks of the bottom portion of No. VIII (*Corniferous Limestone and Cauda Galli Grit*) together with the *Oriskany Sandstone* (No. VII), begin to come up to the south-east and the surface rises again to culminate in *Walpack ridge*, a long, low range of mound-like knobs which enters Monroe (from across the Delaware river) at the E. extremity of the county and continuing south westward extends to and beyond the western line of the same, its

* [This is a moderate statement of the extent of the erosion, and is meant by the author merely as a comparison between the higher Monroe part of the plateau and the lower Pike portion of it. The fact however is, that we must for various reasons believe that the anthracite coal measures once overspread this whole region. Therefore we must add about 7,000 feet to get the original height of the Monroe plateau, and about 8,000 to get the original height of the Pike plateau. More is to be added in Pike than in Monroe, because the general descent of the original geological uppermost beds was southwestward. I calculate the original height of the Monroe plateau at the commencement of erosion, at say 9,000′ above present tide level; that of the Delaware river country at say 10.000′; and that of the Hudson river country at say 11,000′.—See the commencement of Chapter 6.—J. P. L.]

elevation on the knob summits varying from 700′–1200′ A. T. while the gaps between rise 600′–800′ A. T.

The southern slope of this ridge is always precipitous, descending in the eastern portion of Monroe into the Delaware river valley, and in western Monroe into an old buried valley (now occupied by Cherry and Aquanchicola creeks,) worn out of the soft beds of No. V (Clinton) and base of No. VI. The elevation of this valley along the Delaware is 325′ A. T. at its highest point in the bed of the Delaware river, and 293′ A. T. where the river leaves it at the mouth of Cherry creek; the highest point west from this on the divide between Cherry and Aquanchicola creeks being only 625′ A. T.

Southward from the valley last described the surface begins to rise, at first gradually until half way up the ascent when the slope becomes almost precipitous and finally culminates in the Blue mountain crest along the southern border of the western half of Monroe, at an elevation of 1300′–1600′ A. T.

Along the western portion of Monroe, this general topography is modified by the splitting of the *Marcellus shale* valley into two, with an intermediate synclinal ridge (capped by *Chemung and Catskill sandstones*) which begins at the western line of Hamilton township, and extends to the western line of the county. It is known as Wire Ridge, and its crest rises to 1000′–1100′ A. T., 500′–600′ above the *Marcellus shale valleys* north and south from it.

The general topography of Pike county is quite different from that of Monroe; first, because the elevation of the Pocono plateau has been lowered by erosion except in the extreme western portion of Pike county, and secondly, because the county ends southward at the *Marcellus shale* valley in which the Delaware river flows from Matamoras to its south-western extremity, at the mouth of Big Bushkill creek. Should one continue southward into New Jersey from the Delaware river (*Marcellus shale valley*) he would pass over the same succession of topography that we find in Monroe, viz: first a ridge of *Cauda Galli and Oriskany S. S.* then down a steep slope of VI, into a deep, long narrow

valley of lowermost VI, V, &c. rudely parallel to the Delaware valley, and only 1 to 2 miles away from it, its south-western end occupied by Flat Brook creek which empties into the Delaware at the eastern edge of Monroe county, near Decker's Ferry; its north-eastern end is drained by a small stream which cuts through the Cauda Galli ridge (Walpack) and empties into the Neversink river near Carpenter's Point. This Flat Brook valley is the north-eastward continuation of the Delaware, Cherry and Aquanchicola valleys of Monroe county, while the Cauda Galli ridge, overlooking the Delaware from the south along the New Jersey shore of Pike county, is the north-eastward extension of the Walpack ridge of Monroe.

On going south-eastwards from the Flat Brook valley of New Jersey, the surface again rises and rapidly culminates in the Shawaugunk mountain the north-eastward extension of the Blue Mountain whose crest makes the southern boundary of Monroe county.

So much for the principal topographic outlines, the details of which vary with the nature of the underlying rock-material, and the extent of erosion.

The greater portion of Pike county is covered by the *Catskill series* which over the uplands usually presents a great number of irregular ridges (*hard rocks*) separated by narrow, shallow valleys (*red shale*), so that the roads pass over a constant succession of hills.

Where streams cut through these Catskill beds, the side slopes are usually quite steep, often precipitous, and the enclosing hills present a series of outcroping cliffs, this being the case universally along all the larger streams, as illustrated by the Delaware, Lackawaxen, Wallenpaupack and others, the cross sections of whose valleys are usually gorge-like.

The *Chemung* covers such a narrow belt through the district that its rocks exert very little influence on the topography, not so with the *Hamilton*, however; for its rocks are recognized throughout both counties quite as readily from the topography they make as from their physical characters and included fossils.

The Hamilton proper, where the streams pass across its strike, is always eroded into deep narrow gorges in which the water descends over high cascades. Nearly all of the celebrated "falls" of both counties are over these beds. When a stream flows along the strike of the *Hamilton rocks* they rise in steep cliff-like bluffs such as those which overlook the Delaware river between Matamoras and Bushkill.

The *Corniferous limestone*, *Cauda Galli Grit*, and *Oriskany SS.*, always tend to form ridges along the line of strike, and cause falls and rapids in the streams which cut across the same.

Elevations above tide.

The general relief of eastern Pike is shown by the elevation of different points on the Milford and Owega turnpike, which runs from Milford on the Delaware river north-westward across the county, passing out of it over the Wallenpaupack at Wilsonville. The following elevations were obtained with the aneroid barometer, but all were closely checked, and none can be more than 25′ out of the way:

Milford and Owega turnpike.	*Miles.*	*A. T.*
Delaware river, at Milford,	0	380′
Milford and Owega pike, corner of Harford and Broad streets,	¼	490′
" " " at crossing of little brook west from borough line,	1	570′
Summit between Milford and Sawkill creek,	1¼	800′
Milford and Owega pike, at crossing of Sawkill creek,	1½	775′
" " " ¾ mile north of last,	2¼	950′
" " " at by-road to J. H. Newman's,	2¾	1050′
" " " " " Stichler's quarry,	3¾	1110′
" " " at crossing of Br. of Sawkill,	4½	1110′
" " " at forks near Stark's S. H.,	5	1225′
" " " in valley just north of last,	5⅛	1200′
" " " at forks west of Wm. McCarty's,	5¼	1250′
" " " on summit next north,	6	1350′
" " " at crossing of Dubois run,	6¾	1325′
" " " " " Red brook,	7¼	1350′
" " " at summit next north,	7½	1475′
" " " at old valley, near N. Blackmore's,	8½	1275′
" " " at summit next north,	9½	1450′
Shohola creek, at crossing of M. & O. pike,	10	1115′
Milford and Owega pike, at Rosencrans' tavern,	12	1270′
" " " at Mrs. Walsh's hotel,	12¼	1270′
" " " at summit next west,	12¾	1420′
" " " at stream near I. Roberts',	13¾	1165′

	Miles.	*A. T.*
Milford and Owega pike, at Roberts' tavern,	14	1225′
" " " at forks next west,	14¼	1215
" " " at summit near Lawrence & Willet's,	14½	1375′
" " " at stream next west,	15¼	1335′
" " " at summit near C. Smasher's,	15½	1400′
" " " at cross-roads near L. Manley's,	16	1310′
" " " at summit next west,	16½	1355′
" " " where Blooming G. Park rd. leaves it,	17	1295′
Blooming Grove creek at crossing of M. and O. pike,	17¾	1165′
Milford and Owega pike, at crossing of old valley next west,	18¼	1115′
" " " at forks near J. Degroot's,	19¾	1200′
" " " at crossing of Kimble's run,	20¾	1025′
" " " at Tafton,	22½	1185′
Wallenpaupack creek at crossing of M. and O. pike, at Wilsonville, (western line of pike,)	23½	1140′

On going south-west from the Milford and Owega Pike the surface keeps at about the same elevation as that given above, until we come to near the center of the county on a line running parallel with the M. & O. Pike, when along the central portion, it begins to rise quite rapidly and at about 3 miles further south-west culminates in the lofty peak known as High Knob, the beginning of the Pocono range. A line passing across this "Knob" parallel with the Milford and Owega Pike would strike the Delaware at Dingman's Ferry, 8 miles below Milford and would exhibit the following barometric profile in passing from the Delaware north-westward to the Wallenpaupack:

Line across High Knob.	*Miles.*	*A. T.*
Delaware river, at Dingman's Ferry,	0	350′
Factory road, at forks near F. Elenwine's,	1	600′
" " " " " J. W. Kilsby's,	1½	715′
" " " " " P. Reaser's,	1¾	785′
" " " crossing of old State road,	2¾	865′
" " " forks near Fulmerville,	3½	945′
Dingman's creek at 1st crossing above Fulmerville,	3¾	1000′
" " 2d " " "	4	1020′
Factory road, at crossing of Nichecronk creek,	4½	1050′
" " " " of little stream next west,	5¼	1120′
" " " Sheppard's mill,	5½	1150′
" " " crossing of Dingman's creek near G. Jolly's,	6	1200
" " " summit just east,	5¾	1250′
" " " crossing of Dingman's cr. below Silver Lake,	7	1265′
" " " summit next west,	7½	1360′
" " " crossing of Little Bushkill,	8	1250′
" " " " Middle "	10½	1315′
" " " " inlet to Porter Lake,	11	1335′

	Miles.	*A. T.*
Rocky Hill creek just west of last,	11¼	1300′
Bushkill, (Big,) at crossing of Blooming Grove road,	13¼	1310′
Blooming Grove road, at crossing of Br. of Bushkill,	14½	1370′
" " " intersection with Canadensis rd.,	16	1500′
Summit of High Knob,	17	2010′
East Branch Paupack creek, at Laureldale,	20	1700′
Summit of hills north and south of Laureldale,	20	1850′
Cross-roads S. E. from L. Phelps',	22	1725′
By-road to C. Masker's,	23½	1475′
Forks of road at M. N. B. Killam's,	25	1175′
Wallenpaupack creek, at Burn's Pottery, eight miles above (S. W.) Wilsonville,	26	1145′

The levels on the projected N. Y. S. & W. R. R. which crosses the Pocono plateau at its lowest point west from High Knob give the relief of the district between the South Branch of Wallenpaupack in Pike, and Brodhead creek in Monroe. These were kindly furnished by the engineers Messrs. Coons and Schermerhorn and are as follows:

Pocono plateau W. of High Knob.	*Miles.*	*A. T.*
South Branch of Wallenpaupack, 2 miles above Ledgedale,	0	1226′
East Branch of Paupack, 200′ south from its junction with Bridge Brook,	2½	1387′
Crossing of Canadensis road,	7	1625′
Dark Hollow Summit, divide between Paupack and Brodhead waters,	9	1681′
Goose Pond, at Monroe-Pike line,	10	1476′
Stony run, opposite Jos. Brown's,	12	1313′
" " at Elizabeth Feltham's Pond,	13	1291′
" " opposite S. H. No. 5, Barrett tp.,	15	1211′
" " opposite P. Bush's, in Price tp.,	17	1058′
Brodhead creek, at mouth of Stony run,	19	742′

From this point on southward to the Delaware river the slope of the surface along Brodhead creek is given under the description of that stream.

The D. L. & W. R. R. passes across the Pocono plateau north and south through Monroe county and the following table from Report N, page 88, gives the profile of the country it traverses between Scranton and the Delaware Water Gap. From Scranton to Summit Station the road ascends the north-western escarpment of the Moosic Mountain (northern rim of Pocono plateau.)

	Miles.	*A. T.*
Scranton,	0	740′
Greenville,	—	1182′

	Miles.	*A. T.*
Dunning's,	—	1397′
Moscow,	13	1555
Summit,	—	1887′

From this point the line traverses the Pocono plateau for about 12 miles over which the elevation never sinks below 1850′ nor rises above 1970′ A. T.

	Miles.	*A. T.*
Gouldsboro', near Monroe Co. line,	21	—
Tobyhanna,	27	1932′
Summit,	26	1970′
Forks,	—	—
Paradise,	—	1518′
Oakland,	41	1008′
Henryville,	—	593′
Spragueville,	—	487′
Stroudsburg,	53	400′
Delaware Water Gap,	—	316′
Delaware river, in Gap at Monroe-Northampton line,	60	293′

With the exception of Scranton, Tobyhanna, and Delaware Water Gap, many of these levels are wrong; some 25′ only while others are as much as 280′. This has probably resulted from the inability of Mr. Allen to determine the scale of the profile as stated on page 89, Report N. During the season I passed over the road about six times and took careful barometric readings at each station between Scranton and the Water Gap, the mean of which gives the following results, which cannot well differ more than 10′ in any case from the true elevations at each station, while for the most of them the limits of error are still less.

Table of barometric elevations of stations on D. L. & W. R. R. between Scranton and the Delaware Water Gap.

Revised table.		*Miles.*	*A. T.*
Scranton,	same as in Report N,	0	740′
Greenville,	" " "	—	1182′
Dunning's,	" " "	—	1397′
Moscow,	" " "	13	1555′
Summit,	" " "	—	1887′
Gouldsboro',	" " "	21	1890′
Summit, (1 mile N. from Tobyhanna,)	" " "	26	1970′
Tobyhanna,	" " "	27	1932′
Summit, one mile S. from Tobyhanna,		28	1955′
Pocono Station,		—	1840′
Forks,		—	1650′
Tunnel, west end,		—	1550′

	Miles.	*A. T.*
Paradise, (water tanks,)	40	1450′
Oakland,		1225′
Henryville,		800′
Spragueville,		525′
Stroudsburg,	53	435′
Delaware Water Gap, same as in Report N,		316′
Low water in Delaware river at Monroe, Northampton line,		293′

The next line of levels which crosses the Pocono plateau is still further to the south-west and was made by Mr. J. J. Coons in the preliminary survey of the route for the N. Y. S. & W. R. R. Beginning at Moosic in the Lackawanna valley and ascending Mill Brook creek across the Moosic mountain range, southward to the foot of Pocono mountain:

Pocono plateau, farther west.	*A. T.*
Creek at Spring Brook village,	1322′
Summit between this last and Lehigh river,	——
Lehigh river, just below Clifton,	1583
Trout creek, where Sullivan road crosses it,	1692′
Sullivan road, at forks near Jno. Stiger's,	1735′
Tobyhanna creek, ½ m. below its junction with Tunkhanna,	1623′
Forks of road near W. Merwine's,	1876′
Road at Cold Spring hotel,	1843′
Tunkhannock creek, on road 200 rods south,	1839′
Summit of Pocono mountain on this road,	1898′
Stream at road crossing near W. Butts', at base of Pocono mountain,	1149′

From this point the surveyed route runs eastward around the base of Pocono Knob to Pocono creek and thence down the same to Stroudsburg, the elevations along which are as follows:

Descending Pocono creek.	*A. T.*
Forks next S. E. from W. Butts',	1158′
Little McMichael's creek, at road crossing near P. Fraley's,	1129′
Stream at road crossing next east from P. Fraley's,	1108′
" " " near A. Possinger's,	1080′
" " " next east from J. Smith's,	1051′
Road at forks near J. Anglemoyer's,	982′
Pocono creek, above Kistler's tannery,	915′
Cross-roads at " "	916′
Pocono creek, at Tanite Co.'s dam,	530′
Mouth of Pocono creek, at Stroudsburg,	400′

If instead of turning eastward at the foot of Pocono mountain, the southward direction had been maintained to the south line of the county the following profile would be shown as obtained by barometric measurements carefully checked:

	A. T.
McMichael's creek, at McMichael's P. O.,	1000′
" " S. Gearhart's,	710′
Lake Minneola,	680′
Brodheadsville,	695′
Old valley just south,	675′
Summit of Wire Ridge,	1100′
Cross-roads near G. Flyte's,	1075′
Frantz's creek, at Rose Valley Hotel,	635′
Summit of Walpack Ridge,	1200′
Aquanchicola creek, at R. Vanbuskirk's,	595′
Forks of road, ½ mile south of last,	700′
Summit of Blue mountains, at south line of the county,	1500′

The Delaware river enters the district at the north-east corner of Pike county and flowing south-eastward separates Pike county from New York as far south as Carpenter's Point in the vicinity of which it executes a great curve to the west, flowing from this point S. 60°–65° W. along the line between Pike county and New Jersey just north from the great wall of *Cauda Galli Grit* which rising in Walpack ridge athwart the course of the stream at Carpenter's Point, caused it to make the great bend at that locality, and flow down the strike of the *Marcellus shale*. It keeps in the *Marcellus shale* to the southwestern corner of Pike county, at the mouth of Bushhill creek, when it turns southward and cuts through the *Cauda Galli ridge* into the soft beds of *Clinton* (No. V), making the curious Walpack Bend, where the river in cutting through the ridge of hard rocks, doubles on itself, turning round from a south-west course to nearly an eastern one. Then it veers southward into the Flat Brook valley and flows south-westward along the strike of the rocks, its southern shore washing the *Medina* SS. beds until we come to the mouth of Brodhead creek, when it turns south and passes through the Blue mountain out of the district through the famous Water Gap.

The N. Y. L. E. & W. R. R. (Erie) passes down this stream to the point where it makes the great bend to the south-west in the vicinity of Matamoras and the descent of the stream from Deposit at the northern line of Pennsylvania may be seen from the examination of the R. R. profile as given in Report N, pages 96 and 97, as follows:

Delaware river levels (R. R.)

	Miles from Jersey City.	*A. T.*
Deposit,	176	1009′
Hale's Eddy,	171	974′
Dickinson's,	168	954′
Hancock,	163	926′
Stockport,	158	896′
Lordville,	152	864′
Bouchou,	149	850′
Basket,	145.5	830′
Hawkins,	142	809′
Rock run,	138	787′
Collicoon,	135	781′
Cohecton,	130	748′
Nobody's,	125	748′
Narrowsburg, (Pike county line,)	121	714′
Delaware river here by barometer, 670′		
Pine Grove,	116	668′
Delaware river here by barometer, 635′		
Lackawaxen,	110	648′
Delaware river at top of dam here, 600′		
Shohola,	106	648′
Delaware river here by barometer, 575′		
Pond Eddy,	98	571′
Delaware river here by barometer, 510		
" " at bridge across it, 3½ ms. above Port Jervis,		440′
Port Jervis,	87	440′
Delaware river here by barometer, 420′		
" " at Carpenter's Point, junction with the Neversink,		415′

The descent of the Delaware from Port Jervis south-westward is shown by the elevations on the old projected Lehigh and Eastern R. R. the survey of which between Stroudsburg and Port Jervis was made by J. J. Coons of Deckertown, N. J., to whom I am indebted for the following list of levels. Datum: Erie R. R. at Port Jervis, viz: 440′.

Delaware river levels, continued.

	A. T.
Bluff of Delaware back from Matamoras,	452′
Crossing of Van Auken's run,	388′
Delaware river at Milford,	380′
Crossing of Raymondskill creek,	371′
" Connoshaugh creek,	369′
" Adam's creek,	375′
" Dingman's creek,	365′
Delaware river here by Barometer, 350′	

	A. T
Crossing of Hornbeck's creek,	357′
" Rafferty's creek,	347′
" creek at Briscoe's Hotel,	349′
" Van Gorden's creek,	358′
Egypt Mills,	355′
Bonnicle Pond near Wm. Place's, (Del. R.)	342′
Denmark creek,	340
Little Bushkill creek,	355′

Here the route of the R. R. leaves the river and keeps straight on down the old valley north of Walpack ridge, while the Delaware cuts through the latter and flows along its southern slope to the mouth of Brodhead creek. The only levels along this portion of the river were made with barometer.

Delaware river levels, continued.

	A. T.
Delaware river at Decker's Ferry, (Bar.,)	325′
" " at Poxono Island, (Bar.,)	315′
Walker's Ferry, Report N. Table 84,	298′
Low water at N. Y. S. & W. R. R. bridge across Delaware river one mile above Delaware Water Gap, station on D. L. & W. R. R.,	294′
Delaware river in Water Gap at the Monroe-Northampton Co. line,	293′

From Deposit to Port Jervis the fall of the Delaware is 570′ in 90 miles or an average of $6\frac{1}{3}$′ per mile; from Port Jervis to the Delaware Water Gap a distance of 43 miles the descent is (420′–293′) 127′ or only 3′ per mile. This difference of rate is occasioned by the fact that the Delaware flows through a ravine cut transversely across hard rocks from Deposit nearly to Port Jervis, while below there it meanders along the outcrop of the soft rocks of the Marcellus and Clinton formations.

Following the line of the projected Lehigh and Eastern R. R. southwestward from Bushkill, the old valley it traverses exhibits the following elevations:

Levels from Bushkill to Stroudsburg.	A. T.
Big Bushkill just below the mouth of Willow Creek,	403′
Milford Pike near J. Place's,	505′
Summit of old valley just south from Echo Lake,	510′
Milford Pike at forks near J. Coolbaugh's,	508′
" " Jas. Place's,	509′
Marshall's creek just above M. creek P. O.,	469′
Road at Lutheran Church just north from Craigstown,	490′
Sambo creek at road crossing near School No. 4, in Stroud Tp.,	443′

Brodhead creek opposite Ramsey's Brick Yd. in Stroudsburg, ... 393′
Analomink Ave., Stroudsburg, opposite B. Haines', ... 401′
Analomink Ave. at corner of Wm. Garis's lot, ... 404

The following list of elevations along the line of the N. Y. S. & W. R. R. was kindly placed at my disposal by the engineers engaged on the survey of that route, Messrs. Coons and Atkinson, by the permission of J. J. Wood, chief engineer. This line enters the district from the east side of the Delaware river a short distance above the mouth of Brodhead creek and keeping up that stream to its head waters crosses the Pocono divide in a low gap, north from Goose Pond; it there descends the East Branch of Paupack to the South Branch, which it crosses two miles above Ledgedale, and keeping up the West Branch past Hollisterville in Wayne county passes across the Moosic divide to Scranton.

Some of the levels along the line have already been given, but they are repeated here in order to place them all together.

The base line chosen by the engineers through Monroe and Pike counties, was the elevation of the D. L. & W. R. R. at the Water Gap Station (316′ A. T.) which they called 100′; hence their datum line or zero of elevations is 216′ A. T. and reducing their figures to tide level by means of this equation the following list of elevations was obtained for the principal points along the line of the proposed R. R.

From Delaware W. G. along Brodhead and Paupack Crs.	*A. T.*
Delaware river, low water, (1881), at bridge across the same, . . .	294′
Flood plain of Delaware river, on north shore, ...	316′
Top of terrace bluff, (2nd,) just south from Marshall's creek, . .	342′
Level of Marshall's creek, under proposed R. R. bridge, 4,400′ feet from the south bank of the Delaware river, ...	309′
Bluff just west from Marshall's creek, ...	370′
Crossing of small stream and road just opposite the D. L. & W. R. R. bridge over Brodhead creek, ...	331′
Top of Drift bluff just north from last, at 8000′ from Delaware river, .	400′
D. L. & W. R. R. at crossing of N. Y. S. & W. R. R., 8400′ from Delaware river, ...	355′
Brodhead creek, under N. Y. S. & W. bridge across the same, 8800′ from D. R., ...	329′
Bluff just north from Brodhead, ...	386′
Here the road runs along on a terrace of Drift or broad bench, just south from Brodhead creek, the highest point in which is	410′

Brodhead creek, at mouth of little stream, 12,300′ from D. river, ... 345′
McMichael's creek, at R. R. crossing, a short distance above its mouth, . 384′
Crossing of Main street, Stroudsburg, 1000′ from the bridge connecting it with E. Stroudsburg, ... 398′
Top of dam at Adam's mill, one mile above Stroudsburg, ... 420′
Crossing of road at 30,900′ from Delaware river, ... 445′
" Dusenberry's run, at 31,900′ from Delaware river, ... 447′
Hoffman's run, at 40,100′ from D. river, ... 500′
Road crossing at 40,300′ " " . . . . . 517′
Brodhead creek, at 43,000′ " " . . . . . 494′
Crossing of D. L. & W. R. R. here, ... 510′
Sprague ville road, at 45,925′ from D. river, ... 544′
Brodhead creek, opposite proposed tunnel above Sprague ville, ... 519′
Top of hill over tunnel, ... 643′
Road crossing, at 48,750′ from D. river, ... 546′
" " " 51,250′ " " . . . . . 562′
" " " 51,650′ " " . . . . . 564′
Brodhead creek, at 53,400′ " " . . . . . 561′
Spring run, at 60,860′ " " . . . . . 604′
Brodhead creek, at 62,000′ " " . . . . . 612′
Clear run, 63,530′ " " . . . . . 631′
Pine Mt. run, near its mouth, 67,700′ " " . . . . . 665′
Laurel run, " " . . . . . 687′
Stony run, at 77,600′ from D. river, ... 751′
Brodhead creek, at mouth of Stony run, ... 740′
Top of Farga Falls, just above, ... 750′
Brodhead creek, opposite Wm. Bates', ... 770′
Cross-roads near J. Prices', ... 829′
Crossing of Lucky run, ... 877′
Level of little run, near G. Zabriskie's, ... 916′
Spruce Cabin run, half way between the two falls, ... 963′
Road on Brodhead creek, at A. J. Decker's, near Canadensis, 95,000′ from D. river, ... 997′
Brodhead creek here, ... 987′
Stony run, opposite School No. 5, Barrett twp., ... 1211′
Elizabeth Feltham pond, Stony run, ... 1291′
Stony run, opposite Jos. Brown's, ... 1313′
Goose pond, at Pike county line, ... 1476′
Brodhead creek, at mouth of Leves branch, ... 1022′
Leves branch, where first road crosses it above its mouth, ... 1025′
" " at foot of Lower falls, ... 1317′
" " at top " " . . . . . 1435′
" " at road crossing, near C. J. Price's, ... 1517′
" " at foot of Upper falls, ... 1579′
" " at top " " . . . . . 1681′
Dark Hollow Summit of Pocono Plateau, ... 1681′
Eich's pond, in Pike county, ... 1754′
Crossing of Canadensis road, ... 1625′
Crossing East branch Paupack, 200′ above its junction with Bridge brook, 1387′
Water in South Paupack, 2 miles above Ledgedale, ... 1226′
Bluff of South Paupack, ... 1234′

Crossing of Butternut creek, in Wayne county,	1196′
" " West Paupack, 1½ miles below Hollisterville,	1273′
" " " " ¼ mile above "	1371′

(Since the above was written the N. Y. S. & W. R. R. Co. has abandoned the route over the Pocono plateau, having perfected an agreement with the D. L. & W. R. R. by which the track of the latter is used from below Sprague-ville northward to Scranton.

By this arrangement the N. Y. S. & W. R. R. crosses Brodhead creek about one mile and a quarter above Stroudsburg, at Adam's Mill, running out to a junction with the D. L. & W. R. R., as stated, two miles below Sprague-ville.

	A. T.
Elevation of Brodhead creek, just below dam at Adam's Mill,	414′
Track of D. L. & W. RR., at junction with the N. Y. S. & W.,	477′)

The only other RR. profile passing through any portion of the district is that of the Honesdale branch of the Erie, which ascends Lackawaxen creek from the village of Lackawaxen, Pike county, and according to table 95, Report N, exhibits the following elevations:

Levels along Lackawaxen Creek.	*Miles.*	*A. T.*
Lackawaxen,	0	650′
Delaware river here above dam,	0	600′
Rowland's,	4	700′
Lackawaxen creek there by bar,	4	680′
Millville,	8	780′
Kimble's,	12	849′
Lackawaxen here by bar,	12	805′
Hawley, Pike-Wayne county line,	16	899′
Lackawaxen here,	16	880′
White Mills,	21	925′
Honesdale,	25	966′

The *Delaware and Hudson Canal* passes from Honesdale down the north bank of the Lackawaxen to its mouth, and crossing the Delaware river to the New York side, follows it to Port Jervis, when turning down the old Neversink (*Marcellus shale*) valley it reaches the Hudson river at Rondout.

Table 96 of Report N. gives the elevation of a few points along it as follows:

	A. T.
Honesdale,	965′
Hawley,	880′
Port Jervis,	*455′

Rivers and creeks.

The drainage system of the district is quite complicated, but the rainfall is carried away from the district through two main channels, viz: the Delaware river, and the Lehigh river, and since the latter empties into the Delaware at Easton, 25 miles south from the district, we may say that the drainage all reaches the sea through the Delaware river.

Since this latter stream flows around about one half the boundary of the district, it receives by far the larger proportion of the drainage directly, carrying through the Water Gap the rainfall from all of Pike county and all of Monroe except a narrow strip along its extreme western and northern borders, including Coolbaugh, Tobyhanna, Tunkhannock, Polk, and Eldred townships with portions of Ross and Chestnut Hill.

Rivers of Eastern Pike.

The principal tributaries which enter the Delaware in Pike county are as follows, beginning at the Wayne county line and going down it to the Water Gap:

Mast Hope creek, a wild and rapid stream rising in Wayne county; descends through the northern point of Lackawaxen township, draining it into the Delaware at Mast Hope.

Lackawaxen river, flowing eastward through the township of the same name, pours a large volume of water into the

*The top of the canal at Port Jervis when filled with water is 30′ above the level of the Erie R. R. (440′ A. T.) at that locality, as I found by barometer. This would make canal elevation 470′ at Port Jervis or 15′ higher than that (455′) given above. The error may possibly be in the canal levels, since the Erie R. R. Port Jervis level (440′ A. T.) checks to the foot at Stroudsburg with the D. L. &. W. R. R. elevation of Water Gap Station (316′ A. T.) and the latter checks closely with the Delaware river level at Walker's Ferry (opposite Shawnee) (298′ A. T.) given in Table 84 Report N.

The highest part of the canal at the summit level between Port Jervis and Rondout on the Hudson is 58′ above the "12 mile level" at Port Jervis, or only 108′ above the Delaware river, while the summit of the Neversink divide is about 40′ lower or only 70′ above the Delaware river at Port Jervis.

Delaware at the village of Lackawaxen. This stream and its tributaries drain all of western Pike, the main tributary being the—

Wallenpaupack, the stream which separates Pike from Wayne county. The South Branch of Wallenpaupack takes its rise on the Pocono plateau in that elevated region of northern Monroe where the Lehigh river, Tobyhanna creek, and other streams rise to move in such various directions; thence flowing north with rapid fall it receives several tributaries from Greene township, and pouring through a narrow gateway of rock at Ledgedale enters an old buried valley over which it goes at an almost imperceptible rate falling only 5′ from one half mile below Ledgedale until we come to Wilsonville, a distance of more than ten miles. Here however it soon makes up for its sluggish current above by plunging over cascades from 5′ to 60′ high until it accomplishes a descent of 260′ in a distance of only one mile, the greater portion of this descent being made within only a few hundred feet over the cliffs of Paupack Falls. It empties into the Lackawaxen at Hawley, a few hundred yards below the foot of Paupack Falls.

The descent of its bed northward is shown by the following barometric elevations:

Levels along Wallenpaupack.	*Miles.*	*A. T.*
Divide at head of South Wallenpaupack, in Monroe county,	0	2100′
Opposite South Sterling,	10	1400′
" New Foundland,	12	1300′
Crossing of N. Y. S. & W. RR.,	18	1226′
Opposite Ledgedale, Main Br. Wallenpaupack,	20	1150′
Dam at Wilsonville,	32	1140′
Mouth at Hawley,	33	880′

Blooming Grove creek rises in the township of that name where it drains a large area, and flowing northward empties into the Lackawaxen at Millville. Its upper portion has a very gentle descent, often oozing through swamps with a scarcely perceptible flow, but about one mile south from where it crosses the Milford and Owega Pike, the descent steepens and it rushes onward to the Lackawaxen between walls of *Catskill sandstone* making frequent cascades along its rocky bed and falling at the rate of 100′ per mile.

Big Tink creek entering the Lackawaxen half-way between Millville and Rowland's drain a considerable area in that portion of Laxawaxen township. Its source is Big Tink Pond 1300′ A. T. while its mouth is at 700′ A. T.

Shohola creek heads on the north-eastern slope of the Pocono range where it begins in the western portion of Pike at an elevation of 1800′ A. T. From this point to the Milford and Owega pike, it flows in a north-eastward direction with a rather gentle descent draining a large area in Blooming Grove and Dingman townships. At the Milford turnpike it cuts through the Drift, over which it flows for several miles to the south, and then making a plunge of 50′ over *Catskill cliffs* at Shohola Falls, descends at a very rapid rate to the Delaware river just below Shohola village, falling 550′ in about 5½ miles air-line distance. This portion of its course is wild in the extreme, the great sandstones of the Catskill often rising nearly vertically from its bed to a height of 300′.

Big and Little Pond creeks drain a considerable portion of Shohola township and empty into the Delaware at Carr's Rock.

From this point on around the great bend of the Delaware at Carpenter's Point down to Milford, the only tributaries of the Delaware from the Pennsylvania side are small streams which rise on the high plateau 2 to 4 miles back from the river and descend to it at a very rapid rate. Among the largest of these are *Pond Eddy*, *Middaugh*, *Quick's Mills*, and *Vandemark creeks*.

From the New York side the only tributary of any size that the Delaware receives between Narrowsburg and Port Jervis is *Mongaup creek* which empties into it just below Pond Eddy.

At Carpenter's Point, however, it receives the *Neversink river*, a large stream draining the south-western half of the old buried valley which extends from the Delaware river north-eastward to the Hudson at Rondout. Its head is a large spring on a divide so inappreciable that a portion of the water from it passes into the Hudson, while the rest comes down the Neversink to the Delaware. Since the sum-

mit of this divide is only 80′ above the Delaware at Carpenter's Point the flow of the Neversink is very sluggish, meandering continually over beds of Drift underlaid mostly by *Marcellus Shale.*

Rivers of Southern Pike.

From Carpenter's Point to Decker's Ferry, a distance of 28 miles, the Delaware receives not a single tributary from the New Jersey (south) side (a few brooks excepted) but a great many from the Pennsylvania side, among which are the following:

Sawkill creek enters the Delaware at Milford. It rises on the Catskill highlands 8–10 miles west from the river and flows across the strike of the rocks south-eastward, making several great cascades in its course through the *Hamilton sandstone*, and falling about 150′ to the mile from where it strikes those beds at the top of Sawkill Falls until it empties into the Delaware. It drains nearly all of Milford township.

Raymondskill creek drains the eastern half of Dingman township eastward into the Delaware 3 miles below Milford. It too makes a great cascade 125′ high where it passes through the *Hamilton sandstone*, at the Raymondskill Falls one mile above its mouth.

Adam's creek drains the northern portion of Delaware township, and its bed is an almost constant succession of small cascades from the crossing of the State road to its mouth, a distance of two miles.

Dingman's creek, has its source in Silver Lake, a beautiful sheet of water 1265′ A. T. and situated near the western line of Delaware township. It flows eastward through the central portion of the township to the Delaware river at Dingman village, making several large cascades in its course, the two principal ones being *Fulmer Falls* over the bottom layers of *Catskill sandstone*, and *High* or *Dingman Falls* over the top beds of *Hamilton sandstone*, both of which are fully described in the detailed report of Delaware township.

Hornbeck's creek drains the south-western portion of Delaware township, and also has a High Falls (about 100′) in

passing through the *Hamilton sandstone*, 1½ ms. above its mouth.

Rafferty, Mill, Van Gorden, and *Tom's creeks* are small streams which drain the eastern half of Lehman township.

Little Bushkill creek, rises in the southern portion of Dingman township and flowing nearly due south along the line between Porter and Delaware enters Lehman at its north-eastern corner, and keeping south through its central portion empties into Big Bushkill creek at the south-western corner of Pike county.

Bushkill Falls is a wild and lofty cataract made where this stream passes over the top of the *Hamilton sandstone* about 3 miles above its mouth.

Middle Bushkill (sometimes called *Saw*) *creek* rises near the northern line of Porter township, and flowing southward drains the eastern half of the latter and the south-western border of Lehman, into the Big Bushkill, 3 miles above the mouth of that stream.

Middle Bushkill Falls, where this stream passes over the top of the *Hamilton sandstone*, 1½ above its mouth, is a small cascade only 10′ high, but well worth a visit from the great profusion of *fossil corals* which may be collected from that locality.

Big Bushkill creek has its source in a series of lakelets which surround High Knob, in Pike county, far up on the Pocono plateau. The main branch rises in the southern portion of Blooming Grove township, and keeping southward, receives Rocky Hill and Taylor's creeks, after which it veers westward out of Porter township into Barrett in Monroe county; there it is joined by Lake Branch, when it veers south-eastward again into Pike county, but after crossing the southwest corner of Porter, it reënters Monroe, and making a long detour through Middle Smithfield township, returns to the Pike county line at the mouth of Middle Bushkill, from which point it flows east to the Delaware forming the line between the two counties to its mouth at Bushkill village. This stream makes no falls where it cuts through the Hamilton sandstone, but near the base of the

Catskill rocks at Ressaca Tannery it makes a wild cataract 50′ high.

Rivers of Monroe.

Monroe county has a more complicated drainage system than Pike; since the high Pocono escarpment turns the water (down the dip) to the north-west toward the Upper Lehigh; and a low divide extending north and south across the south-western portion of the county sends the rainfall from that portion westward to the Lehigh also.

The great divide which separates the waters of the district which flow southward, from those which go northward begins in Blooming Grove township of Pike county and, keeping westward through Greene, passes into Monroe around the northern edge of Barrett, continuing south-westward along the eastern border of Coolbaugh, following rudely the escarpment of Pocono Mountain around the southern margin of Tunkhannock to the Jackson township line, and south-westward through Carbon county to the Lehigh river.

Since the Delaware leaves Monroe county through the great breach in the Blue Mountains at the Water Gap we find the principal drainage streams of Monroe county converging toward that locality.

Walpack ridge which enters Monroe at the Walpack bend of the Delaware, keeps parallel with that stream and just north from it along the eastern portion of the county, thus compelling the streams to flow along the strike of the rocks until they find an exit through the Ridge across the strike; hence no creeks enter the Delaware river between the mouth of Big Bushkill and Shawnee village a distance of 10 miles.

Shawnee creek here breaks through after draining a small area in south-eastern Smithfield and the western portion of the adjoining township. It heads up against *Place's run* which goes eastward to Big Bushkill.

Pond creek in the same way heads up against *Willow creek* in the old buried valley between Bushkill village and

Stroudsburg, the latter flowing eastward to Bushkill creek while the former goes westward to Marshall's creek.

Marshall's creek rises in the northern portion of Middle Smithfield, and flowing nearly due south cuts squarely across the old buried valley, and continuing southward through Walpack ridge, empties into Brodhead creek a short distance above the mouth of the latter stream.

Brodhead creek and its tributaries drain a large area of the central portion of Monroe. It rises on back of the escarpment of the Pocono Mountain in the northern portion of Barrett township, some of its branches coming from Pike county. The descent of its bed is shown by the table of levels along the proposed N. Y. S. & W. R. R. given on a previous page, its source being about 2000′ A. T. and its mouth 294′ A. T. It carries a large amount of water from Barret, Price, Pocono, Stroud, and Smithfield townships.

From Stroudsburg, Brodhead flows north-eastward along the northern slope of Walpack ridge for about 2½ miles, when turning squarely around it cuts through the ridge to the south-east and continuing onward empties into the Delaware just where that stream turns southward across the strike of the rocks toward the Water Gap.

McMichael's creek is its principal tributary, pouring into it (from the west at Stroudsburg) the rain fall from the northern half of Hamilton, nearly all of Jackson, and the eastern portion of Chestnut Hill. Just before entering Brodhead creek McMichael's creek receives

Pocono creek from the north, which drains portions of Stroud, Pocono and Jackson townships.

Cherry creek is a sluggish stream which rises near the western line of Hamilton township, and flowing north-eastward drains the eastern half of the buried valley which runs south-westward from the mouth of Brodhead creek along the southern slope of Godfrey's * ridge; it empties into the Delaware just below the mouth of Brodhead.

Aquanchicola creek heads up against Cherry creek in a low valley (625′ A. T. where it is impossible to locate the

[*Godfrey's ridge is Walpack ridge continued west of Brodhead creek. Prof. White uses Walpack ridge in preference.—J. P. L.]

exact point of the divide, so gentle is the slope both east and west) and runs along the foot of the Blue Mountain westward to the Lehigh water gap.

Frantz's creek flows westward just north from Godfrey's ridge, heading in an old, wide, buried valley at about 635′ A. T. the eastern end of which is drained into McMichael's creek through the Lake Branch of that stream. Ross and Eldred townships are drained by these two streams (Aquanchicola and Frantz's creeks) the latter of which makes a breach through Godfrey's ridge about 3 miles west from the Monroe county line, and empties into Aquanchicola at Little Gap.

Pohopoco creek, (or *Big creek*) rises in the northern portion of Chestnut Hill, and flowing southward turns westward through the southern portion of Polk township, keeping south-westward through Carbon county along the *Hamilton shale* valley worn out of these soft rocks, brought up by the Lehighton axis. It drains the western half of Chestnut Hill and all of Polk into the Lehigh river at Weissport in Carbon county.

Tunkhannock creek rises on the Pocono plateau in Tunkhannock, and drains that township north-westward into Tobyhanna creek.

Tobyhanna creek rises on the elevated highland in southern Wayne county whence radiate the Lehigh, Wallenpaupack, and Brodhead. Along its upper reaches Tobyhanna meanders through immense swamps with a very sluggish flow southward through Coolbaugh and Tobyhanna townships to the western line of the county, when receiving Tunkhannock creek it turns north-westward forming the line between Carbon and Monroe to its mouth at the Lehigh river.

Tunkhanna creek drains the south-eastern portions of Coolbaugh and Tobyhanna townships emptying into Tobyhanna creek near the center of the latter township.

The Lehigh river flows along the line of Coolbaugh and Tobyhanna townships where they border on Lackawanna county, and drains a considerable area from their western portions.

Lakes and Ponds.

The same phenomena with regard to ponds and lakelets were observed in this district, that I note in my Report G⁵ on Susquehanna and Wayne, viz: the large number of them, and their occurrence chiefly on the elevated plateaus at the sources of the streams.

The following is a brief account of these bodies of water, and taking the townships of the district seriatim, beginning with those of Pike county:

In *Lackawaxen Township* are five ponds:—

Ketchall's Pond, in northern portion: Pike-Wayne line crosses it; situated in *Montrose red shale*; drift heaps surround it; maximum depth 20′; bottom covered to an unknown depth with a *greenish black carbonaceous mud*; elevation A. T., 1165′, no inlet; outlet into *Mast Hope creek.*

Simmond's Pond lies about ½ mile south-east from Ketchall's, having as its only visible feeder the sluggish stream from the latter; but both are doubtless fed by subterranean springs which rise through the drift from their bottoms; situated in the *Montrose red shale*; maximum depth 22′; bottom rocky in places, but covered in others by *greenish black carbonaceous mud*; elevation A. T. 1160′; outlet into Mast Hope creek; area about equal to that of Ketchall's which contains 200 acres. In both ponds occur Catfish, Sunfish, Perch and Eels; no fish have yet been artificially introduced into them.

Wolf Pond, 3 miles south from Simmond's; no inlet; outlet northward into Mast Hope creek; very probably at the horizon of the *Montrose red shale.*

Big Tink Pond, 1½ miles south-east from the last; no inlet; outlet southward through Tink creek to the Lackawaxen river; reported depth 100′; surrounded by Drift; basin in *red shale*; area 600 acres.

West Colang Pond, 2½ miles east from Big Tink; surrounded by Drift heaps; maximum depth 27′; bottom covered with a greenish black ooze; height A. T. 1120′; two small inlets; outlet into the Delaware river 1¼ miles east; area 600 acres.

In *Palmyra township* the only considerable pond is—

Lake Jones. This beautiful sheet of water is situated on the summit of the divide between Paupack and Blooming Grove creeks at an elevation of 1500′ A. T., being the source of the latter stream; depth 30′–40′; one inlet; surrounded by beds of Drift under which the *Cherry ridge red shale* is seen along the shore of the lake; contains Bass (introduced) Sunfish, Pickerel and Catfish; area about 500 acres.

In *Green township* is a cluster of lakelets around High Knob among which are the following:

Lake Laura.—Lake Ernest.—Lake Belle.

These lakes are situated in a wilderness country through which no roads lead, and hence I was unable to visit them, but I learned from hunters that none of them has any inlets, being fed by springs which rise from their bottoms. From what is known of the elevation of the plateau on which they are situated the highest one, Lake Laura, must be about 1800′ A. T., while *Belle* and *Ernest* cannot be much below 1750′ A. T. Their outlets are southward into Big Bushkill creek.

Mud Pond, situated about 2½ miles west from Lake Belle, and at about the same elevation, also empties into Bushkill. All of these lakelets formerly contained great numbers of Brook Trout, but they have been nearly exterminated through continuous fishing.

Goose Pond, situated at the southern edge of Greene township, and partly in Monroe county empties southward into Brodhead creek; elevation as determined by the N. Y. S. & W. R. R. engineers, 1476′ A. T.; surrounded by banks of Drift; no inlet.

Eich's Pond lies about one half mile west from *Mud* but it empties northward into Wallenpaupack creek through Bridge Brook; elevation as determined by Mr. Schermerhorn of the N. Y. S. & W. R. R. engineer corps, 1754′ A. T; no inlet, but surrounded by Drift deposits; area about 550 acres.

Laurel Dale Pond, situated at the northern line of the

township, just east from the Canadensis road; elevation A. T. 1700′, depth 20′; outlet northward into East Paupack; area, when water stands at top of dam at its outlet, 800 acres; surrounded with Drift under which some *red shale* is seen near its outlet.

East Branch Pond is on the same creek, 2½ miles below Laureldale, where the stream expands in a large drift-filled valley so as to cover several hundred acres to a depth of 10′ to 30′; elevation A. T. about 1500′.

In *Blooming Grove township* also are a large number of lakelets, due to its position on the summit of the divide between the waters of streams which flow to almost every point of the compass.

The Blooming Grove Park Association, principally composed of sportsmen from New York and adjacent cities, owns a large body of land in this township, on which no one but members of the corporation and their guests are allowed to hunt or fish. The tract is all wild land and contains about 13,000 acres, being a very irregular narrow strip extending from Beaver Lake near the northern line of the township southward through the eastern end of Greene to Bushkill creek in Porter, the main object having been to get as many lakelets as possible in a continuous tract. Those thus enclosed are,

Bear, *Giles*, *Scott*, *Westbrook*, and *Bruce* ponds, with the three already mentioned in eastern Greene viz: *Laura*, *Ernest* and *Belle*.

Some of these lakelets have been restocked with fish, principally Bass, and the others, being protected from excessive fishing, afford fine sport in that line. A large area has been enclosed by a very high fence, and in this, Deer and other wild animals are allowed to live and multiply unmolested by the huntsmen, except to prevent their becoming too numerous.

Scott, Westbrook, and *Bruce Lakes*, form the source of Shohola creek, and their elevation cannot be far from 1600′ A. T.; though this is only an estimate based upon the known height of Shohola creek several miles below, as no roads

pass near them by which I could gain access to them; but in question, I learned from huntsmen that there were no inlets to any of the three, each being fed from springs which rise from their beds, and this would of course indicate the presence of gravelly drift surroundings.

Giles Lake is a beautiful sheet of clear water almost circular in shape, situated near the center of the township. Extending almost halfway around it, are nearly vertical walls of *Catskill sandstone*, 200′ high on the west and north, but to the east and south is seen nothing except low hills of gravelly drift underlaid by a thick *red shale* in which the lake basin has been excavated. A strong stream flows out of the lake, but no water enters it except what rises from springs under its surface. Its depth is given at 87′ by the superintendent of the Park Club House, who states that this depth was found in dragging for a gun accidentally dropped from a boat, hence it is very probably correct; elevation A. T. 1375′; outlet into Shohola creek; area 400 acres.

Beaver Lake lies about one mile north from *Giles* at a slightly higher elevation, being about 1400′ A. T. It is smaller than the latter and like it has no inlet; outlet into Shohola creek.

White Deer Lake lies about 2½ miles west from *Beaver*, and empties south-eastward into Blooming Grove creek. It has no inlet and is surrounded by banks of drift; elevation about 1400′ A. T.

Two other nameless lakelets are situated in this township, one in its south-east corner emptying into Rocky Hill branch of Bushkill, the other in the north-eastern portion, its outlet leading into Shohola creek.

In *Shohola township* are the following.

Big Brink Pond, situated near its southern border, covers an area of 1,200 acres; depth 20′–25′; surrounded by banks of drift; one small inlet; outlet northward to the Delaware river through Big Pond creek; elevation 1285′ A. T.

Little Brink Pond lies a few rods north from Big Brink, and has neither inlet nor outlet visible, though there is

doubtless a subterranean connection through the gravelly drift deposits between it and the Big pond; maximum depth 40′; bottom gravelly; elevation 1285′ A. T.

Big Walker Pond is a local expansion of Little Pond creek in an old drift-filled valley; depth 10′–20′; elevation 1200′.

Little Walker Pond is another expansion of the same stream one half mile north from the Big Pond; surrounded by drift deposits; depth 25′; elevation 1165′ A. T.

In *Dingman township* are several large ponds among which are the following:

Big Log Tavern Pond, situated near the center of the township in a wide drift-filled valley; oblong in shape, containing over 600 acres of surface; depth 20′–30′; bottom covered with a blackish ooze; no inlet, outlet into Raymondskill creek; elevation 1270′ A. T.

Little Log Tavern Pond lies a few hundred yards east from the Big one from which it is separated by a high sharp ridge; no inlet, outlet into Raymondskill; maximum depth found by Robert Drake (who states that he has frequently sounded it in putting out trout lines to catch fish) 85′; surrounded by Drift heaps, elevation 1260′ A. T.

Both Ponds contain *Eels*, *Pickerel*, *Catfish*, *Perch* (yellow), *Sunfish*, *Black Bass* (introduced.)

Rocky Hill Pond, situated in the extreme western portion of the township, one half a mile south from the Dingman Turnpike in a wilderness through which I could not easily penetrate; the source of Rocky Hill creek, a tributary of Big Bushkill, which 5 miles south from the pond has an elevation of 1280′ A. T. hence the pond cannot well be lower than 1350′ A. T. since that is the elevation of the Dingman Pike just north from it; on the county map it is figured as having no inlet, which is doubtless correct, since the region around it is covered to a great depth by Drift deposits.

Sawkill Pond, situated near the northern edge of the township in a wide Drift valley; depth 20′–30′; one inlet; outlet into Sawkill creek; elevation 1175′; area 150 acres.

Mint Pond lies about one mile west from Sawkill Pond, and its outlet passes into the latter.

In *Delaware township* are only two large lakelets, *Nichecronk Pond* and *Silver Lake.*

Silver Lake lies near the western margin of the township; surrounded by Drift banks; no inlet; outlet into Dingman's creek of which it forms the source; reported maximum depth 100′ around the margins only 20′–30′; elevation 1265′ A. T. beautifully clear water in which *Trout*, *Pickerel*, *Catfish* and *Sunfish* abound but no *Eels* are found it being impossible for them to make the ascent of the overhanging falls of Dingman's creek, near Fulmerville, though they get safely up the much higher one (125′) near the mouth of this stream by wriggling through the moss which covers the almost perpendicular rocky walls; though they reach the base of the Fulmer Falls in countless numbers they never get above it.

Nichecronk Pond is the source of the creek of the same name which puts into Dingman a few miles east from Silver Lake: no inlet; elevation about 1150′ A. T.

In *Porter township* are two considerable lakes, *Twelve Mile* and *Fifteen Mile Ponds*, the latter being sometimes known as *Porter's Lake.*

Twelve Mile Pond is in the southern portion of the township; no inlet, outlet into Middle Bushkill creek.

Porter's Lake is situated north from the central line of the township, and is completely inclosed by low banks of drift; average depth 15′–20′; bottom covered with blackish ooze; elevation 1300′ A. T., one inlet, outlet westward to Big Bushkill creek; area about 700 acres; contains *Black* and *White Catfish*, *Yellow Perch*, *Pickerel*, two kinds of *Sunfish*, *Suckers*, *Chubs*, *Shiners*, and *Eels.*

Lehman township has only two ponds called *First* and *Second*, situated in its western portion, the one just north from the other and emptying into it the water of both being carried to Little Sawkill creek through Pond run; the upper one has a small inlet, and drift heaps surround both.

MONROE COUNTY contains but few lakelets compared with Pike; possibly because fewer streams head up against each other radiating in every direction like they do in Pike, and probably because the rocks are more steeply inclined in Monroe.

Beginning with *Middle Smithfield:*

Echo Lake (*Seyley's Pond* as it is often called) is situated on the summit of the buried valley which extends south-west from the Big Bushkill to Stroudsburg. The county atlas gives it an outlet to Big Bushkill, through Willow creek, but it is separated from the drainage of that stream by a broad bank of drift 25′–30′ high, being in fact surrounded by drift deposits with neither inlet nor outlet visible, though of course there is an underground outlet, south-westward into Pond creek through Coolbaugh Pond; since in very rainy weather the water rises over the low divide which separates it from the latter, and sends a surface current into it; maximum depth found in eight soundings made in different parts of the lake, 35′. This result was somewhat surprising, since it had been reported to me as being altogether bottomless, one man having let down a line 300′ without reaching bottom. The result is a good commentary on the general unreliability of the depths assigned to these lakelets by those who have had no experience in making soundings. From a certain point, in the lake, a fine echo can be heard, the sound being repeated three or four times by reverberations from the steep drift banks, 30′ high, which enclose it; elevation 500′ A. T.

Coolbaugh Pond is situated only a few hundred yards south-west from Echo Lake, in the same old drift-filled valley, underlaid by *Marcellus shale*; depth 15′–20′; elevation 500′ A. T. outlet through Pond creek into Marshall's creek.

At the western margin of Hamilton township

Poponoming Lake lies in a wide drift-filled valley; its shore bluffs 40′–50′ high entirely of Drift materials; outlet into the Lake Branch of McMichael's creek; one small inlet; maximum depth 35′, elevation 620′ A. T.

In the southern portion of Chestnut Hill township

Minneola Lake lies in a buried valley on the summit of the divide between McMichael's creek and Pohopoko. It is surrounded on every side by great banks of Drift, has one small inlet but no visible outlet being evidently a "Kettle Hole" left by the melting glacier, since several other smaller "Kettle Holes" are seen in the Drift of the immediate vicinity, which were destitute of water when I visited the locality. The lake is abundantly fed by springs from its bottom, and of course the water must find some other escape from the Lake basin than evaporation, else it would fill up and overflow; it very probably passes westward through the gravelly deposits around its margin to McMichael's creek, which flows past it about ¼ mile distant and 50′ below the surface of the lake; elevation, 680′ A. T.

Wire Lake is a small body of water at the head of Wire creek in the south-western corner of Hamilton township. It lies in a drift-filled valley, is fed entirely by springs, and has its outlet westward into Pohopoco creek; elevation about 675′ A. T.

Long Lake is a curious body of water situated near the central portion of Tunkhannock township; it apparently results from the expansion of Tunkhannock creek in its passage across the drift-covered Pocono plateau, being about 3 miles long but only a few rods wide, and 5′–10′ deep; bordered by Cranberry marshes for a long distance on its southern shore, while steep banks of Drift occur along the northern margin; elevation 1835′ A. T., outlet by way of Tunkhannock creek and Tobyhanna to the Lehigh river.

Many other ponds and lakelets exist about the sources of Tobyhanna creek and Tunkhanna in Coolbaugh and Tobyhanna townships, but they are situated in a wilderness country where access is very difficult, and they have not even been mapped in the county atlas.

Origin of the Lake Basins of the District.

The constant association of Drift materials around the margins of the lakelets of the district, naturally leads to

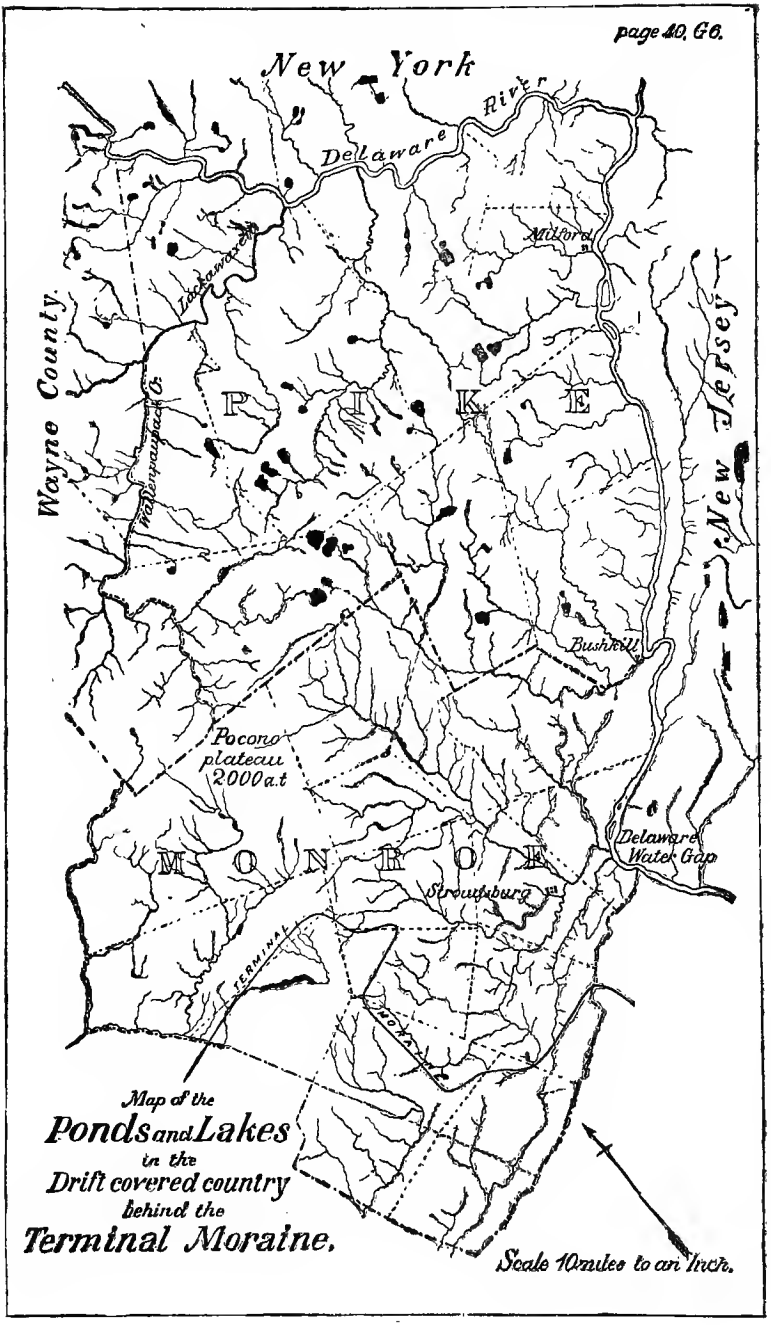
the inference that these deposits must in some way be connected with the origin of the lake basins.

In some cases like that of *Echo*, *Coolbaugh*, *Poponoming*, and *Minneola* lakes, the evidence is perfectly clear that the basins had the same origin as the "Kettle Holes" so often found associated with glacial deposits, since their basins are in two cases completely surrounded by bluffs of drift with no visible outlet. It is highly probable that some of the lake basins scattered over the highlands of Pike county have originated in the same way.

Many others, however, seem to have been formed by the dams of glacial debris which were often thrown athwart the course of pre-glacial valleys. The presence of a soft underlying rock seems also to have had considerable influence in determining the site of the basins, since several in Pike county are excavated out of *red shale.*

The presence of a soft underlying stratum would doubtless determine the erosion of a wide level valley, but how such a valley could be converted into a lake basin 25′–100′ in depth is not so readily seen, unless some such hypothesis as I have given be adopted, since the outlets of these lakelets are always through drift material, and not through such deposits as might have accumulated by the impeded drainage of any low country, such as Peat growth, over dams of driftwood.

[It is well known that in Greenland large streams of water descend the surface slope of the great glacier, between walls of ice, and plunged into crevasses. The cascades thus produced must often be of great height and force; and if they reach the bottom of the glacier, they must excavate the mother rocks over which the ice moves. This seems to be a sufficient explanation of many of the inequalities of surface in the country formerly covered by the great Canadian ice sheet. J. P. L.]


page 40, G6.
New York
Delaware River
Milford
Wayne County
Lackawaxen R.
Lackawaxen
PIKE
New Jersey
Bushkill
Pocono plateau 2000 a.t
Delaware Water Gap
MONROE
Stroudsburg
TERMINAL
MORAINE
Map of the
Ponds and Lakes
in the
Drift covered country
behind the
Terminal Moraine.
Scale 10 miles to an Inch.

Chapter III.

Surface Geology.

Drift; buried valleys; preglacial drainage; soils.

The glaciation of the district has been all but universal, since the only portion of it not covered by the great *northern ice sheet* is the extreme south-west corner of Monroe county. This glaciation is indicated alike on the highest summits and in the lowest valleys by the continuous heaps of *morainic debris*, and the *polished*, *planed*, and *striated* rock surfaces seen wherever the soil and drift have been removed.

South 30° West seems to have been the prevailing direction of the *ice movement*, as determined by the *striae*, though of course there are many exceptions to this where local causes have supervened to change the direction of ice movement to almost every point of the compass between due south and due west.

The intervention of valleys and mountain ranges seems to have had very little effect on the direction of movement, since the ice kept straight on its course S. 30° W. across the elevated summit of the Kittatinny or Blue mountain. Very deep valleys however, like that of the Delaware, acted as a groove to turn the ice out of its course in the lower portion of the same, since at the few localities where the striae can be seen along this stream, the direction conforms to the trend of the valley, viz: S. 60°–65° W.

The same fact was also noted along the north side of Walpack ridge when it attains an unusual development, since at one locality in Middle Smithfield the striae along its northern slope go S. 50° W. or nearly the same direction as the trend of the ridge.

The only part of the district over which the ice did not pass, is that included in portions of Ross, Eldred, and Chestnut Hill townships at the extreme south-west corner of Mon-

roe, since the Terminal Moraine of the great northern glacier may be distinctly seen at the eastern border of Ross, while beyond it westward we enter upon a driftless area.*

The composition of the drift throughout the district is much the same as in other portions of the State, consisting of a heterogenous mass of both angular and rounded bowlders of almost every size from a mere pebble up to masses of rock weighing hundreds of tons and containing 25,000 cubic feet; intermingled with these much sand and clay are often found, but except in the valley of the Delaware no *quicksand* has been reported to or seen by me.

No granitic or *metamorphic rocks* were observed by me among the materials of the drift in any portion of the district, the bowlders being apparently all of them rocks which come to the surface in this and adjoining counties.

Oneida conglomerate bowlders, very generally rounded, and polished, are found scattered over the tops of the highest hills 10 to 12 miles north-west from the Delaware river, and nearly 15 miles in a direct line from the outcrop of this rock in the Blue mountains. Along the Delaware river these *Oneida bowlders* are first met with in the neighborhood of Shohola, very scattering at first but becoming more and more numerous, as one decends that stream toward the Shawangunk (Blue or Kitatinny) mountain.

The area over which the *Oneida bowlders* are distributed may be traced south-westward from Shohola through Pike county (the north-western margin passing just north from

*This total absence of *drift* from the greater portions of Ross and Eldred townships, as well as the extreme southern portion of Chestnut Hill is difficult to account for, since the ice undoubtedly passed as far west as the Lehigh river, because there we find the old channel of Aquanchicola creek choked up with drift, and the stream compelled to cut a new one around it to the south through the solid strata, before entering the Lehigh. It is quite probable that *Wire ridge*, a synclinal ridge of *Catskill* and *Chemung beds*, (which extends along the southern margin of Chestnut Hill township separating it from Ross and rising 400'-500' above the wide *Marcellus shale valley* just north,) may have acted as a shield which preventing the already much wasted ice sheet from crossing it, diverted the glacial current off more to the west down the valley of Pohopoko creek. That this was the true state of affairs seems to be confirmed by the fact that the ice passed southward over the western portion of Eldred down the great valley through Wire ridge just south from Kresgeville, (for an account of which see page —— following.)

Shohola Falls) and so on, westward, past Porter lake, entering Monroe county near the northern line of Middle Smithfield township, whence it rapidly declines southward to within four or five miles of the *Oneida outcrop*.*

The thickness of the Drift is quite variable, running up to 200′ or more in some of the valleys, while along some of the summits it is so thinly spread that but for the occurrence of occasional bowlders of *Oneida conglomerate* and parallel *striae*, one would be likely to infer that the ice had never covered the regions in question. It is highly probable that post-glacial erosion has had much to do with removing the drift deposits from the uplands and piling them up along the valleys. (See Mr. H. C. Lewis' forthcoming report.)

Across the Pocono plateau the Drift is spread quite uniformly; since, owing to the gentle slope, erosion has not been able to remove it very unequally. Over much of that region it has a thickness of 20′ to 25′, while in some of the wells its bottom was not penetrated at a depth of 35′.

At Port Jervis, N. Y. just across the Delaware from the Pike county line, a hole was drilled through the Drift deposits 113′ without penetrating to the bottom.

Bowlders were quite abundant in the uppermost 30′; but below that the material was mostly *quick sand*, with only an occasional bowlder.

Kettle Holes are quite frequent in the Drift of many localities, some of them being now occupied by small lakes such as Echo and Minneola. *Poponoming Lake basin* is nothing but a large *Kettle Hole* filled with water, which finally broke across the narrow bank of Drift separating it from the Lake Branch of McMichael's creek.

Many of these *Kettle Holes* are seen in the vicinity of Brodheadville besides the one in which Lake Minneola is situated; and in some of them *Peat* has accumulated to a considerable depth.

*How these Oneida bowlders could have been carried so far *northward* from their parent bed, while the general *Ice movement* was constantly *southwestward*, within this district, is a problem whose solution I cannot even conjecture, unless glacial movement across southern New York east from Pike county, was nearly *westward* and thus transported the *Oneida blocks* further and further away north of the strike of the outcrop, S. 60°–65° W.

About two miles north from Stroudsburg, a large *Kettle Hole* occurs, the height of the rim being 50′ above its bottom.

These singular depressions have most probably originated as suggested by Mr. H. C. Lewis by the melting of immense masses of buried ice on the retreat of the Glacier northward (see his coming special Report Z).

Mounds.—Nothing was seen in this district answering to the New England *Kames* of Mr. Upham. True, the Drift materials are often seen making apparent ridges and mounds; but in every such case the resulting forms can be clearly traced to post-glacial erosion. Many mound-like heaps of Drift are seen along McMichael's creek below Snydersville. A remarkable one near Sciota, covering about one acre at its base, and rising from an almost level plain, in a cone-shaped pile, to the height of 75′ and others of the same nature, are due, I think, to erosion, since they nearly always occur in the vicinity of streams.

Till.—Fine exposures are seen along the D. L. & W. R. R. on Brodhead creek between Stroudsburg and Water Gap Station, some of the localities exposing more than 100′ of it in an almost vertical escarpment in which occur immense bowlders of *Corniferous Limestone* and *Cauda Galli Grit*, more than 10′ in diameter mingled with much bluish clay, sand and smaller bowlders.

The vicinity of Stroudsburg is an excellent place to see and study the Drift deposits both modified and unmodified. Just north from the borough line much clay occurs in the Drift from which bricks are manufactured. Imbedded in the same deposits are bowlders of *Corniferous Limestone* 50′ long, 20′ broad and 25′ thick.

Glacial Erosion.—Did the great Northern glacier exert any appreciable influence in modifying the rock surface over which it moved? As Prof. Lesley suggests in his preface to G⁶, this is not a question which can be decided by mere sentiment or belief, but must be settled by the facts. During the past season I have given particular attention to a careful examination of all the localities where

rock surfaces are exposed in the district on which glacial action is indicated; and with the following results.

On very hard rocks the direct grinding action of the *ice movement* seems to have had but little effect except to polish and striate; the proof of this being in the fact that the rocks are nearly always polished and planed off conformably with the bedding planes, even where the dip is strongest and there was every opportunity to rasp the layers off across the planes of stratification. I have noted only a few exceptions to this general rule in the case of *hard rocks: one* the phenomenon known as *roches moutonnées; the other* a single instance where hard rocks had been rasped away across the bedding planes.

The only genuine *roche moutonnée* I have seen in the district, occurs along the road in Middle Smithfield township, Monroe county, just east from Place's school house. It is a large hump of *Cauda-Galli Grit* scored and polished on every side. In this immediate vicinity, by a singular coincidence, the *Cauda-Galli Grit* is seen to be cut away to a considerable extent, the dip being only about 15° N. W. while its surface, where exposed along the road, has been scored off by huge broad furrows to an angle of 35°, giving unmistakable evidence of having suffered considerable erosion by the direct grinding action of the rocks embedded in the bottom of the moving glacier. Just here however it is easily shown that the exceptional grinding was the result of local causes; for immediately south of the localities in question, Walpack ridge rises in a steep slope 400′ to 500′ higher, and the ice along its lower portion being forced out of its general direction (S. 30° W.) westward along the trend of the ridge (S. 60° W.) would of course be jammed forcibly against the northern slope of the ridge. That the ice current was so diverted at this locality is certain, for the *striae* go S. 50° W.

Several examples of *roches moutonnées* occur in the vicinity of Carpenter's Point, N. Y., just across the Delaware river from the eastern extremity of Pike county, the material being the same hard *Cauda-Galli Grit*; and here the *ice erosion* seems to have been locally increased by the same

causes which operated in Monroe county since the ice current was turned more to the westward by impinging against the foot of the Blue mountain slope, as shown by the direction of the *striae* there (S. 40° to 45° W.)

That the moving ice which covered this district did *shave down* comparatively hard rocks to *some* extent, is also clearly shown by the examination of its path over the *Corniferous limestone*; for wherever it moved over the rocks of this series without displacing them, I find the *flint nodules* of which it is so largely composed, planed off perfectly smooth with the rest of the stratum directly through the center of many which were at least a foot in diameter.

Regarding the eroding power of the northern ice sheet by *direct cutting* when passing over *soft rocks* there is much room for doubt, since the surfaces of these soft beds are usually so covered up by debris as to obscure whatever evidence may exist *pro* or *con*; but wherever the glaciated *soft rock* surfaces are exposed I always find the ice-grooves broader and deeper on them than on hard strata, and usually find that the glaciation does not conform so closely to the bedding planes as in the latter class of rocks.

There are also some facts connected with the buried valleys of this district, (see pages —) which would seem to indicate that the soft rocks of the district (notably the *Marcellus beds*) have suffered much from glacial erosions either by the direct grinding of the ice, or else by the waters flowing underneath it.

Admitting that the Northern Glacier exerted practically no influence in modifying the general topography of this district, in removing the rocks by direct abrasion, there is yet another way in which they have suffered much from the passage of the Ice sheet, and one in which the evidence is perfectly clear. I refer to what might be called the *pushing* or *disrupting* power of the moving Ice, when passing over rocks which are divided into blocks by joints as limestone usually is.

The Corniferous limestone has been removed from the long northern slope of Walpack ridge in eastern Monroe, chiefly through this pushing power which the Ice exerted

to break loose and transport bodily forward the immense masses into which it was already subdivided by the two systems of joints and the bedding planes. That it was so removed from the northern face and summit of Walpack ridge is certain because the slope is so gentle, and the rock itself so indestructible (owing to its containing a multitude of flint nodules) that no other form of erosion could have removed it. Its resistance to ordinary aqueous or atmospheric erosion may be seen in the vertical cliffs and high ridges that it forms along the foot slopes of Walpack ridge between Bushkill and Stroudsburg. But then there is direct proof that this limestone (200′-300′ thick) was thus removed from many square miles of the area in question; for wherever a slight fold in the strata or depression of the surface offered a protection from the Ice this rock is still found in scattered isolated patches, while the vast number of great bowlders from it (many of them as large as a good sized house) which lie strewn over the southern slope of Walpack ridge in many localities, and scattered widely in others, attest in the plainest terms the manner of its removal from the top of the *Cauda-Galli Grit* whose scored and polished top now forms the surface rock along the northern slope of this Ridge from Carpenter's Point to Stroudsburg.

A short distance below Carpenter's Point, on the New Jersey side of the Delaware river, several acres of the *Cauda-Galli Grit* are perfectly bare, the *Corniferous limestone* having been removed from its top in the manner I have described, viz; by disruption of the rock in large masses which were transported onward and deposited like other morainic debris. One of these fragments (of which mention has already been made as lying just north from Stroudsburg) is so huge that I at first mistook it for an outcropping cliff, until closer investigation showed it resting in genuine Drift underlaid by *Marcellus shale.*

Any rocks crossed by two systems of joints would be peculiarly subject to such erosion as this; and since the hard rocks like the *Medina*, *Hamilton*, and *Catskill* sandstones, are so universally planed off smooth conformably with the

dip, it is possible that the ice in pushing across their beds has accomplished a considerable amount of rock destruction in the manner described.

Terraces.

The Delaware river and Brodhead creek are the only streams in the district along which any well defined *terraces* exist.

In the vicinity of Matamoras and Port Jervis at the eastern extremity of Pike the following series may be seen:

1st Terrace, extending from 420′ A. T. to 440′ A. T. at top, constituting the flood plain of the river, and the principal portions of the sites on which Matamoras and Port Jervis are built, composed principally of fine material 4′–5′ of "hard pan" coming at top, below which occurs quicksand, gravel and occasional small bowlders.*

2nd Terrace, top 470′ A. T. going up with a steep escarpment from the top of the 1st Terrace, and then expanding into a broad, level area on which the upper portion of Port Jervis is built; made up of vast numbers of bowlders intermingled with coarse sand.

3rd Terrace; this is seen on the New Jersey side of the Delaware a short distance below Carpenter's Point; top 510′ A. T. and 100′ above the Delaware river; river slope quite steep; at top, a wide, and almost level plain thickly strewn with small rounded bowlders. This terrace has probably suffered much from erosion, since no traces of it occur at Matamoras and Port Jervis.

At Milford the lower *terraces* have been removed on the

[*If this elevation be exact (and the vicinity of the railway secures a close approximation to the truth) it tallies in a remarkable manner with the elevation above tide of the gravels at Easton and Bethlehem, and with the high *Bryn Mawr gravel* of Philadelphia, as described by Mr. Lewis, and Mr. Hall, in Reports Z and C⁶. The gravel patches of Lancaster county reported by Mr. Frazer are also high, but no levels have been taken, and it remains to be seen whether or not they can be correlated with those of the Delaware river country. As the ice sheet did not approach Philadelphia nearer than 60 miles, it seems necessary to postulate an elevation of the sea level more than 400′ above where it now stands. Whether higher terraces require its still greater elevation, or whether they can be explained by ice-dams, remains to be seen. J. P. L.]

Pennsylvania side, and the *3rd* is the only one left; the river washes its northern shore at this locality and the bluff rises nearly perpendicularly from the bed of the river to the top of the 3rd terrace, and from 380′ A. T. to 480 A. T. The town of Milford is built on the top of this beautiful terrace which is 100′ above the Delaware at its outer margin, and gradually rises northward until it attains an elevation of 125′ to 150′ above the river, where the terrace deposit ends and the slope of the bounding hill begins.

The composition of the great terrace deposit at Milford is quite heterogeneous, containing bowlders of *Oneida conglomerate*, *Medina SS.*, *Cauda-Galli grit*, *Corniferous limestone*, *Hamilton*, *Chemung* and *Catskill sandstones*, together with much coarse and fine sand; nearly all of the bowlders are rounded, and in the bluff on the river bank the deposit seems to have the appearance of rude stratification. There can be little doubt that it is largely composed of *modified Drift* rehandled and brought to its present position by the combined action of the Delaware river, and the two streams which debouch into it here (Sawkill and Vandemark's creek) during the *flooded river epoch* which accompanied the retreat of the Northern Ice cap.

Below Milford onward through Pike county, glimpses of these *three main terraces* are often caught, but they have suffered so much from erosion that the definite succession from one to the other cannot be made out.

In the vicinity of Dingman's Ferry (8 miles below Milford) the *1st* and *2nd terraces* are well shown, the upper one exhibiting a steep escarpment facing away from the river just south from the Milford road with a wide bottom eroded out of it, as the Delaware had once sent one arm across the bend made at the Ferry. A rise of 40′ would send the water of the Delaware through this short cut now; so that, either it or Dingman's creek has accomplished the erosion.

High, broad, level expanses in the vicinity of Bushkill (at the Monroe county line) represent the *1st* and *2nd terraces*.

In Smithfield township, Monroe county, many fine ter-

races occur along the Delaware river. Near Mr. Wm. Walter's (1½ ms. below the eastern extremity of the township) the following succession appears:—

	A. T.
Top of 4th terrace 150′ above Delaware river,	460′
" 3rd " 100′ " " "	360′
" 1st " 25′ " " "	335′

The 2nd Terrace is wanting at this locality, there being an almost precipitous descent from the top of the 3rd to that of the 1st; but that a *2nd* belongs here, and has been removed by erosion is certain, because, about ½ m. above, it makes its appearance as a broad shelf 45′ to 50′ above the Delaware river.

The lowest (1st) terrace is composed of fine material only, no bowlders occurring in it, there being nothing but river silt. Judging by the fact that it is higher along its outer margin, and slopes gradually away from the river to the foot of the steep escarpment which begins the ascent to the 3rd terrace, it would appear to be nothing else than the present flood plain of the river. But this same feature characterizes the *3rd* and *4th terraces* also; for their outer or river-ward rims are higher than the other portions of their tops, thus giving them a gentle slope away from the river. These facts would seem to favor Prof. J. D. Dana's theory for the formation of *river terraces* in glaciated regions, (see Amer. Jour. Sci. Feb. 1882.)

The expanse of the uppermost (4th) terrace is quite broad, extending back about one fourth of a mile from the river; and its escarpment down to the top of the 3rd terrace is steep. The 3rd terrace is only about 100 yards broad, while the 1st terrace is a mere shelf along the river.

Rounded bowlders of almost every description, except *metamorphic*, or *igneous*, cover the slopes and tops of the 3rd and 4th terraces, while a few angular blocks are also seen jutting out of the steep escarpment between the tops of the 1st and 3rd terraces.

About the mouths of Brodhead and Marshall's creeks the succession of the three lower terraces is very distinctly shown as follows:

	A. T.
Top of 3rd 100′ above Delaware river, or	395′
" 2nd 45′–50′ " " " "	345
" 1st 20′–25′ " " " "	320′

The first terrace is composed entirely of fine mud and river silt, while the 2nd and 3rd terraces are perfect masses of rounded bowlders intermingled with small gravel and coarse sand.

The slope is gradual from the top of the 1st terrace up to the top of the 2nd; but from the 2nd to the top of the 3rd the escarpment is very steep, at the summit of which is a very broad level expanse.

This *3rd terrace* may be traced up Brodhead creek along the line of the N. Y. S. & W. R. R. (which cuts through its top at two or three points) until we come to Stroudsburg, where it forms the first of a series that begins there and extends upward, the succession and elevations of which are as follows:

Top of 5th	above Brodhead,	115′	and		500′
" 4th	"	"	100′	"	485′
" 3rd	"	"	75′	"	460′
" 2nd	"	"	50′	"	435′
" 1st (3rd at Del. river)	"	"	20′	"	405,

In the vicinity of Stroudsburg three large streams (Brodhead, McMichael's and Pocono creeks) unite in the midst of a broad plain which extends northward and westward for one or two miles, rising by successive stages like those given above, to a height of 500′ A. T. All of this wide area is covered with drift material much of which seems to have been rehandled and spread out by these three streams during the *flooded river epoch.*

This seems proven from the fact that excavations in the escarpment of the 2nd terrace show it to consist of stratified material.

In East Stroudsburg an excavation at the roadside in this terrace reveals 5′ to 6′ of small *cobble stones* resting immediately upon a bed of clean coarse brown sand.

A bed of sand exactly like this and overlaid by cobble stones, is seen at an elevation of 370′ A. T. at a cutting on the N. Y. S. & W. R. R. one mile above the mouth of Brodhead creek.

The eastern portion of Stroudsburg is built on the top of the *1st terrace* given above, which from its elevation, (405′ A. T.) would seem to have some connection with the *3rd terrace* along the Delaware river at the mouth of Brodhead creek.

The main portion of Stroudsburg is built on the *2nd terrace*, Elizabeth and Monroe streets being laid out on its upper surface. The depot of the D. L. & W. R. R. in East Stroudsburg is also situated on this terrace.

The top of the *3rd terrace* is seen along the north line of borough of Stroudsburg.

The top of the *4th* terrace occurs in the same vicinity, and along the road leading west from Stroudsburg past Mt. Paul school house. This is the broadest and most extensive of all the Stroudsburg terraces, unless it be the uppermost (5th) which seems to connect itself with the old buried valley that extends through from Bushkill to Stroudsburg at about this same elevation (500′ A. T.)

Buried Valleys.

The District of Pike and Monroe counties is remarkable for the number and variety of its *buried valleys.*

The Delaware river flows over a bed of trash which extends down probably 100′ below its present surface; at least, this is true for that part of its course between Port Jervis and the Water Gap. No borings or excavations have ever reached the bottom of this buried channel, though a well, drilled for water at Port Jervis passed 63′ below the bed of the Delaware without striking bed rock.

This well at Port Jervis was put down by Messrs. Buckley and Thompson, beginning on the top of the 2nd terrace, 50′ above the river; and for the following facts concerning it I am indebted to Mr. Buckley:

"Rounded bowlders were very abundant down to 32′, at which point *quicksand* was struck; and nothing else except alternate layers of *mud*, *sand*, and *quicksand* was found; the boring having been abandoned in quicksand at a depth of 113′ from the surface," or 357′ A. T. at the bottom of the hole.

This result was quite unexpected by me; for my work of 1880 in Wayne county had shown that the upper Delaware flows over a rocky bottom as far south as the Pike county line; where (at Narrowsburg) the rocks close in on the river and leave a channel only about 200′ wide, floored with solid rock.

The Delaware has a fall of (670′–420′=) 250′ in 35 m. between Narrowsburg and Port Jervis; hence it seemed improbable that its old channel could have been silted up to so great a depth (at least 100′ and possibly more), in so short a distance, when the fall is sufficient all the way to give a very rapid current.

Finding that an old buried valley led from Port Jervis north-eastward to the Hudson river at Rondout, and that its summit is only about 80′ higher than the water in the Delaware river at Port Jervis, the suggestion seemed not unreasonable that the Delaware in pre-glacial times turned north-eastward at Port Jervis. and receiving a large tributary from the south, kept along this old buried valley to the Hudson river. But a subsequent study of the Delaware valley southward, rendered this view uncertain, since the Delaware seems to have flowed through the Blue mountains at the Water Gap during its entire history.

There is no *immediate* rock bottom to the Delaware at Lackawaxen, 11 miles below Narrowsburg; for, in building the piers for the great aqueduct there, the D. &. H. Canal Co. could find no rock foundation at a depth of 20′ below the present river bed.

In driving piles for the N. Y. S. & W. R. R. bridge across the Delaware above the Water Gap, no bottom was found at a depth of 30′.

Where the river passes through the great gorge at the Water Gap, the depth of the Delaware is about 50′ and I was informed that it was formerly 70′, below which there is, probably, an old silted up channel.

It thus appears that between Port Jervis and the Water Gap, the Delaware river flows over an old river channel, silted up to a depth of perhaps 100 feet.

"How did this buried channel get worn out and then filled

up again?" is a question that I was frequently asked while working in the district. The answer is at best problematical, and depends somewhat on the proper reply to another query of a similar import concerning the origin of the great buried valley which stretches from the Hudson river at Rondout to the Delaware at Port Jervis.*

This buried valley of Neversink creek in New York, as we have seen, rises only 80′ above the Delaware at Port Jervis, (say to 500′ A. T.,) at its highest point, while both north and south it is bounded by hills which rise 700′–800′ higher. Great heaps, and mounds of drift are found all along this old valley, as well as *striae* on the rocks, and *roches moutonnées*.

The Neversink river rises at the summit of the old valley in a spring where the divide is so low that a portion of its water goes to the Hudson through Wallkill creek, while the rest comes to the Delaware through the Neversink. What could have excavated this old valley?

The Stroudsburg buried valley.—This begins near Bushkill at the Monroe county line, where the Delaware turns southward to cut through Walpack ridge, and keeping south-west along the northern foot of that ridge, the buried valley extends through to Stroudsburg. It is filled with Drift deposits and its summit rises to 509′ A. T. according to the levels of Mr. Coons for the Lehigh & Eastern R. R. survey. Just opposite this however the bottom of Lake Echo extends down 44′ lower; so that the bed rock under the Drift at the summit of the valley may possibly not be

*There is no evidence whatever that the Gap was made by any cataclysmic action, that is, by any earthquake, deluge, or other convulsion of nature, as is commonly supposed by the inhabitants of the neighborhood. [The mountain has been cut through by river water; and is still being cut down deeper by the waters of the Delaware river. How the cutting commenced, and what was the topography of the country then, would require a long disquisition to explain. There is a twist and perhaps a fault of the rocks in the Gap, as is shown by the different angles of dip of the bed plates in the bordering cliffs. But this twist, or warp, whether faulted or not, did not open the Gap, but merely served as a determining cause or occasion for the drainage of the back country to flow over and through the Blue mountain here and not elsewhere. A detailed map of the Delaware Water Gap made by Mr. Chance will be published in the report of Northampton county; and the subject of the origin of the Gap will be then discussed. J. P. L.]

higher than 400′ A. T. The Delaware river flows in this same buried valley between Port Jervis and Bushkill; so that the valley may be regarded as continuous from the Hudson river to Stroudsburg, a distance of 90 miles.

The Marcellus shale underlies this old valley throughout its entire extent in Pennsylvania, and for a large portion of its course through New York.

From Stroudsburg westward the same valley may be traced as a broad drift-filled plain 500′ to 550′ A. T. until it debouches into the valley of McMichael's creek near Kunkleville. From this point south-westward there is a great valley one to two miles wide, filled with Drift, in which no rock outcrops occur. Near Sciota in the western portion of Hamilton township this great valley bifurcates, one branch passing north-westward along the North Branch of McMichael's creek to Brodheadsville. Here it leaves that stream, keeping westward across a low Drift divide, the surface of which is only 700′ A. T. at its lowest point while both north and south the surface rises 400′ higher. This valley is more than a mile wide here, (though no stream whatever is flowing in it now,) and it continues south-westward at about the same level until it debouches into the valley of Pohopoko creek which it follows to the western line of Monroe county and through Carbon county to the Lehigh river near Weissport.

The other branch of the buried valley keeps south-westward from Sciota along the Lake Branch of McMichael's creek, through Hamilton township, reaching its highest elevation (635′ A. T.) in a wide drift-filled plain just west from that district in Ross. Here the drainage starts westward from an extensive marsh just west from the summit of the almost imperceptible divide, and the water is then carried westward by way of Frantz's creek. This branch valley however suddenly terminates just after Frantz's creek enters the *driftless* area south-west of the great *terminal moraine* which covers the eastern portion of Ross township. For, when Frantz's creek enters the driftless area its valley narrows up to a deep trench about 100 yards wide cut out of the *Marcellus shale* along the north slope of Godfrey's

ridge, in marked contrast to the (over a mile) wide drift-covered plain to the east, under which *Marcellus shale* also extends.

Flat brook buried valley.—Lying just south from the last described *buried valley*, and separated from it by Walpack ridge, there is another very similar to it. and of almost equal extent, in length at least, since it reaches from the vicinity of Port Jervis to the head of Cherry Valley.

This buried valley begins in Orange county, N. Y. just south from Port Jervis and keeping along the base of the Blue (Shawangunk) mountains, passes through New Jersey to the Delaware river at the Walpack Bend near Decker's Ferry, this portion of its course being filled with Drift and drained by Flat Brook and another small stream which heads up against it on a low (600′? A. T.) drift-covered divide, the latter draining its extreme northern end, north-eastward into the Neversink at Carpenter's Point.

The Delaware river having cut through Walpack ridge, enters the Flat Brook buried valley, and flows down it to the mouth of Brodhead creek, when it turns out of it southward through the Water Gap. Our buried valley however keeps straight along with the *strike* of the rocks, passing south-westward up Cherry creek. Near Saylorsburg, the surface is 625′ A. T.

This old Flat Brook-Delaware-Cherry creek valley is underlaid throughout its whole extent by the soft Clinton red beds No. V and at many localities *ice grooves* are seen on its surface.

How did these two long parallel valleys originate? Had aqueous erosion acting on the comparatively soft rocks out of which both have been excavated, brought them during pre-glacial times into the condition of the deeply trenched valleys which we now find, so that the frozen rivers of the *Glacial Epoch* merely filled and buried their rocky bottoms from sight; or did these *Ice rivers*, following the valleys which pre-glacial erosion had undoubtedly marked out, contribute largely both in widening and deepening them?

In the case of the southern branch of the Stroudsburg buried valley the rapid narrowing up and disappearance of

this *buried valley* is coincident with the disappearance of the Terminal Moraine which spreads over the valley of upper Frantz's creek. There is therefore little doubt that *subglacial rivers* did both widen and deepen it to a considerable extent; for Frantz's creek after entering the *driftless* region flows along its narrow valley in the same soft *Marcellus shale* which underlies its wide drift-filled eastern prolongation.

Whether this *erosion* that we find marking the tracts of Glacier motion over *soft rocks* be due principally to the grinding action of the ice and its imbedded rocks, or to the waters flowing beneath the ice, and from its terminal moraine may be matter of doubt, but as both come under the head of Glacial agencies, the question is immaterial, though if the broad deep grooves seen on the soft rocks wherever exposed in these two valleys, teach any thing, they would certainly favor the idea that the ice which was forced to follow along these preëxisting trenches did exercise considerable *rasping power*.

Postglacial rock-cuts.

But whatever may have been the origin of these two, long, *buried valleys* there is *another class of buried valleys* found in many portions of the district about whose origin the evidence is so clear and satisfactory that there can be no doubt. I find that the present topography of the surface in this district has been greatly affected by the northern ice sheet in a different manner than by direct erosion. When this great ice cap crept down from the north-east, it found the surface already deeply trenched into valleys by the preglacial drainage. Crossing these ancient water-ways at all angles the ice current filled many of them up to so great a height with morainic debris, that when the post-glacial drainage was reëstablished many of the streams found lower outlets to other valleys around these morainic dams, at times making a circuit of several miles.

The new channel of *Wallenpaupack creek* is one of the most striking examples of this class. While studying the geology of Wayne county in 1880 the north bank only of

this stream was examined and hence in commenting on the remarkably slow descent of its water bed from Ledgedale to Wilsonville, as contrasted with its wild plunges over the rocks from Wilsonville to the Lackawaxen at Hawley no sufficient explanation was at hand; for the north bank gave no evidence whatever that the stream had ever had any other exit to the Lackawaxen valley than over the cliffs at Paupack Falls.

But during the present year (1881), while studying the south bank of the stream, I unexpectedly came upon the track of the ancient pre-glacial stream, and traced it to its mouth at Kimble's, 4 miles below the present mouth of the Paupack. The ancient stream turned eastward from the present valley in the vicinity of Tafton (a short distance above Wilsonville) and keeping south-eastwards along what is now a low wide drift-filled valley in which no stream flows, passed into the present valley of Kimble's run one mile above its mouth and followed the same to the Lackawaxen valley at Kimble's.

In short, the history of this stream seems to have been somewhat as follows: Descending from the northern slope of the Pocono plateau with a large volume of water, it had carved a wide and deep channel through the Catskill measures to the level of the Lackawaxen, having a continuous slope with no falls of any moment in its course between Ledgedale (1150′ A. T.) and its mouth at Kimble's (740′ A. T.) The *Glacial Ice* coming down from the north then filled this. its old valley, with debris, to a height of more than 300′ near Tafton; so that, the reëstablished drainage found a lower outlet to the Lackawaxen across the rocky cliffs by a short cut of only one mile instead of four by way of Kimble's. We thus get a good explanation of the sluggish course of this stream for the ten miles above Wilsonville, in which it meanders over beds of silt, falling only ½′ per mile until it begins its cataract descent at the latter village descending in a narrow gorge by a succession of cascades and rapids 260′ in one mile, although carrying nearly as much water as the Lackawaxen into which it empties.

The channel of the Paupack between Wilsonville and

Hawley is therefore clearly of Post Glacial origin. The broad valley along either bank of the Paupack between Wilsonville and Ledgedale was once an extensive lake, as proven by the silt and clays found over its surface, but when the new outlet had cut its way down through the rocks at Wilsonville the lake was drained off; but much of the valley remains quite swampy. The surface of this ancient lake stood about 75′ higher than the water in the Paupack above Wilsonville now, if one may judge from the amount of erosion or cutting down that has plainly been accomplished since the water first started over the Paupack Falls.

Blooming Grove creek in a similar way, was forced to cut a *new channel* several miles long, from a point two or three miles south of the Milford and Owega turnpike to its mouth at Millville.

This is made plain by the fact that a few rods west from where the M. & O. pike crosses this stream, there is a deep, wide drift-filled valley in which only a very small stream is now flowing, yet the surface of this valley is 50′ lower than the rocky bed of Blooming Grove creek which overlooks it from the top of the bluff to the east. This stream rushes down to the Lackawaxen through a continuous gorge carrying a large volume of water, and descending over frequent rapids and cascades at the rate of 100′ per mile. The old drift-filled valley just west from it debouches into the buried valley whose outlet to the Lackawaxen is at Kimble's, hence the Blooming Grove waters were once tributary to the Wallenpaupack about one mile above its pre-glacial mouth.

In many parts of Pike county, there are evidences of *pre-glacial valleys* that were so choked up with Drift as to entirely derange the former drainage. One of these deep, drift-filled ancient water ways is seen crossing the Milford and Owega pike about a mile and a half west from Shohola Falls; it extends eastward from the Turnpike toward Great and Little Walker Ponds which most probably originated from the damming up of this ancient valley with Drift heaps.

Shohola creek once emptied into the Delaware about one

half a mile below its present mouth through a now deeply buried valley which leaves its present channel about one mile and a half above the mouth of the creek, keeping to the south of the same. But the retreating *Ice* left this old valley buried to a depth of more than 200′, so that the water found a lower outlet to the Delaware around it northward over the rocky cliffs, and the creek cutting down through them has excavated the great gorge at Shohola Glen since the close of the *Glacial Epoch.*

Another wide *buried valley* seems to extend south-westward from the region of the Brink Ponds, past the Log Tavern Ponds, and Silver Lake, connecting with the present head waters of Little Bushkill. Whether this valley was drained by one continuous stream in the past or otherwise it seems certain that the lakelets along its seeming course originated by the filling up with Drift material of previously excavated valleys.

There is an *ancient buried valley* extending directly across the Pocono plateau from Greene township of Pike county into Barrett in Monroe, for there is a low, drift-covered divide connecting the head streams of East Paupack with those of Big Bushkill and Brodhead creeks, cut down to 1681′ A. T. while both east and west from this "Gap" the surface rises to 2000′ A. T. How deep the filling of Drift may be in this old valley, it is impossible to know, but judging from surface indications it is probably not less than 50′–100′. How such a valley as this running squarely across the Pocono plateau, could have been excavated in pre-glacial times, it is difficult to understand, for the surface falls away on either side of its highest point (1681′ A. T). It may therefore with some probability be ascribed to ice.

Milford rock-cuts.—Very interesting *buried valleys* occur in the vicinity of Milford. The famous Sawkill and Raymondskill Falls are both due to the change in course of those streams around drift-buried valleys.

The ancient Sawkill left its present channel about 2½ miles from the Delaware river, and keeping east of its present course near the line of the Milford and Owega pike down

the old buried valley in which the Milford Water Works are located, passed into the Delaware under the borough of Milford receiving the Raymondskill as a tributary from the west near the north-western corner of the town. But the *Glacial Ice* left the old Sawkill valley filled with trash to so great a height that its water found a lower exit to the Delaware over the *Hamilton Sandstone cliffs* just west, thus giving origin to the Sawkill Falls.

The Raymondskill ancient channel also, was at the same time buried so deeply as far west as Mr. J. Brink's, 2½ miles from its former mouth at Milford, that it, too, found an outlet southward over the same *Hamilton* cliffs which everywhere overlook the Delaware river between Matamoras and Bushkill, and cutting through them in successive leaps, resulted in the grand falls of that stream.

Thus both the Sawkill and Raymondskill Falls are of post-glacial origin. The evidence going to show this is perfectly clear and satisfactory; for in the case of the Sawkill, a narrow ridge of drift, only 25′ higher than the bed of the stream at the crossing of the Milford and Owega Pike, separates the present stream from a deep drift-filled valley just east, cut down far below the rocky bed of the present Sawkill where it starts over the *Hamilton* cliffs and yet nothing flows in this old valley except the water which arises from two or three springs, hence the conclusion is irresistible that the Sawkill once flowed through the same; for no other could have acoomplished the excavation. The drift-filling in this old valley at its deepest point cannot be far from 300′ since its uppermost surface is 420′ above the Delaware river only, 1½ miles west from the same.

That the Raymondskill emptied into the Sawkill near Milford in pre-glacial times is quite certain; for a deep, wide drift-filled valley leads from the Sawkill south-west to the Raymondskill near J. Brink's, the lowest point in the drift-filled divide being now only 20′ higher than the water in the Raymondskill at the road crossing. A very insignificant stream flows in this old valley now, and its erosion could only have been accomplished by the long continued flow of

a large volume of water such as no other stream than the Raymondskill could have furnished.

It is possible that the other great cascades over the *Hamilton cliffs* along the Delaware river, such as those on Adam's, Dingman, Hornbeck, and Little Bushkill creeks owe their origin to a similar diversion of these streams by the drift dams thrown across their pre-glacial channels, but this is only a conjecture as I had no time to make a detailed study of the topography along their courses.

In Monroe county, there are several other examples of buried valleys besides those already given; for example *Marshall's creek* in pre-glacial times appears to have turned south-west in the vicinity of Marshall's Falls P.O. and flowed down the strike of the *Marcellus shale*, along the present valley of Sambo creek, to Brodhead, near Stroudsburg; for only a low divide of drift in a broad valley, 30′ higher at its summit than the water in Marshall's creek now separates the drainage of the latter from Sambo creek. Yet this low dam was sufficient to throw the water across a low place in Walpack ridge to the south, thus giving the water an outlet southward to Brodhead creek, near the mouth of the latter. That this portion of its course is of comparatively recent origin is fully shown by the character of its valley between Marshall's Falls and the present mouth.

Frantz's creek.—Near the west county line an old buried valley cuts squarely through Wire ridge connecting the buried valley of Topoko creek with the valley of Frantz's creek to the south, the summit of the wide drift-filled plain being only 730′ A. T. while Wire ridge rises 400′ higher both east and west. The occurrence of Drift in this old valley renders it quite probable that the excavation was done by the overflow waters from the southern terminus of the Glacier which filled the Pohopoko valley, since the *Ice* did not cover the region south from Wire ridge east of this great gap.

The Wind Gap is a deep notch in the Kittatinny (Blue) Mountain just south from Saylorsburg, at the south-west corner of Hamilton township, Monroe county. The sum-

mit level at the centre point of the bottom of the notch has an elevation of 978′ A. T. The crest of the mountain rises about 500′ higher. Measured at the crest line of the mountain the width of the Gap is about ¾ mile. The side slopes are beautifully rounded and curved downwards and pretty steep, so that the floor of the notch is about ⅛ mile wide.

Excavations for a proposed railroad through the Wind Gap show that the floor of the notch is covered with rock trash ; and some of the small bowlders seen in the excavation at the depth of 10′ to 12′, are rounded as if water worn.

I could find no evidence that the *Northern Ice* had ever passed through this notch, so that its origin cannot be ascribed to glacial erosion although it may have served as a waste weir through which the water from the melting Ice escaped southward when it filled the old valley to the north to an elevation higher than the level of the surface in the Gap.*

The soils of Pike and Monroe counties.

The soils of the district have been largely derived from the decomposition of Drift, except in localities where this material has been shed by erosion ; but as this has occurred over wide areas the soils may be classified in the order of their relative fertility, according to their place in the geological column.

Thus the poorest soils are derived from the lowest (*Oneida*

[* After Mr. Hall's study of the Till, crushed slates, and sand-moraine barrier at the Lehigh Water Gap, by which he was led to the conclusion that a tongue-glacier had descended the Lehigh Valley to and perhaps through and beyond the Lehigh Water Gap, I thought I saw a mode explaining not only the anomlous Wind Gap, but the very curious half-bowl scooped out of the south flank of the Blue mountain, beneath the Bake Oven Knob west of the Lehigh Water Gap. If this gap and the Delaware Water gap were occupied, the one by a high wide tongue of ice banked against the Bake Oven, and the other by the great New York main glacier, then, although the *sub-glacial* waters would still issue by ice caverne through the two gaps, the residual *surface glacial water* would probably be obliged to pour over the crest of the Blue Mountain. If they did this at the Bake Oven for a short time, and at the Wind Gap for a long time, the only part of the problem of the genesis of these two remarkable topographical phenomena remaining unexplained would be, the selection of these two points along the crest in preference to any others. J. P. L.]

conglomerate) and the highest (*Catskill*) beds of the district. The former is so silicious that not a single cultivated field is seen where it forms the surface rock along the entire south line of this district.

The Catskill massive sandstones form so large a portion of the surface rocks where this series prevails, that but for the occurrence of occasional beds of *red shale* or the finer materials of the Drift the *Catskill area* of the district would be quite as desolate as the Blue Mountains. As it is, many extensive tracts of country are so barren that one may drive for 10 to 12 miles in some localities without seeing a single cultivated field, the surface being exceedingly rough, and constantly covered with immense bowlders of sandstone. Since the Catskill beds spread over all of Pike county except a narrow strip 2–3 miles wide along the southern border, and by far the larger portion of Monroe is thus covered, it follows as a natural consequence, that but a small fraction of the area of the district has any lands that furnish a first class soil.

The Chemung area is narrow owing to the fact that its rocks are so steeply inclined; hence it can hardly be taken into the account as a soil producer. Its soil however is but little better than that of the Catskill, since its rocks are quite arenaceous; and then the surface where it outcrops is so littered up with Catskill debris that its soil is almost as inhospitable as that in which the latter forms the bed rock.

The Hamilton beds, being somewhat calcareous, and decomposing quite readily into small fragments, present quite an advance on the soil-making properties of the *Catskill and Chemung*. *The Marcellus shale* division is much superior in this respect to the rest of the *Hamilton*, for it nearly always forms a wide level valley. In Pike county, it underlies the Delaware bottoms, and has exerted little influence on the soil of the same except to form a broad level shelf in many localities for the reception of the alluvial material of the Modified Drift out of which the most of the soil along the Delaware has been formed.

The Genesee shale often makes some rather good soil on a

broad shelf of the underlying *Hamilton sandstone.* But the latter rock is too silicious in Pike county for soil making purposes; and not until we come into the western portion of Monroe does it decompose and crumble into any slopes that can be farmed. The soil of the *Hamilton area* brings splendid crops of oats and grass; and when a liberal dressing of lime is applied very good crops of wheat and corn can be grown thereon.

The Corniferous limestone, Cauda-galli grit and *Oriskany sandstone,* can hardly be accounted among the soil producing rocks of the district, since with a few exceptions in favored localities the country over which they outcrop is quite as barren as the *Catskill* or *Oneida lands.*

The finest wheat lands in the district are the Delaware bottoms in Monroe county, and the continuation of the same valley along Cherry and Aquanchicola creeks. The reason is evident; for, the lower limestones of the *Lower Helderburg* underlie much of the region in question, while the upper members of the same crop out in the steep slopes which continuously bound the north wall of the Delaware and Cherry valleys through Monroe.

From this hasty survey of the soils, it will be observed that the *Hamilton* and *Lower Helderberg,* together with the soft *Clinton red beds* underneath the latter, furnish the only arable lands in the district that can be farmed with any pleasure or much profit, and, by reference to the accompanying geological map it will be seen, that these areas are so limited in extent that this district can never become conspicuous as an agricultural region. Of course there are some localities in the *Catskill area* where the outcrops of *red shale* have softened down the topography, or, the distribution of the finer Drift debris has covered up the unyielding rocks of that group, and then some good farming lands may be found; but these circumstances are so exceptional compared with the great area covered by these beds (Catskill) that the arable lands thus produced may be entirely neglected in a general review of the agricultural resources of the district.

Flora of the Region.

Owing to the wilderness condition of a large portion of Pike county, much of the original forest is undisturbed.

Pinus rigida is the principal forest tree, and where it grows almost every thing else is excluded except low underbrush and herbaceous vegetation.

The Hemlock Spruce (*Abies Canadensis*) is also an important forest tree in many localities, especially along the waters drained by Paupack creek and its tributaries, where its bark furnishes supplies for the great tannery at Ledgedale, and logs for the extensive saw mills at Paupack Falls. The Pocono plateau in Monroe county also contains extensive forests of this tree from which supplies of bark are obtained for the tanneries at Stroudsburg, Tannersville, Canadensis and other points, while the trees furnish logs for the mills at Tobyhanna, Pocono and other localities.

Other forest trees, such as several kinds of *Oak*, *Hickory*, *Maple*, *Chestnut*, *Beech*, as well as several other varieties of *Pine*, exist in limited quantity in many portions of the district.

Lycopodium vulgare occurs in large quantities and is extensively collected on the Pocono plateau, and shipped to New York and other cities for winter decorations.

A great variety of small undergrowth and herbaceous vegetation exists, consisting principally of the same species as those enumerated in G⁵ as being found by J. W. Dolph in Wayne county. One interesting addition to that list was found in the neighborhood of Matamoras, Pike county where Dr. Barrett of Port Jervis has discovered the *Prickly Pear Cactus* (Opuntia Vulgaris) growing in great numbers on the *Hamilton sandstone* cliffs which overlook the Delaware river 400′–500′ above the same. So far as known to the writer it has never heretofore been found so far (80 miles) inland from the sea coast, being generally confined to 20 miles from the sea according to Gray.

In the dense tangle of forest growth which covers the Pocono plateau many of the larger wild animals still find a safe retreat, *Bears*, *Deer*, *Wild Cats*, and *Panthers*; the first three in considerable numbers; the last is now rarely seen.

Chapter IV.

The Geological Structure.

The geology of Pike county is as simple in form as that of the counties lying north of it; the strata being wholly of Devonian age and lying nearly horizontal.

The geology of nine tenths of Monroe county is precisely similar to that of Pike county. The remaining tenth along the southern border, is a narrow belt of Silurian strata rising (at a pretty high angle) to the surface from beneath the Devonian rocks, and somewhat folded.

The simplicity of the structure of Pike county is revealed by the cliffs along the Delaware river.

At the Wayne county line the *Catskill* strata lie horizontal. Lower down the river they rise gradually southward. Then the *Chemung* series take their place, rising southward at an angle of 5° to 8°. Then, in regular succession, and with increasing dip, appear from beneath the river the underlying formations:—the *Hamilton*—the *Upper Helderberg*—the *Oriskany* (No. VII)—the *Lower Helderberg* (No. VI)—the *Clinton* (No. V)—and finally the *Medina* and *Oneida* (No. IV) in the Shawangunk mountain of New Jersey; where the dip has increased to 30° and 40°.

Anticlinals and synclinal basins.

The horizontality of the stratification along the Delaware river is however not absolute; slight local rolls are observable.

The *Laxawaxen anticlinal*, crosses the river half way between the valleys Laxawaxen and Shohola.

The *Shohola basin* which corresponds to this roll crosses the river at Shohola.

The height of any given bed of rock on the top of the *Laxawaxen anticlinal* above its place at the bottom of the

Shohola synclinal is only 250 feet. Therefore it is not surprising that neither the Laxawaxen anticlinal nor the Shohola synclinal could be traced across the northern region of Pike county into the high plateau of Monroe; which may contain other such undulations unrecognizable for want of rock exposures along the shallow water-courses which traverse it.

Shallow as the basin of the *Shohola synclinal* is it was sufficient to determine the course of the Shohola creek.

At Port Jervis there may be a slight undulation in the Hamilton strata, but there are no visible outcrops; and a local flattening of the general dip would suffice to account for the breadth of belt underlaid by this formation.

The anticlinals and synclinals of MONROE county are of much greater importance.

The *Pocono anticlinal* is an undulation which traverses Delaware and Porter townships, about the region of Twelve Mile Pond and causes the set back (northward) of the mountain wall of the great plateau in Pine township. It is the cause of the great cove behind, or to the north of, the Pocono Knob.

In its eastern range it can hardly be called an anticlinal; for it amounts only to a flattening of the dip northward. Consequently it merely broadens the outcrop-belts of the Portage, Chemung, and lower Catskill measures.

But as it advances westward, it shows an exceedingly gentle south dip; thereby producing the exceedingly shallow and wide synclinal on the center line of which rises the Pocono Knob.

The next anticlinal, going south is that called by the geologists of the first survey the *Walpack anticlinal.*

The *Walpack anticlinal* forms that part of the Shawangunk mountain in New Jersey at the north foot of which flows Flatkill creek as far as Walpack bend, where the Flatkill enters the Delaware river. A mile or two further on down the river, the mountain ends, but the anticlinal runs on westward and crosses the river diagonally into the Walpack ridge, flattening and broadening the top of the ridge

and throwing the limestone rocks into the form of a trough and an arch, with three distinct outcrops instead of one.

The *Stroudsburg anticlinal*, a very sharp low roll which crosses Brodhead's creek, at the southern limit of the East Stroudsburg borough, is probably a continuation of the *Walpack anticlinal* westward. It passes through the middle of the plain south of Stroudsburg and crosses McMichael's creek twice within three miles; then passes on into the Hamilton shale country of Snydersville and Kellersville where, in the soft rocks hid beneath the Glacial Drift it cannot be further traced.

This anticlinal is well shown in the long railway cutting at East Stroudsburg, the rocks dipping 25° to 30° both ways; and, 100 feet north of the axis, they are overturned beyond the perpendicular.

Where it crosses McMichael's creek, 2 miles further west, it is finely exhibited in the high bluffs of Corniferous limestone capped by Cauda-galli grit, which border the creek to within five hundred yards of Kunkleville, where the anticlinal axis re-crosses the creek.

The synclinal trough south of this axis on Brodhead's creek (just above where the N. Y. S. & W. R. R. first crosses the creek above its mouth) is also excessively sharp; the beds here also being vertical and the lower layers overturned.

Another small anticlinal crosses Brodhead's creek, a mile and a half north of Stroudsburg, but it cannot be traced successfully eastward and westward. It elevates an arch of Corniferous limestone about 100′ above the creek.

The *Red Hill* or *Kimmererville anticlinal* elevates the northern ridge of the Shawangunk mountain, which the Delaware river first cuts through at the Water Gap. The arch of sand rock appears at the D. L. & W. R. R. station. Mountain run, west of the hotels, cuts through and exhibits the arch finely, the strata dipping about 30° both ways. As the anticlinal dies down, westward, the ridge also declines into Cherry Valley, and from behind it issues, in a curve, the South branch of Cherry run. The anticlinal axis passes under Kimmererville, where the Helderberg limestones and

Oriskany sandstones sweep over it southward towards the Wind Gap, causing Godfrey's ridge to encircle the head of Cherry Valley, in that direction.*

The Kimmererville anticlinal appears to die away against the east end of the great synclinal of southern Monroe and Carbon counties, to be described below; but, in a general structural sense we may consider that this anticlinal participates with that of Stroudsburg, in representing that great *Lehighton anticlinal* (of Carbon county) which produces so marked an effect upon the topography of southern Monroe.

The *Lehighton anticlinal* was traced by Professor Lesley in 1839 from within the Pottsville Coal basin, through the Sharp and Second Mountains (on the Little Schuylkill); down along Mahoning creek to Lehighton (on the Lehigh river); and up along Big creek and Head's creek (past Kregesville) to within a few miles of Stroudsburg,—a total distance of more than 40 miles, in an almost perfectly straight line N. 65½° E.

Along 20 miles of its course in Carbon county the Lehighton anticlinal throws the whole Devonian and Sub-carboniferous measures over, northward, and vertially downward to the depth of many thousand feet. From Lehighton to Mauch Chunk the north dipping outcrops along the Lehigh river are continuously vertical.

But ascending the valley of Big creek eastward, the north 90° dips of the Lehighton anticlinal become 80° and 70°; and after passing into Monroe county, only 40°; 30°; and 20°; until they are lost beneath the glacial drift west of Stroudsburg. But the Stroudsburg anticlinal is on the line of direct prolongation of the Lehighton anticlinal and may be considered therefore its theoretical continuation.

Wire ridge synclinal lies next south of the Leighton anticlinal, and contains a wide ridge or rather a plateau of three parallel ridges, about 400′ to 500′ higher than the valleys on each side of it. The eastern half of Wire ridge in Monroe county used to be called Chestnut ridge; its west-

*Minor rolls in the limestone outcrop of Godfrey's ridge (south and southwest of Stroudsburg) will be mentioned in the details of this report.

ern half in Carbon county was known as *Yellow Pine Ridge.* The long narrow plateau commences opposite the Wind Gap, and runs straight S. 60±W. through Hamilton, Ross and Eldred townships of Monroe county, and through Upper and Lower Towamensing and Franklin townships of Carbon county, to the Lehigh river below Weissport and Lehighton, where the synclinal structure is finely exhibited.

From the east the synclinal deepens westward in Ross township; and is deep enough in Eldred township to hold from 1500′ to 2000′ of the Catskill rocks.

The *Mauch Chunk synclinal* (or first anthracite coal basin) in Carbon county rises rapidly from the Lehigh river eastward. This creates the red shale Kettle, and the semi-circular end of Kettle mountain.

The Nesquihoning anticlinal.—The Cove behind Kettle mountain between it and the wall of the plateau, Pocono (Pohopoco) mountain, is made by the first great anticlinal of Nesquehoning mountain north of Mauch Chunk.

Both the Mauch Chunk synclinal and the Nesquehoning anticlinal north of it flatten as they approach Monroe county, and apparently flatten out entirely at the head of Big (Pohopoco) creek. Consequently the north dips of the Lehighton anticlinal, in Monroe county, gradually flatten northward, from 25° or 30° at the axis of the anticlinal (along Big creek) towards the Pocono mountain, in which the Catskill rocks show only north dips of 3° or 4°.

In the cuts of the Erie R. R. along the Delaware, the *Catskill beds* often dip slowly and regularly north-westward for long distances, then they suddenly pitch down to the south-west from all sides something like the end of a canoe. This may continue for 50′ or more at an angle of 30°–50°; then the rocks as suddenly become horizontal or resume the prevailing dip until another local disturbance of the same kind takes place.

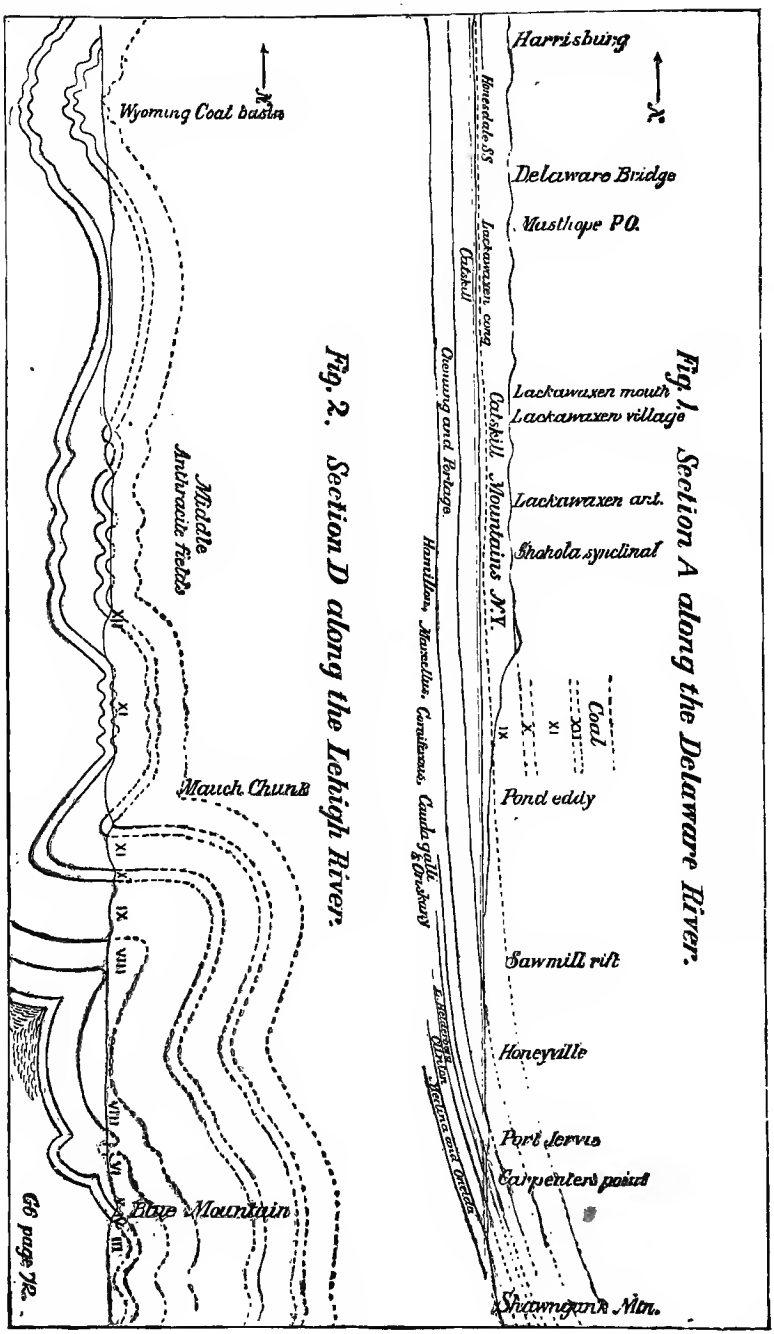


Fig. 1. Section A along the Delaware River.

Fig. 2. Section D along the Lehigh River.

Chapter V.

Four Cross Sections.

Section A.

Along the Delaware river, from Narrowsburg to the Shawngunk Mountain near Otisville, N. Y.

This section commences at top with the highest rocks capping the hills at the northern corner of Pike county. These rocks belong to the *Catskill* formation (No. IX of the First Survey.) From beneath them appear, successively, descending the Delaware river, the *Chemung*, [*Portage,*] *Genesee*, *Hamilton*, *Marcellus*, and *Corniferous* formations (No. VIII);—then the Cauda-galli and Oriskany (No. VII);—then the *Lower Helderberg* (No. VI);—then the *Clinton* (No. V); and finally the *Media* and *Oneida* (No. IV) which make the Shawngunk mountain slope and crest. The section reads as follows:—

1. *Honesdale sandstone group*, consisting of two massive pebbly strata, each 30′ thick, separated by 40′ of red sandy shale, ... 100′
2. *Montrose red shale;* 125′ of sandstone with little shale at top; 100′ of *red shale* below, ... 225′
3. Greenish-gray sandstones, ... 30′
4. *Lackawaxen conglomerate*, ... 50′
5. Greenish current bedded sandstone strata, each 20′ to 30′ thick, alternating with greenish gray shales, ... 300′
6. *Red shale*, ... 50′
7. *Delaware flags*, consisting of alternate beds of bluish-green and greenish gray sandstone strata, 20′ to 40′ thick, separated by greenish sandy shales; only one reddish bed (10′–15′ thick) being seen in the entire interval; the sandstones usually splitting into large smooth layers 3″ to 6″ thick, which are extensively quarried for flagging along the Delaware river and sold under the name of "Blue Stone"; the entire series probably represents the *New Milford sandstone group* of Susquehanna and Wayne counties; thickness . . . . . 1000′
8. *New Milford group*, . . . { red shales 20′ / green sandstone 40′ / red shale . . . . 15′ } . . . . 75′

9. Greenish gray sandstone down to the base of the Catskill formation, seen in the bed of the river ½ mile above the Erie R. R. bridge, and 4⅛ miles above Port Jervis Station (being 300 yds. above the 92nd N. Y. mile post,) thickness not far from . . . . . 600′

10. *Chemung rocks*, consisting of blue sandy shales, and *fossiliferous* sandstones; rising southward (10°) to a point opposite the 90th N. Y. mile post, where the bottom layers emerge from the river bed. (Calling the distance 2 miles, the dip 10°, and the fall of the river bed 22′,) . . . . . 1850′

11. *Genesee Shale*, a succession of bluish-black sandy shales; bed planes dipping 11° N. 25° W.; rude cleavage planes dipping 50° to 60° S. E.; nodules of *iron ore* seen near the middle of the bed; contain *Spirifer mucronatus*, *Athyris Spiriferoides*, and very abundant remains of *Tropidoleptus carinatus;* well exhibited along the eastern bank for nearly a quarter of a mile, opposite the 90th mile post, (Erie RR.) This, at 10°, would give . . . . . 200′

12. *Hamilton* proper, consisting of hard gray sandstones, of very fine grain, and often containing gray sandy shale so hard and compact as to be indistinguishable from sandstone;—always exhibiting a coarse cleavage to the south-east at a high angle;—breaking into oblong, irregular, splinter-like pieces, much used in repairing roads, and commonly called "slate gravel;"—exposed along the river, dipping N. 25° W. 10° to 15° for a mile and a half. This, at 10°, would give . . . 1375′

13. *Marcellus shales;* a dark bluish-gray shale, cleaving to the south-east, and dipping N. 25° W. 12° to 15°, as seen in the 100′ which is exposed in the foot of the bluff at Port Jervis. The rest of the formation is concealed by Drift. The *Corniferous Limestone* comes up from beneath it with a dip of 20°, one mile south from where the *Marcellus* is first seen emerging from the river. This distance, at an average dip of 15°, would give 1366′, which seems excessive. In the concealed interval the strata may be folded; therefore, say 800′

14. *Corniferous limestone;* seen rising out of the Delaware river on the N. Y. shore, 700 yards north from the 87th N. Y. mile post, and finely exposed all along the banks down to Carpenter's Point, at the mouth of the Neversink, (Tri-state Corner);—dip N. 25° W. 20°; distance at right angles to strike, about 750′; thickness not less than . . 250′

15. *Cauda-galli grit*, a very massive, hard, fine-grained sandstone, making a great bare outcrop along the Walpack ridge; width of belt, 250 yards; dip, 25°; thickness, 315′

16. *Oriskany sandstone;* a series of bluish and mud-colored limy shales, containing much chert and characteristic *Oriskany fossils;* dip N. 25° W. 25°; thickness down to the *Trilobite ledge*, ... 50′

17. *Lower Helderberg, No. VI.*

(*a*) *Trilobite bed* containing vast numbers of *Dalmanites dentatus*, and a species of *Chonetes*, ... 10′

(*b*) Shaly, calcareo-silicious, very fossiliferous beds, containing *Chonetes complanatus*, *Avicula textilis*, *Pentameras mutabilis* and *Eatonia singularis* in great numbers, . 140′

(*c*) Massive, cherty silicious limestone, quite fossiliferous, containing great numbers of *Pentameras galeatus*, *Strophomena Beckii*, and many other forms, ... 10′

(*d*) Shaly, silicious, limy beds, mostly concealed, ... 75′

(*e*) Massive silicious limestone, fossiliferous, ... 8′

(*f*) *Stromatopora limestone bed*, full of large corals, principally *Stromatopora*, some of which are 1′ in diameter, . . . 12′

(*g*) *Blue quarry limestone*, containing *Pentameras galeatus*, . 12′

(*h*) Blackish limestone, with concretionary nodules, ... 13′

(*i*) Shaly, curly limestone, ... 15

(*j*) *Water Lime*, ("Pethstone" of Prof. Cook,) . . . 5′

(*k*) Shaly limestone, dark bluish and concretionary at base, (lower 8′,) . . . . . 12′

(*l*) Shaly limestone, abounding in *corals*, ... 14′

(*m*) Gray, shaly limestone, containing multitudes of *Crinoidal fragments*, and *corals*, ... 15′

(*n*) Greenish shales, and shaly limestone, ... 10′

(*o*) Massive, bluish gray limestone, full of *Crinoids*, *Corals*, &c., *Chaetetes* being abundant, ... 10′

(*p*) Limy, gray shales, containing *Atrypa reticularis* and *Chaetetes*, ... 2′

(*q*) *Slaty limestone*, apparently non-fossiliferous and very much resembling in physical aspect the *Bossardville beds* at the base of No. VI in Monroe county, . . visible 3′

(*r*) Concealed to probable base of No. VI in the steep bluff at Wm. Nearpass's quarry on Mill Brook, in New Jersey, . 200′

18. *Clinton red shale* (No. V) entirely concealed under an old buried valley which is about 500 yards in width at right angles to the dip; thickness probably not less than . . 600′

19. *Medina sandstone*, a succession of greenish-gray, red and variegated sandstones, not well exposed at any point, but frequently seen along the Erie R. R. between the Neversink river and Otisville; probable thickness, 700′

20. *Oneida conglomerate*, gray, hard conglomerates coarsest toward the base, seen finely exposed along the cuts in the Erie R. R., one mile west from Otisville dipping 30° N. 25° W.; containing very large quartz pebbles, and toward the base, many fragments of *No. III, Black slate;* resting uncomformably upon No. III, as seen in the cut one mile west of Otisville, the latter dipping 42° to 47° along the line of contact; thickness, ... 750′

Sum of thicknesses, (mostly *estimated,*) . . . . . 9886′

Call No. 13, 1366′ . . . . . 10452′

Section B.

Along Broadhead's creek and the Delaware, Lackawanna and Western Railroad, from the northern line of Monroe county, southward, past Sprague ville, and Stroudsburg, to the Delaware Water Gap.

This section commences at the top with the basal beds of the *Pocono Sandstone formation* (No. X,) capping the highest points along the county line, 2000′ to 2050′ above tide; under which lies the whole *Catskill formation*, (No. IX,) constituting the great Pocono plateau and outcropping in the escarpment at the head of Broadhead creek. Beneath these all the formations mentioned in Section A appear successively along the course of the creek and in the cuttings of the railroad, until the Delaware Water Gap is reached, in which the Medina and Oneida rise in bold cliffs. The section reads as follows:

1.	*Mt. Pleasant conglomerate*, greyish white, sometimes with a reddish tinge; quartz pebbles, often angular,	50′
2.	*Mt. Pleasant red shale* seen along the Easton and Belmont Pike at an elevation of 2000′–2100′ A. T., consisting of blood red shales interstratified with greenish-gray sandstones, estimated thickness,	300′
3.	Interval which could not be measured with any approach to accuracy, for want of continuous exposures. Thickness estimated by the dip to be not less than	200′
4.	*Delaware flags*,	1200′
5.	*New Milford red shale*,	100′
6.	Greenish gray sandstone to base of *Catskill* formation, just below Sprague ville,	600′
7,	*Chemung beds*; gray and blue, hard *fossiliferous* sandstones; seen for about 210 rods dipping N. 20° W. 30°,	1750′
8.	*Genesee Shale*; a dark sandy shale,	200′
9.	*Hamilton sandstones*,	1200′
10.	*Marcellus shales*; { dark shales, 500′, gray shales, 300′, }	800′
11.	*Corniferous limestone*,	200′
12.	*Cauda-galli grit*,	250′
13.	*Oriskany sandstone*, a cherty, limy, quartz conglomerate,	50′
14.	LOWER HELDERBERG, No. VI.	
(*a*)	*Stormville shales*, limy, fossiliferous, ash colored, often cherty, with a massive cherty limestone at base 10′ thick,	160′
(*b*)	*Stormville conglomerate*, a calcareo-silicious, fossiliferous bed containing many quartz pebbles,	15′
(*c*)	*Stormville limestone*, cherty, sandy, massive beds, containing numerous fossils, *Pentameras galeatus* and *Stromatopora* being especially abundant in some portions,	75′

(*d*) *Water Lime*, ("Pethstone" of Prof. Cook,) . . . . . 5′
(*e*) Bluish, shaly limestone, (*Decker's Ferry*,) . . . . . 20′
(*f*) *Decker's Ferry Sandstone*, a pebbly, very fossiliferous, and often massive rock, ... 15′
(*g*) Greenish shales, (*Decker's Ferry*,) . . . . . 15′
(*h*) *Bossardville limestone*, the main quarry lime through Monroe county; almost entirely non-fossiliferous; upper portion consists mostly of bluish-black layers, with thin veins of calcite intersecting it in all directions, and usually about 65′ thick; then at base comes a grayish, slaty limestone often exhibiting a *columnar structure* as may be seen at the Experiment Mills quarry above the Water Gap station; thickness there 25′; total thickness of Bossardville limestone, ... 90′
(*i*) *Poxono Island Shale*, a series of buff, greenish, and variegated, limy shales, totally non-fossiliferous, and seen well exposed only opposite Poxono Island, on the Delaware river, and at one or two localities south-west from that; thickness, ... 200′
15. *Clinton red shale*, (No. V,) mostly concealed in a valley about 200 yards wide, at right angles to the strike, the dip of both the overlying and underlying beds being N. 25° W. 30°, which would give a thickness, provided there be no intermediate variations of dip, . . 900′
16. *Medina Sandstone*, a succession of greenish-gray and reddish sandstones, occasionally interstratified with *red sandy shales*, and containing a few quartz pebbles in some of the layers; seen well exposed along the Delaware river in the Water Gap, where two or three anticlinal rolls cross these measures, rendering it difficult to determine the thickness, but a rough estimate makes it . . . 700′
17. *Oneida Conglomerate*, a succession of grayish-white, massive, pebbly beds, increasing in coarseness towards the base and seen finely exposed at the Delaware Water Gap, dipping 30° to 45° N. 25° W., thickness,* . . . . . 800′

Sum of thicknesses, mostly estimated, ... 13,495′

Section C.

Through Brodheadsville; from the northern line of Monroe county, southward, to the crest of the Kittatinny (Blue) mountain.

The rocks of this section are the same as in Section B, commencing, at the top, with the bottom layers of the *Pocono* formation, No. X.

1. *Mt. Pleasant conglomerate*, not seen in place, but no doubt concealed beneath the surface, which is covered with loose blocks, ... say 50′

*The *Hudson river black slates*, (No. III,) are entirely concealed at its contact with the overlying *Oneida Conglomerate*.

2. *Mt. Pleasant red shales*, top of the Catskill series, not exposed at any locality, but undoubtedly forming the surface rock under the drift on the Pocono plateau southward almost to the Pocono mountain escarpment, ... about 350′
3. Shales and sandstones, ... 100′
4. Cherry Ridge Group, { *a*. Conglomerate, ... 30′ / *b*. Shale, ... 20′ / *c*. Conglomerate, . . . 25′ / *d*. Red shale and sandstone, 500′ } . 575′

The upper, or conglomerate portion of this group crests the southern front of the Pocono mountain escarpment from the west branch of Brodhead creek westward to the Carbon county line, the uppermost member being remarkably coarse, containing quartz pebbles 2″ to 3″ in diameter, together with many pieces of shale, sandstone, &c., all cemented by a coarse reddish matrix, the whole making a very massive cliff, which is almost perfectly paralleled in every respect by the conglomerate below.*

5. *Honesdale Sandstone Group*, ... 500′
6. *Montrose red shale*, ... 1500′
7. *Delaware flags*, ... 1200′
8. *New Milford red shales*, ... 500′
9. Greenish-gray sandstones, base of *Catskill series*, ... 600′
10. *Chemung beds*, ... 1600′
11. *Hamilton*, { *c*. *Genesee shale*, 200′ / *b*. *Hamilton flags*, 1100′ / *a*. *Marcellus shale*, 700′ } . . . . . 2000′
12. *Corniferous limestone*, absent.
13. *Cauda-galli grit*, absent.
14. *Oriskany*, ... 200′
15. *Lower Helderberg*, all concealed by great heaps of the Oriskany sandstone débris in the southern face of the Walpack ridge, except the quarry portion of the *Bossardville limestone*, of which 40′ is visible at some localities; the whole thickness of the series cannot be (from the space it covers between the *Oriskany sandstone* above and the *Red shales of No. V* below) much greater than . . . . . 450′
16. *Clinton red shales* (*No. V*,) mostly concealed in the valley of Aquanchicola creek, but from the breadth of its outcrop (800 yards) and dip N. 25° W. 30°, the thickness cannot be much less than . . . . . 1200′
17. *Medina sandstone*, ... probably 700′
18. *Oneida Conglomerate*, ... about 800′

Sum of thicknesses, mostly estimated, ... 12,325′

[*The *Cherry Ridge conglomerates* were considered by the First Survey as the base of No. X. Hence I named the whole of No. X the *Pocono formation*, because the entire crest of the escarpment, and the face of the plateau behind it, are made by these rocks. W. White prefers to carry the top of the *Catskill formation* 500 feet higher up the column.—J. P. L.]

Section D.

Along the Lehigh river, in Carbon county, from Mauch Chunk to the Lehigh Water Gap.

As this section is only intended to serve for comparison with A, B & C., it commences, on top, with the top layers of the *Pocono* formation (No. X,) which here stand vertical, instead of horizontally spreading over the Pocono plateau in Monroe county. The Mauch Chunk red shale, Pottsville conglomerate and overlying Coal measures are omitted.

The measurement of the vertical beds of No. X, IX, and VIII along the Lehigh river, is comparatively easy, and the thicknesses given in the text below are therefore more reliable than those of sections A, B, & C. But until an instrumental geological survey of the gaps of the Lehigh at Mauch Chunk has been made, the *exact* thickness will not be known.

Pocono Series, No. X.

1. Conglomerate, very massive, grayish-white large pebbles,	50′	750′
2. Greenish-gray, sandy shales,	50′	
3. Conglomerate, dark gray, with coaly streaks, large pebbles,	50′	
4. Buffish-gray, sandy shales,	120′	
5. Dark buffish sandstones with some shales,	430′	
6. *Mt. Pleasant conglomerate*, base of *Pocono*,	50′	

Catskill, (No. IX.)

7. *Mt. Pleasant red shale,*	red shale,	40′	500′
	red sandstone,	40′	
	red and green shales,	60′	
	red conglomerate,	10′	
	red shale,	250′	
	red shale and sandstone,	100′	
8. Sandstones and shales, reddish,			200′
9. *Cherry Ridge conglomerate,*	conglomerate,	40′	200′
	greenish sandstones,	110′	
	conglomerate,	50′	
10. Concealed,			200′
11. Gray pebbly conglomerate,			60′
12. Greenish flaggy sandstones,			350′
13. Grayish sandstones with two or three layers of red,			175′
14. *Calcareous breccia,*			2′
15. Massive, gray sandstone, interstratified with a few thin red beds,			120′

16. *Red sandy shales*, ... 30′
17. Very massive, greenish-gray sandstone, ... 120′
18. *Red sandy shale*, ... 60′
19. Massive, greenish-gray sandstone beds with some pebbles, 165′
20. *Calcareous breccia*, ... 8′
21. Greenish-gray sandstone, ... 180′
22. *Calcareous breccia*, ... 2′
23. Greenish gray sandstone, ... 60′
24. Variegated (green and red) beds, ... 60′
25. *Red sandy shale*, ... 30′
26. *Calcareous breccia*, 2′
27. Massive, reddish-gray sandstones, containing some quartz pebbles, ... 60′
28. *Red shales and sandstone*, ... 120
29. Gray sandstones with very little red, ... 150′
30. Red, and grayish-green sandstones, ... 150′
31. *Montrose red shale*, only a few thin streaks of gray in the whole interval, 2000′
32. *Delaware flags*, no red beds whatever, ... 1200′
33. A succession of gray sandstones, interstratified with *red shales* and *sandstones*, the *red beds* largely predominating, . . . 700′
34. Greenish-gray flaggy sandstone in which occurs occasional *red beds*, the lowest of the latter being 120′ above the base of the series, thickness . . . . . about 600′

Chemung, (*No. VIII.*)

35. A succession of bluish-gray and olive sandstones with some shale, sparingly fossiliferous, ... 1200′

Hamilton, (*No. VIII.*)

36. *Genesee shale*, a dark fissile shale, ... 200′
37. *Hamilton*, gray, sandy shales, fossiliferous, ... 760′
38. *Marcellus shales*, mostly dark, ... 800′

Oriskany, (*No. VII.*)

39. *Oriskany sandstone*, a very coarse, reddish-brown sandstone, containing many quartz pebbles, and dipping N. 25° W. 55°, making a bold bluff one mile below Bowman's, known as Stony Ridge; no fossils seen in it, thickness about, . . 200′
40. *Oriskany shale.* Cherty calcareous sandstone, containing casts of fossils too indistinct for identification, 10′
41. Shales containing some cherty layers, together with some thin beds of sandstone, ... 60′ } 140′
42. Concealed, ... 20′
43. Shales with thin layers of reddish sandstone, ... 50′

Lower Helderberg, (*No. VI.*)

44. Greenish shales, and limy sandstone, . . . 30′
45. *Bossardville limestone*, slaty fracture, black, and filled with streaks of calcite, . 40′
46. *Poxono Island shales*, consisting of buffish-gray, and greenish-gray, limy shales, variegated with red near the base, ... 225′ } 295′

Clinton, (No. V.)

47. A succession of red shales strongly folded and not well exposed, thickness estimated by Prof. Lesley (in 1839) at . . 2000′

Medina, (No. IV.)

48. A succession of greenish-gray, and reddish sandstones, occasionally interstratified with red sandy shales, probably about (estimated) . . . . . 750′

Oneida, (No. IV.)

49. Massive beds of gray quartz conglomerate, quite hard, the layers 1–5′ thick, increasing in coarseness toward the base, many chips of *No. III Black slate* being seen in the lower half; dipping N. 25° W. 30°; resting *unconformably* * on the underlying *No. III Black slate*, which dips 45° in the same direction only a few feet from the point of contact; thickness, roughly measured, ... 750′

Sum of thicknesses, ... 15,349′

Comparison of the Four Sections.

Formations.		*D. Mauch Chunk.*	*C. Brod-head sville.*	*B. Strouds-burg.*	*A. Port Jervis.*
Pocono, X,		750	750	750	750
Catskill, IX,		7,544	5,325	4,200	3,430
Chemung,	VIII,	1,200	1,600	1,750	1,850
Genesee,		200	200	200	200
Hamilton,		760	1,100	1,200	1,375
Marcellus,		800	700	800	800
Corniferous,		*absent*	*absent*	200	250
Cauda-galli,		*absent*	*absent*	250	315
Oriskany, VII,†		340	200	50	50
Lower Helderberg, VI,		295	450	585	566
Clinton, V,		2,000	1,200	900	600
Media,	IV,	750	700	700	700
Oneida,		750	800	800	800
		15,389	12,975	12,385	11,686
No. VIII, as a whole,		2,960	3,600	4,400	4,790
Gen. Ham. and Marcellus,		1,760	2,000	2,200	2,375

[* The unconformity is merely apparent. We have here, as at the Schuylkill Water Gap and elsewhere along the south slope of the Kittatinny mountain, a *local fault*, produced by the rigidity of the great sandstone mass above, and the feeble tenacity of the slate mass below. See the demonstration in Mr. H. M. Chance's map and section of the Schuylkill Gap at Port Clinton in Schuylkill county.—J. P. L]

[† The Upper Silurian of Murchison. But geologists differ as to the place of No. VII. Some make it the base of the Devonian.—J. P. L.]

Devonian, IX, VIII, ...	10,504	8,875	8,600	8,220
Silurian, VII, VI, V, IV,*	4,135	3,350	3,035	2,716
Devonian and Silurian, ...	14,639	12,225	11,635	10,936

Notes on the above table.

The reader must remember that great difficulties stand in the way of the *exact* measurement of the thickness of strata which are nearly but not quite horizontal, and when the gentle dip is subject to slight but frequent variations; or when the general dip, always in one direction increases as the observer advances along his line of section.

If the observer could be sure that his rocks are dipping precisely 5° neither more nor less, for a mile,—or if he could rely upon the correctness of an *average* dip of 5° for a mile, —he could then state positively that the thickness was exactly (5280′ × the log. of the tang. of 5° =) 462′.

But if he should mistake a dip of 4° for 5°, his calculation would be nearly a hundred feet in excess; and if the real dip were 6°, then his calculation would fall nearly a hundred feet short.

This consideration affects the value of the alleged thicknesses of the upper 8000′ of sections A, B, and C; therefore caution must be observed in drawing the conclusion that the *Devonian system*, in whole or in part, *diminishes in thickness eastward* between the Lehigh and the Delaware rivers, in Monroe and Pike counties.

In section D, the rocks stand vertical for several miles along the Lehigh river between Lehighton and Mauch Chunk, and can therefore be measured without the same risk of error. The sum total of section D, is nearly 25 per-cent greater than that of section A.

The *Catskill* appears to be nearly twice as thick on the Lehigh as on the Delaware. So great a difference can hardly be explained away by any supposable errors of measurement in detail along the Delaware.

There can be no mistake about the great thickness of the *Catskill* formation on the Lehigh; for all the beds (except

* In the first survey of Pennsylvania, No. VII included the Cauda-galli grit with the Oriskany.

Nos. 33 and 34) are beautifully exposed along the railroad (N. J. Central,) and standing vertical can be easily measured. Nos. 33 and 34 are also well exposed where they come up on a rather steep north dip, 2½ miles below Lehighton, or 1 mile above Bowman's.

The *Chemung* was easily measured on the Lehigh, along the N. J. C. R. R. beginning at the 38th mile post.

The *Hamilton* was measured on the west bank of the Lehigh along the Lehigh Valley railroad opposite Bowman's.

The *Oriskany* and *Lower Helderberg* were measured on the railroad track about a mile below Bowman's.

To bring the columns A, B, C and D into comparison it was necessary to restore to A, B and C the full thickness of *Pocono* (No. X) found in D, viz, 750′.

To complete the column A, which only goes up to the *Honesdale sandstone*, it was necessary to add the 1000±feet of eroded Catskill rocks *above the Honesdale sandstone* up to the base of the *Pocono sandstone* (No X). The measurements in Wayne county show that this 1000′ cannot be far wrong; certainly the error will not exceed one or two hundred feet.

[In 1874, I directed Mr. H. M. Chance to make contour-line maps of the Delaware, Lehigh, and Schuylkill Water Gaps, by which the alleged non-conformability of *Oneida Conglomerate* (No. IV) on *Hudson river slate* (No. III) was resolved into a mere fault or slip structure. At the same time very exact measurements of the Silurian formations (*Oriskany*, *Lower Helderberg*, *Clinton*, *Medina and Oneida*) were obtained.

These measurements I append here to Mr. White's report, as *instrumental* corrections of his estimates of the thicknesses at the base of his sections B and D.

Instrumental Section at the Delaware Water Gap.

V. *Clinton*	No exposures in the valley of Cherry Run for	740′	
	upper red shale,	155	1685′
	varigated shales and ore sandstone,	450	
	lower red shales,	740	
	lower olive shales,	340	

IV.	*Medina*	upper sandstone,	200	1040′
		upper shales and sandstone,	530	
		white conglomerate,	200	
		lower shales and sandstone,	110	
	Oneida	gray sandstone,	75	525′
		shales and sandstone,	240	
		white conglomerate,	210	
				3250
III.	*Hudson river*	slates,	2600	
		" and *Utica* slates,	1300′±	

Instrumental Section along the Lehigh River.

Chemung red sandstone, not measured.			
Portage flaggy sandstone and calcareous shales,			320
Hamilton flags and shales,		more than	1350
Marcellus slates and shales,		more than	1200
Upper Helderberg,	*Corniferous* chert,	5	
	Corniferous cement beds,	20	
	Paint ore, 1′ 8″, say	2	37
	Clay,	5	
Oriskany sandstone,		150	525
Oriskany shales, with iron ore,		375	
Limestone,		?	
Water-lime shales,		70	225+
Onondaga shales,		more than 155	
			787′+

Instrumental Section at Lehigh Water Gap.

Clinton	Top concealed in the Aquanchicola Valley.		
	upper red shale,	650+	1275+
	variegated shale,	90	
	upper olive calc. shale,	120	
	ore sandstone, (Fourth rib,)	125	
	lower red and olive shale,	290	
Medina	upper sandstone, (Third rib,)	85	665
	upper shale,	180	
	gray sandstone, (Second rib,)	70	
	lower shale,	330	
Oneida	conglomerate sandstone,	290	460
	conglomerate, (First rib,)	170	
			2400+

Instrumental Section at Schuylkill Water Gap.

Clinton,	Top eroded in the synclinal.		
	Upper red shale,	750	
	" " " and sandstone,	630	
	Upper olive shale,	680	2606
	Ore sandstone,	96	
	Lower olive shale,	450	
Medina,	Upper sandstone, (Third rib,)	90	
	Upper ferruginous shales,	480	
	White sandstone, (Second rib,)	60	1030
	Lower ferruginous shales,	600	
Oneida,	White conglomerate, (First rib,)		200

Comparison of the three Sections.

(*Mr. Chance's Measurements.*)

	Schuylkill W. G.	*Lehigh W. G.*	*Delaware W. G.*
Clinton,	(visible,) 2606′	(visible,) 1275′	(visible,) 1685
Medina,	1030′	665′	1040′
Oneida,	200′	460′	525′
	1230	1125	1565

Professor Cook's Estimates.

Corniferous limestone,	(according to dip,)	500′ to 800′
Cauda-galli grit,	(" ")	400
Lower Helderberg,		
Clinton,		
Medina,	(") at Erie RR., 800′. (") at Walpack bend,	1800′
Oneida,	(")	800′ to 900′

Measurements given by Prof. H. D. Rogers, in Geology of Penn'a, 1858, Vol. 1, pp. 125 to 142.

XIII.	Coal measures,	Coal measures,	*Lehigh river.*	
XII	Seral,	Pottsville conglomerate,	(estimated,)	950
XI.	Umbral,	Mauch Chunk red shale,	"	3000
X.	Vespertine,	Pocono sandstone,	"	1300
IX.	Ponent,	Catskill red rocks,	"	5000
VIII.	Vergent, Shales, Flags,	Chemung, Portage,	"	1750
	Cadent, U. black slate,	Genesee,	"	250
	Cadent, Shales,	Hamilton,	Unknown thickness.	
	Cadent, L. black slate,	Marcellus,		Thin.
VII.	Meridian, Sandstone,	Oriskany,	(estimated,)	90
	Meridian, Slate,		Varies between 0′ and 100	
VI.	Premeridian limestone, Scalent limestone,	Lower Helderberg,	Unknown thickness.	

V. Surgent,	Marl,	Clinton,	975	(estimated,)	1475
	U. Shale,		120		
	Ore SS.,		110		
	L. Shale,				
	U. Slate,		166		
	Iron SS.,		4		
	L. Slate,		100		
IV. Levant,	White SS.,	Medina,		(estimated,)	760
	Red SS.,				absent.
	Gray SS.,	Oneida,		"	400

From top of Pottsville to bottom of Oneida, ... 15,480

From top of Pocono to bottom of Oneida, ... 11,530

[The measurements given above are of mixed values, partly historical, partly practical.—J. P. L.]

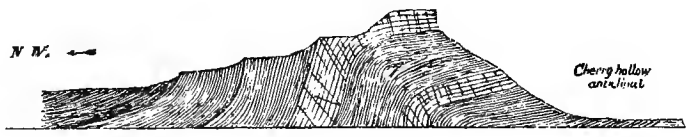


Fig. 3 Godfrey's Ridge, S.W. of Stroudsburg.

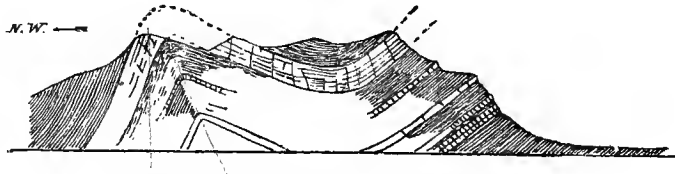


Fig. 4. Godfrey's Ridge, S.W of Stroudsburg.

Chapter VI.

Description of the Geological Formations.

No. XIII. The Coal Measures.

[In reply to a question frequently asked: Why have coal beds never been opened in Pike or Monroe county? it is only necessary to refer to the plain fact that the *Anthracite Coal Measures*, which once spread over the whole country between the Lehigh and Delaware rivers, have been swept away from it by the slow but constant operation of frost and rain water through the long ages represented by the Trias, Lias, Cretaceous and Tertiary systems.

The removal of the whole Coal Measures from all Middle Pennsylvania (including Pike and Monroe counties) south and east of the Allegheny Mountains is one of the most certain of geological facts.

In this case, as in so many others, there are exceptions to prove the rule.

The exceptions are, 1, the isolated remnant of the Coal Area left in Huntingdon and Bedford counties called the Broad Top coal field; 2, the isolated coal field of Pottsville and Mauch Chunk called the First Anthracite coal field; 3, the isolated little basins on Broad Mountain; 4, the isolated basin of Shamokin and Mahanoy; 5, the isolated basins of Beaver Meadow, Hazelton, Eckley &c; 6, the great isolated basin of Wilkes-Barre and Scranton; and 7, the small patches of lower coal measures left on the great plateau of the North or Allegheny mountain, in Sullivan, Lycoming and Tioga counties.

All these (except No. 7,) are remnants of the universal outspread of Coal Measures which have been preserved by the greater depth of the basins or synclinals beneath the general level; as is plainly to be seen by the steepness with which the coal beds pitch into and rise out of the basins:

and by the depth to which mining slopes and shafts have been sunk.

At the eastern ends of the Mauch Chunk, Beaver Meadow, Hazleton and Eckley or Council ridge basins, west of the Lehigh, the lowest coal beds are seen spooning up into the air. The place they once occupied is now high in the air over all the country east of the Lehigh river. The lowest coal bed lay formerly at least 3000 feet in the air above the highest points of the great Pocono plateau in Monroe county. This calculation is an easy one. It is made by observing at Mauch Chunk what rocks underlie the lowest coal beds, and what is their thickness.

No. XII. The Pottsville Conglomerate.

Underneath the coal beds lie the 1000 feet of sandstone and conglomerate rocks in Sharp or Mauch Chunk mountain. All this has been eroded from the country east of the Lehigh river; together with the coal measures over it.

No. XI. The Mauch Chunk red shale.

Underneath the Conglomerate at Mauch Chunk lie 3000 feet of the red shale, which fills the Kettle, Room run, Quakake, Conyngham, Catawissa and Locust valleys west of the Lehigh. Some of this formation still remains in Synclinals heading up east of the Lehigh in Carbon county. Formerly it was supposed that patches or belts of it remained on the top surface of the Pocono plateau in Monroe county; but it is now pretty certain that it has all been removed, and that the red shale seen in may places belongs to the Catskill formation.

Therefore it is evident that in the prolongation of the line through Pottsville, Tamaqua and Mauch Chunk, eastward to Pocono Knob, near Stroudsburg, the lowest coal bed (which is about 1350 feet above tide at Mauch Chunk) must be sought for, not beneath the summit of the Pocono

mountain (2000′ above tide,) but *more than 7000 feet in the air above the summit of the mountain.*

The citizens of Monroe county should try to realize the fact, that *Pocono Mountain was formerly 10000 feet high* above the present level of the sea.

The uppermost 3000′ of this 9000′ consisted of *Coal Measures*; the next 1000′ consisted of *Pottsville Conglomerate*; the next 3000′ consisted of *Mauch Chunk red shale*; the next 1200′ consisting of the *Pocono formation* (with the *Mt. Pleasant shales* of the *Catskill formation*) resting upon the *Cherry Ridge conglomerate* which now forms the crest of the mountain, all above it (7000′ of strata) having been gradually entirely washed away into the Atlantic ocean.

But even the whole of the *Pocono formation* has not been spared; its upper and middle layers have also disappeared and only the lower strata remain to constitute the higher parts of the plateau.]*

No. X. The Pocono Series.

The Pocono rocks make but a feeble showing in this district, since only the lowest member of the series comes into the tops of the knobs on the Pocono plateau, viz: the

Mount Pleasant Conglomerate.

In the Wayne and Susquehanna Report (G⁵) this stratum was referred to a *transition series* (between the *Pocono* and *Catskill,*) of which it was the base, owing to some doubt which it belonged to.

The work of the present year in Pike and Monroe, connected with a section that I made along the Lehigh river in Carbon, removed my doubt concerning the true horizon of this bed being the *basal member of the Pocono formation.*

The Mt. Pleasant conglomerate does not occur in Pike county, unless the great pebble bed which caps High Knob,

[* The foregoing paragraphs I have thought it desirable to prefix to Prof White's descriptions of the formations which now follow.—J. P. L.]

and is seen at two or three localities along the Pike-Monroe line, at the head of Brodhead creek, should prove to be its representative.

On the road which leads from Canadensis up Brodhead creek northward into Pike county, a very white pebbly stratum occurs on the summit of the Pocono mountain 1950′ A. T. It is 20′ thick, with massive gray pebbly beds immediately below, and seems to represent the *Mt. Pleasant conglomerate.*

In Monroe county this massive member of the series is frequently seen capping the summit of lofty knobs near the northern line of the county. One of these occurs just east of the D. L. & W. R. R. one half mile south from the Wayne county line, in Coolbaugh, where a grayish-white conglomerate makes a long, bold cliff, 40′–50′ high, extending to an elevation of 2050′ A. T. at top.

The same rock also occurs on the Easton and Bellmont Pike, one half mile north from C. S. Baylis', at an elevation of 2050′ A. T.

It also seems to be present in the hills along the Lehigh river, where that stream borders the western line of Coolbaugh, for a great many white bowlders occur there which could have come from no other horizon.

It is also possible that isolated patches of this rock may occur on the Pocono plateau, in Tobyhanna and Tunkhannock townships.

For the character of the *Pocono series* just west from this area, the reader is referred to the general section along the Lehigh river given in section Fig. 4, where it has a thickness of only 750′, while the Catskill below has just ten times that. It is possible that previous observers have made the *Pocono* thicker than it should by extending it down to the base of the *Cherry Ridge conglomerate.* If If this were done in the Lehigh river section, it would make the *Pocono* 1650′ thick, and at the same time reduce the Catskill to 6600′, a result not much larger than is found in some other portions of the State, but the great *red shale* under the *Mt. Pleasant conglomerate* makes such an interpretation inadmissible.

NOTE.—From the small thickness of the *Pocono* in Sect. D, it becomes very probable that *No. XI*, as given in the Wayne and Susquehanna county section G⁵, page 55, should be extended down 240′ further, as suggested in foot note to page 46. This makes the *Mauch Chunk beds* 410′ thick instead of 170′ and the Pocono 800′ instead of 1040′; for the great *125′ yellow sandstone* in the Wayne and Susquehanna section seems to represent the massive *Conglomerate horizon*, 150′ thick, immediately below the *No. XI, red beds* at Mauch Chunk.

No. IX. The Catskill Series.

In describing the rocks of this series found in Wayne and Susquehanna counties, I stated in G⁵ page 71, that the thickness (1530′) of these beds measured along the northern portions of those counties would very probably not represent their thickness under the southern portion of Wayne. This inference has been amply bourne out by the facts, since the general section of eastern Pike (which abuts against southern Wayne) given on a preceding page, shows a thickness of 3430′, or more than double that found in northern Wayne.

Does this immense thicknening take place gradually or rapidly? Very fortunately a deep boring has been made by the Wayne county Oil Co., 25 miles south from the northern outcrop at the State line.

This well was put down on Dyeberry creek about six miles north from Honesdale. At my request a very careful and accurate record was kept of each bed passed through, by washing and bottling samples of each. For this faithful record the Survey is indebted to the courtesy of the Secretary and Treasurer of the company Mr. Edward Torrey of Honesdale. The well begins at about 1050′ A. T. and at 200′ below the base of the *Honesdale sandstone group*, or say 1000′ above the top of the *Catskill beds* of Wayne county.

The record, as preserved in the office of the company in Honesdale, reads as follows:

Dyeberry creek well.

Conductor hole, through drift,	36	to	36
Red shales and gray sandstone,	29	to	65
Reddish sandstone,	10	to	75
Red sandy shale,	5	to	80
Sandstone, greenish-gray, with quartz pebbles,	5	to	85
Sandstone, reddish-gray,	15	to	100
Red sandy shale,	10	to	110
Sandstone, greenish-gray,	26	to	136
" " some pebbles,	4	to	140
" brownish-gray, fine,	3	to	143
" greenish-gray, coarse,	4	to	147
" gray, pebbly,	5	to	152
" greenish-gray,	8	to	160
" grayish-brown,	5	to	165
Shale, greenish, sandy,	8	to	173
Sandstone, gray, with reddish tinge,	5	to	178
" gray,	5	to	183
Shale, sandy, micaceous,	7	to	190
Sandstone, dark gray,	4	to	194
Shale, gray, quite sandy,	6	to	200
Shale, dark red,	15	to	215
Slate, bluish-green,	40	to	255
Sandstone, greenish-gray,	175	to	430
" shaly, brown,	30	to	460
" fine, greenish-gray,	20	to	480
Shale, greenish, sandy,	35	to	515
" gray, sandy,	15	to	530
Sandstone, greenish-gray, small pebbles,	30	to	560
Sandstone, dark gray,	5	to	565
Sandstone, dark red,	35	to	600
Shale, light red,	10	to	610
Shale, dark, sandy,	20	to	630
Sandstone, greenish-gray,	10	to	640
Shale, red,	45	to	685
Sandstone, greenish-gray,	30	to	715
Shale, light gray, sandy,	5	to	720
Sandstone, dark gray, shaly,	20	to	740
" light gray,	20	to	760
" fine, gray,	10	to	770
Shale, red, (fresh water cased off at 778',)	30	to	800
Sandstone, reddish-gray,	25	to	825
Shale, dark red, sandy,	10	to	835
Shale, gray, sandy,	30	to	865
Sandstone, greenish-gray,	10	to	875
Shale, red,	5	to	880
Sandstone, hard, greenish-gray,	20	to	900
" greenish-gray, micaceous,	30	to	930
Shale, bluish, sandy,	95	to	1025
Sandstone, gray,	50	to	1075
" greenish-gray, small pebbles,	25	to	1100

Sandstone, greenish-gray, pebbly,	20	to	1120
" gray, (weak vein of salt water at 1140′,)	20	to	1140
" shaly, gray,	10	to	1150
" greenish-gray,	15	to	1165
Shale, green, sandy,	25	to	1190
Sandstone, greenish-gray,	5	to	1195
" hard, gray,	10	to	1205
Sandstone, coarse, greenish-gray,	5	to	1210
" gray, small pebbles,	10	to	1220
Shale, red,	15	to	1235
Sandstone, coarse, (strong vein of salt water at 1240′ which filled the hole to 100′ from top,)	15	to	1250
Sandstone, greenish-gray, fine,	5	to	1255
Shale, red, sandy,	10	to	1265
Sandstone, coarse, greenish-gray,	17	to	1282
" yellowish-brown,	13	to	1295
Shale, dark red, sandy,	30	to	1325
Sandstone, gray, small pebbles,	5	to	1330
" fine-grained,	10	to	1340
" greenish,	5	to	1345
" greenish-brown,	10	to	1355
Shale, dark-gray, sandy,	5	to	1360
Sandstone, shaly, micaceous,	35	to	1395
Shale, reddish, sandy,	5	to	1400
Shale, red,	36	to	1436
Sandstone, shaly, red,	5	to	1441
Shale, dark red, sandy,	5	to	1446
Shale, red, dark,	5	to	1451
Sandstone, grayish-green, micaceous,	14	to	1465
Shale red, sandy,	20	to	1485
*Shale, dark red,**	20	to	1505

The sub-divisions of the *Catskill rocks* established in Wayne and Susquehanna counties as published in G⁶, page 59, seem to hold good in a general way through Pike and Monroe, though of course such an enormous thickening up of these measures is accompanied by corresponding changes in the character of the beds.

For the sake of ready comparison, the Wayne and Susquehanna section is here introduced together with the summary of the Catskill beds from the general sections, A, B, C, D, of the preceding pages, to which the reader is referred for details.

Section W is the Wayne and Susquehanna section.

" A, that from eastern Pike.

[*The continuation not being received when the book went to press is referred to the appendix.—J P. L.

Section B, that through Spragueville.
" C, that through Brodheadville.
" D, that along the Lehigh below Mauch Chunk.

	W.	A.	B.	C.	D.
Mt. Pleasant red shale, . . .	150′	Interval to top of Honesdale SS. estimated at 1000′.	Interval from top of Catskill to base of Montrose red shale, estimated at 2500′.	350′	500′
Elk Mountain sandstones, .	150′			100′	200′
Cherry Ridge, Conglomerates,	60′			75′	200′
Cherry Ridge, Red shale,	110′			500′	1,157′
Honesdale Sandstone Group,	90′	100′		500′	987′
Montrose red shale, . .	180′	225′		1,500′	2,000′
Delaware river flags, (New Milford & Paupack SS. of G⁵,)	585′	1,430′	1,200′	1,200′	1,200′
New Milford red shale, . .	100′	75′	100′	500′	700′
Starrucca shales and sandstones, ...	105′	600′	600′	600′	600′
Totals, ...	1,530′	3,430′	4,200′	5,325′	7,544′

The substantial identity of the *Mt. Pleasant red shale Cherry Ridge Conglomerate, Montrose red shales, Delaware river flags, New Milford red shale* and *Starrucca beds* in each of these sections may be regarded as very highly probable, but the beds on the Lehigh river included above under the head of *Cherry Ridge red shale* (1157′) and *Honsdale sandstone group* (987′) have become so thickened and changed in character (as may be seen by consulting the detailed section D) that their identification, except in the most general way with these beds in Wayne county, would be wholly problematical.

Mt. Pleasant red shale.

This topmost member of the *Catskill beds* seems to overshoot the most elevated summits of Pike county, unless the great pebble rock which crowns High Knob, should turn out to be the *Mt. Pleasant conglomerate*, and in that event the *red shale* would be represented under the same by 300′–400′ of massive sandstone interstratified with which only

50′–75′ of *red shale* occur, (see below). In Monroe county, it covers much of the broad Pocono plateau between the southern margin of the same and the northern line of the county. It occurs along the Easton and Belmont Pike in Coolbaugh township, one half mile south from Dowling's Hotel's, at an elevation of 2150 A. T., scored and polished by Glacial action. A well was dug into it at Dowling's, and the red rock brought up was so heavy that some supposed it a valuable *Iron ore*, but it contains only about 20 per cent. of iron at that locality.

At the western line of Monroe, I have estimated these beds to be 350′ thick, but the only basis for this estimate is the measured thickness of these rocks, 15 miles further west, as given in section D along the Lehigh.

On the Lehigh river, this member is 500′ thick and is well exposed along the Central R. R. of New Jersey just below Mauch Chunk station.

Elk Mountain sandstones and shales.

Below the last member there comes a series of green sandstones and shales of uncertain thickness in Pike and Monroe counties, since they are always found on the Drift covered summit of the Pocono plateau where everything is usually concealed. They belong at the horizon of the *Elk mountain sandstones* of Wayne and Susquehanna (G⁵ page 59) and possibly do not exceed 200′ in thickness, since that is their measured thickness on the Lehigh below Mauch Chunk.

The Cherry Ridge Group.

Under this heading in G⁵, I described a *conglomerate* a *sandstone*, a *limestone*, and a *red shale*, all of which are prominent features in the geology of Wayne and Susquehanna counties. As might be expected the character of the group changes decidedly when traced southward into Pike and Monroe, as may be seen from the following section, (11,) taken in the high Pocono escarpment, two miles northwest from Tannersville, in Monroe county:

Cherry Ridge,	*upper conglomerate*, . .	30′	
	shale, ...	20′	
	lower conglomerate . . .	25′	. . . . . 325′
	red sandy shale, visible, .	250′	

The upper conglomerate is a very massive bed, consisting largely of *quartz pebbles* ¼″–2½″ in diameter, *pieces of sandstone*, *shale*, and *fish fragments*, all cemented into a reddish gray matrix of coarse sand.

The lower conglomerate is almost a duplicate of the upper in every respect, except that the quartz's pebbles are not quite so large nor numerous, and its lowest portion contains more *fish remains* than the former, being also slightly *calcareous* and separating into large angular blocks 5′–6′ on a side and as many thick, very much like the *Cherry Ridge limestone* or *calcareous breccia*, at this same horizon in Wayne and Susquehanna counties. In fact this whole deposit represents both the *sandstone* and *limestone* of those counties the former having become a true conglomerate and the latter having lost practically all of its lime and become merged with the former, so as to be indistinguishable from it, just as the *limestone* and *sandstone* were often so associated in Wayne (see G⁶ page 65).

This conglomerate and the *upper one* make the front escarpment of the Pocono mountain west from Tannersville, and crop out in long lines of cliffs high up near the crest of the same range around the south-eastern portion of Tunkhannock and Coolbaugh townships passing into Pike through the northern portion of Barrett and very probably forming the bold conglomerate outcrop in the summit of High Knob, Pike county.

On the Lehigh river, this *conglomerate group* is 200′ thick the *upper* and *lower conglomerate* beds being each 50′ thick, and the separating shale beds 100′. They are seen where the Lehigh Valley R. R. crosses the river one mile below Mauch Chunk.

The Cherry Ridge red shale is quite sandy at the several localities where it occurs in Pike and Monroe counties.

This stratum is pretty well exposed along the road which leads up over the Pocono plateau northward from Cana-

densis, in Barrett township, Monroe county, where 150′ of red shales occur in addition to much sandstone.

Toward the western line of Monroe, I have estimated its thickness at 500′, but it is probably greater, since on the Lehigh river, fifteen miles west, the beds which seem to come at this horizon are 1157′ thick, with only about 100′ of *red shale* in the entire interval, unless the 200′ of concealed should be *red shale*. All the rest of the rocks consist of grayish-green sandstones in which some shaly beds often occur, (see detailed portion of section 4 above.)

A bed of red shale 100′–200′ thick, with 15′ of green sandstone near its middle, is found over a wide area in Blooming Grove, Green and Palmyra townships of Pike county; and this most probably belongs in the base of the *Cherry Ridge Group*, since it occurs at an elevation of 1500′–1600′ A. T. This same *red shale* is seen on the south side of High Knob, its top having an elevation of 1600′ A. T., while 250′ of massive sandstones sparingly interstratified with *red shales* continue upward to the base of the *conglomerate* member at 1855 A. T.

The Honesdale sandstones.

The rocks of this group cover a considerable area in Lackawaxen, Palmyra, and Greene townships of Pike county, on the north; while on the south they make a narrow band through Blooming Grove and Porter into Barrett township Monroe county, through which they continue, and passing westward across Paradise, Pocono, Chestnut Hill and Polk, from which latter they enter Carbon, crossing the Lehigh river near Packerton where the structure seen in section D, Nos. 19–30, inclusive, was obtained along the Central R. R. of New Jersey.

North from Lackawaxen creek this group consists of two massive, pebbly sandstones 25′–30′ thick each, separated by 40′–50′ of reddish shaly sandstone, the whole being about 100′ thick. Along Paupack creek in Palmyra and Greene township, the *upper* member is very massive, full of large pebbles and often contains much *calcareous breccia*, large bowlders of which, 10′ in diameter, are seen scattered in great

numbers over the surface in the vicinity of Ledgedale. The stratum has a thickness of 40′–50′, and its base comes 1300′ A. T. opposite J. Atkinson's in the hill at the southern edge of Palmyra.

This Group expands in thickness westward being over 200′ where measured just west from Tannersville in Monroe, and estimated at 500′ near the western line of Monroe. On the Lehigh river it is 987′ thick and contains several layers of *calcareous breccia* as may be seen from section D, where it is perfectly exposed along the Central R. R. of New Jersey, below Packerton, the different beds being there vertical, pebbly at several horizons, and contain more than 150′ of red shale.

The Montrose red shale.

This bed, so widely extended in Wayne and Susquehanna counties, proves to be equally persistent in Pike and Monroe.

The Montrose red shale is seen at the eastern line of Pike, along the Delaware river hills, one mile below Lackawaxen where the *red shale* portion is only 50′–75′ thick, and 1000′ A. T. The *red* part does not attain a thickness greater than 100′ at any locality found in Pike county, but it is probably much thicker under the drift-covered area along the western line of the same, since it would seem to have a thickness of several hundred feet on Brodhead creek in Barrett township, Monroe county, and at least 600′ where these beds cross the D. L. & W. R. R. in the vicinity of Henryville. It makes a great *red band* westward from the last locality through Pocono, Jackson, Chestnut Hill and Polk townships, attaining an estimated thickness of 1500′ in Chestnut Hill. It is probably thicker than this at the western line of the county, since on the Lehigh river, 15 miles west, these *red beds* have thickened up to 2000′, in which not more than 50′ of gray rocks can be found. This great thickness of the *Montrose red shale* as shown in section D, No. 31 was measured along the C. R. R. of New Jersey ¼ mile below Packerton, where the layers are vertical and the R. R. crosses them at right angles to the strike.

The rock material in this red shale is usually of a dark dull red color and though often quite sandy it contains but few layers so far as I have observed, that could properly be termed sandstone.

The Delaware river flags.

(*Paupack and New Milford sandstone group of G⁶.*)

In this report I have given the name *Delaware river flags* to the series of greenish gray sandstone and shale which intervene between the base of the *Montrose red shale* and the top of the *New Milford red shale.* In the Wayne and Susquehanna report, (G⁵,) page 59, these beds were subdivided into several members under the head of *Paupack* and *New Milford sandstone groups*, whose combined thicknesses were 585′ but these intervals were found to increase so enormously southward that the Wayne and Susquehanna county subdivisions could not be followed, hence I deem it best to replace the names *Paupack* and *New Milford sandstones* by a single geographical term which would include both the latter and at the same time suggest the nature of the beds.

As nearly all the great *flagstone quarries* along the Delaware are found at various horizons in these measures the name *Delaware river flags* would seem most appropriate.

The rocks composing this series are finely exposed along the Delaware river between Narrowsburg and Pond Eddy, and along this line have a thickness of 1430′ according to the closest and most careful measurements that I found it possible to make by following along the cuts of the Erie R. R. and either measuring or estimating each layer.

The entire absence of *red beds* from the lower two thirds of the group is a marked characteristic along the Delaware this portion consisting of alternate beds of greenish-gray sandstone separated by greenish sandy shales. The sandstones jut out of the river hills in long lines of massive looking cliffs, exhibiting the usual current bedding but when quarried into, those in the places most exposed to atmospheric influences are found to split very evenly into smooth flagstones 2″–8″ thick, and of every desirable size, flags 10′–15′ square being easily obtained in many localities.

It was from this series on the New York side of the Delaware below Shohola that the great flagstone (15′ ×25×8′) was quarried which now graces the side walk in front of Wm. H. Vanderbilt's new mansion, on Fifth Avenue, New York. Flags quite as large as this could have been easily obtained on the Pike county side, but the N. Y. bed was chosen simply for convenience to the D. and H. canal, on which the monster stone was to be transported.

The rocks of this series are extensively quarried at Stairway, Pond Eddy, Shohola, and other localities along the Delaware river; also at Millville, Kibler, and Rowland's, along the Lackawaxen, from all of which localities large quantities of flags are shipped to New York and other cities under the name of *blue stone*, the flags usually having a bluish-green cast.

Some beds of red shale are found in the uppermost 430′ of this series on the Delaware river there being one at the bottom which is 50′ thick.

The Lackawaxen conglomerate is a name by which I have designated a very massive pebbly bed 50′–60′ thick, which occurs near the top of this series in the vicinity of Lackawaxen, Rowland's and other points in Lackawaxen township, Pike county; as may be seen in the detailed portion of this report.

The Delaware river flags make a broad band of gray from the Delaware river clear across Pike, Monroe, and Carbon counties to the Lehigh, its southern outcrop passing through the following townships from the Delaware westward, Westfall, Shohola, Dingman, Delaware, and Porter in Pike county; Barrett, Paradise, Pocono, Jackson, Chestnut Hill, and Polk in Monroe.

It seems to decrease in thickness westward from the Delaware, since in each of the sections B, C, and D the thickness is only 1200′. This reduction may however take place by the *Montrose red shale* extending downward into the uppermost 430′ which contain *red beds* on the Delaware.

These *flags* cross the D. L. & W. R. R. between Henryville and the first bridge across Brodhead creek, near the

southern point of Paradise township, and have there been quarried and shipped to some extent.

Excellent flagging could doubtless be obtained at any locality in this series in either county.

The Delaware river flags are perfectly exposed in vertical outcrop on the Lehigh river, along the Central R. R., one mile below Packertown where a very accurate measurement gave the thickness 1200′, all grayish-green sandstone in layers ½-4′ thick, in which no red beds are seen, except for only a few inches at two or three horizons.

The New Milford red shale.

The New Milford red shale has been provisionally identified with a bed of *red sandy shale* which first makes its appearance along the upper Delaware river at Pond Eddy, where it consists of three divisions as seen in section A, 25′ of *very red shale* at top, followed by 40′ of greenish, flaggy sandstone, below which comes 10′ of greenish red sandy shale, 75′ in all. Owing to the fact that this is the first *red horizon* above the base of the Catskill, it can be followed westward through Pike to the Monroe county line, crossing Big Bushkill creek near Ressaca, and Brodhead creek one eighth mile above Sprague ville, where a broad red band is seen crossing the D. L. & W. R. R. dipping 25° N. 25°. W.

It crosses Pocono creek about one mile and a quarter above Bartonsville. Westward from this through Jackson, Chestnut Hill, and Polk, it seems to increase in thickness quite rapidly, since it makes a much broader *red band* than it does further east.

On the Lehigh river this bed is exposed along the Central R. R. of New Jersey, about one mile above Bowman's Station, where we see about 700′ of *red beds* in which occasional grayish-green sandstones occur.

This *red bed* is also caught in the Stroudsburg syncline, along the northern portion of Eldred township, and northwestern part of Ross, in Monroe county, where it appears to have a thickness of 500′ or more.

I have identified this with the *New Milford red shale* of Susquehanna and Wayne, simply because it is the *first red*

bed above the base of the Catskill all through Pike and the eastern half of Monroe.

Starrucca (shale) sandstone.

In Wayne and Susquehanna counties, the *Catskill series* is terminated below by a bed of greenish-gray sandy shales in which are often interstratified thin beds of sandstone which rarely become massive; from its occurrence near Starrucca it was called the *Starrucca shale.*

In Pike and eastern Monroe, everywhere occurs, below the lowest *red rocks* just described, a succession of hard greenish-gray sandstones destitute of organic remains, and so like the *Catskill sandstones* physically that they would seem to be a true part of the latter, and hence I have considered them as representing the *Starrucca beds* at the north, though they have thickened up wonderfully southward; for, at the northern line of Wayne and Susquehanna counties the *Starrucca beds* are only 105′ thick, while on the Delaware, below Pond Eddy, the rocks between the *New Milford red shale* and the top of the Chemung have a thickness of at least 600′.

These beds are finely exposed along the New York side of the Delaware river between Pond Eddy, and one half mile above the Erie R. R. bridge across the Delaware; often rising in vertical cliffs from the bed of the Delaware and Hudson canal to a height of several hundred feet, one locality showing nearly 600′ of grayish-green sandstone in layers 1′–3′ thick in an almost vertical escarpment, in which not a single *reddish bed* is to be seen.

The rocks in this series seldom exhibit current bedding, and it is possible that some of this interval would be called *Chemung* at the northern line of the State, especially if the fossils of that group extend up into these beds.

The basal layers of these *Starrucca beds* rise above the Delaware river about one half mile above the Erie R. R. bridge, in Westfall township; and from this point the line of outcrop passes south-westward through Pike county rudely parallel to the Delaware river and about three miles north from the same. Entering Monroe county about three

fourths of a mile above the Middle Bushkill Falls, it passes south-westward through the same, crossing Big Bushkill below Ressaca, Brodhead creek and the D. L. & W. R. R. at Sprague ville. Here it has the same thickness that is found on the Delaware river in Pike county, the only *red bed* in the series being a reddish-gray sandstone 50′–100′ below the top of the same.

The Starrucca beds cross Pocono creek about one mile above Bartonsville, westward from which *red beds* begin to make their appearance in the same, increasing in number and thickness westward until on the Lehigh river in Carbon county they extend down to within 120′ of its base and constitute about one third of the entire thickness of the series, which is there the same that we find it at all other localities in Pike and Monroe, viz; 600′.

These beds also occur in the Stroudsburg syncline in Ross and Eldred townships and have there several *red horizons* beginning about 150′ above the base of the same.

Fossils of the Catskill.

The only evidence of *animal life* during the epoch of the *Catskill* is the occasional appearance of what appears to be *fish bone fragments* in the *calcareous breccias* which are common in the upper half of the series; not a single *molluscan fossil* being observed in all the large area over which these rocks were minutely examined.

Plant remains are of very rare occurrence, the only locality in the district where any determinable forms were seen being a short distance below Henryville in a cut on the D. L. & W. R. R. There near the base of the *Montrose red shale* great numbers of *Archæopteris Jacksoni* occur. It is true that many *pieces of stems* and *fragments of plants* are often seen, but in all cases they have been so macerated and broken up as to be totally indeterminable.

That the epoch was marked by an unusal dearth of life, (both plant and animal), is certain from the great beds of *red shale* which characterize the same, as well as the total absence of *iron ore*.

The quantity of *iron* present in these *red shales* may be

estimated from the following analysis of specimens made in the Laboratory of the survey by Mr. McCreath and Mr. Stinson:

	I	II
Silica,	60.610	62.880
Alumnia,	19.202	18.820
Sesquioxide of iron,	7.678	8.000
Lime,	0.340	0.330
Magnesia,	1.527	1.682
Phosphorus,	0.003	0.051
Water,	3.800	3.604

I From Tobyhanna township, Monroe County.
II From Pocono township, Monroe County.

No. VIII. The Chemung Series.

The passage from *Catskill* to *Chemung beds*, downward, is instantly preceptible when the line of contact is exposed, though there is not the slightest unconformability. But the hard greenish-gray, micaceous Catskill sandstones are underlaid by blue, sandy, fossiliferous shales; and these by olive and gray micaceous sandstones which are destitute of the peculiar greenish cast so common in the Catskill.

It was found impossible to identify any of the beds between the base of the *Catskill* and the top of the *Hamilton* with the *Portage series* of other portions of Pennsylvania, either on lithological, or palæontological grounds, and hence I have applied the name *Chemung* to the entire interval, preferring to regard the *Portage series* as absent from this district. In this view of the matter I am influenced by several considerations, the chief of which are:

1st. The occurrence of characteristic *Chemung fossils* throughout the entire interval;

2nd. The total absence, so far as my observation has extended, of all the characteristic *Portage fossils*, not even a *single Fucoid* having been seen;

3rd. The *Chemung character* of the rocks considered lithologically; there being a total absence of those interstratified hard blue sandstones which distinguish the *Portage* from the *Chemung*;

4th. The small thickness of the interval between the *Hamilton* and *Catskill*, the greatest being only 1850′, which is even less than one would expect to find in the *Chemung alone*, where the *Hamilton* and overlying *Catskill beds* are so largely developed.

It was also found impossible to sub-divide the rocks of this interval into any groups that could be characterized and traced from one point to another.

The series is made up of a succession of bluish-gray, hard sandstone beds in layers ½′–2′ thick, often somewhat micaceous, and usually interstratified with blue sandy shales. Occasionally *olive sandstones* make their appearance, but they are exceptional at the eastern line of the district. The whole series is sparingly *fossiliferous*, the most common forms being, *Streptorhynchus*, *Chemungensis*, *Spirifer disjunctus*, *Pteronites* sp? *Productella* sp? The species are generally badly preserved, and while all have a well-known *Chemung facies*, many were undeterminable.

The Chemung beds cover a belt about one mile in width in eastern Pike, but this gradually narrows south-westward both because the dip steepens and because the series thins perceptably, the dip being above Matamoras on the Delaware 10°–11° (section A) while on Brodhead it is 30° (sec. B), 45° at the western line of Monroe, and nearly vertical along the Lehigh river, 55° being the lowest dip observed there in these beds.

The basal outcrop of the *Chemung* rises from the Delaware river opposite the 90th Mile Post on the Erie R. R. (2 miles above Port Jervis, N. Y.) and continuing thence south-westward through Pike county, crosses Sawkill creek one fourth mile above the High Falls, Raymondskill about one mile above the top of the great Falls on that stream, and keeping on south-westward nearly parallel to the Delaware river, passes into Monroe county at a point about 300 yards above the Middle Bushkill Falls, reaching Brodhead creek ⅘ mile below Spragueville and continuing on south-westward through Monroe as shown on the accompanying geological map.

The Chemung rocks are also caught in the Stroudsburg

syncline along the northern portion of Ross and Eldred townships.

These beds have a thickness of 1850′ as shown in section A, at the eastern line of Pike county, 1750′ near Spragueville in Monroe county, as exposed in sec. B, and also 1600′ at the western line of Monroe according to sec. C.

On the Lehigh river the *Chemung rocks* come down to the Central R. R. of New Jersey about one half mile above Bowman's, where they have a thickness of only 1200′. They rise above drainage again on the south-east slope of the Lehighton axis one mile below Lehighton station on the C. R. R. of New Jersey and arching into the air over the axis come down again with vertical dip one half mile north from Lehighton.

The total absence of red beds from the Chemung of this district is interesting, since they are everywhere present, (*the Mansfield reds especially*) all along northern Pennsylvania in what has always been regarded as good Chemung, judged by its fossils. It is barely possible that the greater portion of the 600′ of rocks in what I have assigned to the basal member of the Catskill, (*Starrucca sandstones*) may have been invaded by Chemung life-forms along the northern border of the state, its *red beds* becoming the *Mansfield reds*, in Wayne, Susquehanna, Bradford and Tioga. The affinity of the *Mansfield reds* with the *Catskill* would also seem to be indicated by the great numbers of *fish remains* reported from these horizons in Bradford and Tioga by Mr. Sherwood in Report G. Should this suggested relationship of the *Starrucca beds* of this district and the *Mansfield red beds* of the north, prove to be real, it would be an interesting question as to whether the *Mansfield beds* should be regarded as *Catskill* or the *Starrucca beds* as *Chemung*. Lithology would give one answer, palæontology another, the truth probably lying between the two, viz: that these rocks are a *transition series* in both cases, and therefore while retaining the *Chemung life forms* at the north, they prefigure to some extent in their lithology the near approach of the *great red rock period* which began in earnest with the *New Milford red shale*, above.

(*No. VIII continued.*) *The Hamilton Series.*

The rocks of the *Hamilton Series* are divisible into three groups which correspond in a general way to the *Genesee, Hamilton*, and *Marcellus beds* of the New York Reports.

The Hamilton Series extend through Pike county along the Delaware river, making a belt from two to two and a half miles broad.

On entering Monroe county at Bushkill the southern outcrop of the *Hamilton* leaves the Delaware river, keeping along the northern foot slope of Walpack ridge (the Delaware having cut through the same to the south), and continues in a broad belt approximately S. 65° W. to the western margin of Hamilton township, where the rapidly deepening Stroudsburg syncline causes it to bifurcate, the southern prong keeping just north from Walpack ridge, and having a breadth of one mile; continues on through Carbon county, reaching the Lehigh river at Bowman's, where it forms a belt about one half mile broad. The northern prong passes along the valley of Big creek just north from Wire ridge making an outcrop about two miles in breadth, and continuing south-westward reaches the Lehigh river on the crest of the Lehighton axis making an outcrop there over a mile in breadth.

The thickness of the whole *Hamilton series* at the eastern line of the district as given in section A is 2,375′; at Stroudsburg, in Monroe, 2200′(Sec. B); at the meridian of Brodheadsville (Sec. C) 5,000′; on the Lehigh river at Bowman's (Sec. D) 1,760′. From which it will be seen that the *Hamilton* thins away about 600′ in passing from the eastern line of Pike county south-westward to the Lehigh river.

The Genesee Shale.

(*Upper Hamilton.*)

The top of the *Hamilton* is marked off everywhere in this district by the appearance of a dark sandy fossil slate or shale, which seems to be identical with the *Genesee black slate* of the N. Y. Reports.

The color is never a jet black, but rather a bluish-black and the material is often quite sandy.

It is well exposed along the Delaware river on the N. Y. shore, two miles above Port Jervis, where it is seen dipping N. 25° W. 10°–11° and exhibiting cleavage planes at a high angle to the south-east. It is also quite fossiliferous, containing *Spirifer mucronatus*, *Athyris spiriferoides*, *Microdon bellistriata*, *Trodidoleptus carinatus*, and many other forms.

Two rows of *iron ore nodules* are seen in the lower portion of the group on the Delaware.

The outcrop of the Genesee is always indicated in the topography by a narrow valley along its strike, between the hard *Chemung rocks* above, and the sandy *Hamilton beds* below.

In Pike county, several of the great cascades which occur on the streams emptying into the Delaware begin at the base of the *Genesee*, the narrow cañons above the heads of the cascades being cut through the rocks of this group; thus the Genesee is seen at the tops of the great falls on the Sawkill, Dingman's, Little Bushkill and Middle Bushkill creeks.

The Genesee enters Monroe county just west from the falls of Middle Bushkill, and continuing westward crosses Brodhead creek at the county bridge, one mile and a quarter below Spragueville; westward from this it continues across the north portion of Stroud township crossing the Pocono creek near Bartonsville, and skirts along the northern edge of Hamilton township to near its middle portion, where the line of its outcrop veers northward into southern Jackson, whence it passes through the central portion of Chestnut Hill and Polk to the Carbon county line one half mile north from the meridian of Kresgeville, reaching the Lehigh river a short distance above Lehighton station on the C. R. R.

Another band of the *Genesee* circles around the eastern end of Wire ridge, (Stroudsburg synclinal,) making a narrow band both north and south along the base of the same. The southern arm of this loup reaches the Lehigh about 30 rods above Bowman's station on the Lehigh Valley railroad. The northern arm crosses the same just below Lehighton station on the same railroad.

The thickness of the group seems to remain constant at about 200′, from the eastern line of the district clear through to the Lehigh river in Carbon county.

Tully Limestone horizon.

A great coral bed is found directly under the *Genesee shale* at many localities in the district, *Corals*, *Shells* and *Crinoids* being often so abundant as to constitute it an *impure limestone.*

It is seen at the heads of Sawkill, Raymondskill, and Dingman Falls, while probably the best exposure is at the falls of Middle Bushkill, one mile and a half above its junction with the Big Bushkill. Here it is a perfect mass of *corals*, and *shells* for about 30′, a great number of *species* and genera being represented, among which the following were recognized: *Zaphrentis Rafinesquii*, *Z. gigantea*, *Heliophyllum Halli*, together with several species of *Syringopora*, and other forms that I could not determine. This is by far the richest *coral horizon* in the district, being in fact a regular *fossil reef*. The calcareous portions of the *coral stems* have often been removed by solution, and then the matrix (usually a dark gray calcareous shale) is penetrated by small branching cavities extending in every direction, thus giving it a honey-combed appearance.

This same *coral horizon* is seen near the western line of the district, in Monroe county, just south from Gilbert's P. O. along the road at E. F. Kresge's, and also about one mile north from Kresgeville in the same township (Polk.)

On the Lehigh river this bed appears to be represented in a cut on the Lehigh Valley railroad, about 50 rods north from Bowman's station, where *corals*, *shells*, and *crinoids* are unusually abundant.

When exposed to atmospheric influences this bed becomes quite spongy and rotten owing to the removal of its lime, as may be seen along the road near E. Bonynge's, one mile and a half south from Spragueville, where it is finely exposed in a cutting at the roadside.

There can be little doubt that this stratum represents the *Tully limestone horizon* of the New York Reports, and it

thus becomes a valuable guide in correlating and classifying the rocks of the district.

The profusion of coral life in this old reef, strikingly reminds one of the great *coral horizon* at the Falls of the Ohio, and would lend much plausibility to Whitfield's conclusion concerning the *Hamilton age* of the Ohio Falls beds, since some of the genera and many of the species found in Monroe county at the Tully Limestone horizon, have the same general facies as those from the Ohio river.

The Hamilton Sandstones.

(*Middle Hamilton*; *or Hamilton proper.*)

Directly beneath the *Tully Limestone horizon* come a succession of very compact sandy slates and sandstones, of a bluish gray or ashen color, often slightly calcareous and always exhibiting a coarse cleavage structure at an angle of 50°–60° to the south-east. These beds I have regarded as the equivalent of the rocks of the *Hamilton epoch* in New York.

They are finely exposed along both banks of the Delaware north from Matamoras, in Pike county, where especially on the New York shore they are seen rising out of the Delaware and Hudson canal in vertical cliffs 10′–50′ thick.

These Hamilton sandstones make the great cliffs which constantly overlook the Delaware river all along the south-eastern margin of Pike county from Port Jervis to Bushkill at the Monroe county line. This almost vertical wall of rock which contributes much to the picturesqueness of the Delaware valley often rises in peaks and ridges to an elevation of 600′–800′ above the water in the river, as for example Utter's peak near Milford.

The coarse cleavage which everywhere cuts the rock at a high angle to the south-east has doubtless contributed much to make the very steep escarpment facing the Delaware between the two points mentioned.

Immense quantities of debris from the higher portions of these cliffs have accumulated along the lower slopes, making great heaps of small fragments broken by frost and the

friction of sliding down the cliffs into irregular oblong and often splinter-like pieces, which are much used on the public roads under the name of "slate gravel." Being quite hard, slightly calcareous and already broken up into pieces of the size most suitable for use on the road, they are highly prized for that purpose, the unrivaled excellence of the Delaware valley road between Matamoras and Bushkill being due to the fact that vast beds of this "slate gravel" are found along its entire extent so convenient to the road that hauling is often unnecessary for several miles at a stretch.

The rocks of this group are coarser toward the east portion of the district, small pebbles having been seen scattered quite plentifully through a bed 20′ thick on the N. Y. side of the Delaware, one mile above Port Jervis. In this direction they seem to obtain their greatest development, since the construction of section A gives a thickness of 1375′ for these beds along the eastern border of Pike county; while north from Stroudsburg in Monroe (sec. B) they have decreased to 1200′; to 1100′ at Brodheadville and on the Lehigh river (sec. D) there seems to be not quite 800′ of rock material referable to this group.

High casacdes.—Over these hard rocks fall the Sawkill, Raymondskill, Adams creek, Dingman's creek, Hornbeck, Little Bushkill, Marshall's, Pocono, McMichael's creek, and many smaller streams.

Through Monroe county this belt of rocks is not so sterile, and precipitous as in Pike, which is largely due to the fact that the rock materials grow finer and more yielding in that direction.

No minerals of any value need ever be expected in this series, though at some localities (as on Quick's Mill run above Milford) it contains small quantities of *manganese binoxide*, but never in amount sufficient to be of any commercial value.

The fossils in these beds are not numerous and seem to be confined to the larger forms, the following being the most common: *Spirifer granuliferus*, *Spirifer arrectus*, *Grammysia bisulcata*, among mollusks; while *Heliophyllum Halli*, and numerous other *corals*, together with large

numbers of *Crinoidal fragments* represent the Radiates. Not a single specimen of a *Trilobite* was observed in all this thickness of rock at the many localties where it is exposed for observation within the district.

The breadth of the *Hamilton sandstone* outcrop through Pike and Monroe is not far from one mile, though this varies somewhat with the nature of the topography and the strength of dip.

The *Hamilton sandstone beds* come down to water level on the Lehigh river in the vicinity of Bowman's station on both the Lehigh valley and New Jersey Central R. R.

The Marcellus Shale.

(*Lower Hamilton.*)

Below the ashen-gray and mud-colored sandy rocks of the Hamilton group, there occurs a series of darker, and more shaly beds which I have referred to the *Marcellus shale horizon* of the New York sub-divisions.

All through Pike county, a very slight portion of the rocks at this horizon are exposed, from the fact that the channel and valley of the Delaware are excavated out of the same, between Matamoras and Bushkill.

The Marcellus beds extend about one fourth way up the steep bluffs which border the Delaware between the two last-mentioned towns, and are frequently exposed at the cuttings along the roads, and in the beds of streams which enter the Delaware, removing the alluvial and Drift deposits from their channels. As thus exposed, its upper portion is always a bluish-gray or bluish-black sandy shale, which also breaks under atmospheric influence into oblong splinter-like fragments, much like those of the *Hamilton sandstone* above, only finer and smaller.

The only glimpse obtained of the lower portions of the *Marcellus* beds, along the eastern portion of the district, is in the bed of the Delaware river, one half mile below Matamoras, where an interrupted line of gray, hard, sandy slates dipping 15°–20° N. 20° W., and cleaving S. S. E. 60°, extends nearly across the stream from the Pennsylvania to

the New York shore, looking from a distance like the remnants of a dam projecting 2′–5′ above low water.*

After the Delaware leaves the Marcellus valley at Bushkill, the lower portion of these beds is frequently seen along the Milford road, in Monroe county, and in every case it is a dull-gray, sandy slate, with coarse cleavage, often containing thin layers of lighter colored shale, which give the rock a kind of banded appearance.

The exact line of contact of this *lower* or *gray Marcellus* with the underlying *Corniferous limestone* could not be discovered anywhere within the district, though in several cases the concealed interval was only 5′–10′. One of these localities is on the Milford and Stroudsburg pike, one mile south-west from Shoemaker's P. O., where the gray Marcellus is seen cleaving into slabs 2″–4″ thick, inclined 60°–70° to the south-east in a cutting for a house foundation at J. V. Coolbaugh's, the *limestone* coming up just across the road from the *Marcellus outcrop*, so that the interval between the *gray slates* and the former cannot be more than 10′ at this locality.

Black slate.—The gray beds are well exposed for several feet at Coolbaugh P. O., further west, on the Milford pike, and at several localities between these and Marshall's Falls P. O., at none of which are any *black slates* observed.

These lower gray beds of the *Marcellus* are well exposed for several feet just above the *Corniferous limestone*, in the bed of McMichael's creek, opposite the east end of Elizabeth street, Stroudsburg, Monroe county. There they consist of alternate layers of bluish-gray shales, 1′–2′ thick, interstratified with yellowish-gray bands of shale 3″–4″ thick.

The thickness of these gray beds cannot be accurately determined, but in the Stroudsburg region they cannot be much less than 300′–400′, since no *black shales* come into the section for about one third of a mile north-west from where the bottom of the gray beds go under (at the bridge) on a dip of 27°. They may even be 500′ thick.

[*This *rock dam* across the bed of the Delaware river must play an important role in any glacial theory of Eastern Pennsylvania.—J. P. L.]

When the Marcellus beds are traced west from Stroudsburg to the western extremity of Monroe, *black slates* make their appearance down near the base of the group, seemingly coincident with the thinning away of the *Upper Helderberg beds* (Corniferous and Cauda Galli), at the western line of Hamilton township.

Coal.—These black slates become quite *bituminous* near the western line of Ross, on the land of Mr. Bonser, just south of Frantz's creek, along the northern foot slope of Godfrey's ridge. The strong folding of the beds has given some of the layers (through metamorphism) the appearance of impure anthracite, and a large expenditure has been made in driving tunnels into the hill in search of *coal.*

The same mistake has been made at Kunkletown in Eldred township, where these highly bituminous slates have been partially metamorphosed, only that here several thousand dollars—variously estimated at from $4,000–$6,000—have been expended at one time and another in driving tunnels into the base of Walpack ridge in search of *coal.* It is needless to tell the geologist that none will ever be found at this horizon, but it seems necessary constantly to repeat this assertion for the benefit of the land owner in order to warn him against a useless expenditure of money and labor.*

Brown Hematite iron ore occurs in connection with these *black slates* both at Kunkletown and Bonser's. At the former locality it was once burned and manufactured into *mineral paint*, on a small scale, by Mr. Metzger.

The *ore* seems to rest on the upper surface of the slates directly under the covering of soil and surface débris. It would probably average 40 per cent of metallic iron, and should a considerable body of the ore be found on further exploration it would doubtless warrant mining, were any means of transportation at hand.

A bed of this *Brown Hematite* is also seen along the road decending Little McMichael's creek, a short distance west from Sand Hill P. O. It was once hauled to Weissport in Carbon county, and used quite extensively in the manufac-

[* Even where these bituminous layers are developed into regular coal beds, as in Perry county, such coal beds are absolutely worthless.—J. P. L.]

ture of *Mineral paint* for barns, bridges, freight cars, &c. It rests upon the upper surface of the slates, just like that at Bonser's, and Kunkletown, and hence it has all accumulated since the present topography was channeled out, because the *ore* does not lie in a flat bog but on a considerable slope where the drainage must have been free, except the arresting power of a clayey soil.

The thickness of the Marcellus could not be accurately measured at the eastern line of this district owing to the fact that it is nearly all concealed. In section A I have placed its minimum at 800′, but if constancy of dip could be depended upon, between its uppermost and lowermost exposures, this would have to be increased by at least 500′, and if there is a *thinning away* of the gray beds instead of a change in character (to black) coincident with the disappearance of the *Upper Helderberg* in Hamilton township Monroe county, then 1300′ instead of 800′ would be the true thickness of these beds where they underlie Port Jervis and Matamoras at the eastern line of Pike county. In the absence of any means of determining the question I have preferred to regard the smaller figure as most probable, since that agrees with the thickness of these beds on the Lehigh river where they are nearly vertical below Bowman's station on the Lehigh Valley R. R. and can be measured without danger of serious error from the presence of unknown anticlinals, as may possibly be the case at Port Jervis.

School slates were once extensively manufactured from a quarry in the *Marcellus* at the extreme western line of Monroe county, in Polk township. The business was abandoned, not through inferiority of the *slate* for such purposes, but from lack of rail transportation making it impossible to compete with localities more favored in this respect.

The fossils of the Marcellus are not numerous, there being only one locality where I have found them abundant, and that is in a low cliff just north from the borough of Stroudsburg in the lower portion of the *black Marcellus*. They are usually however quite badly preserved, so that

the *species* could not certainly be determined. The genera represented at the Stroudsburg locality seem to be *Spirifer*, *Chonetes*, *Productus*, *Orthis*, with many *crinoidal fragments.—Spirifer umbonatus* was not recognized anywhere in the district.

The Upper Helderberg Beds.

(*The base of No. VIII.*)

The rocks of this period are represented in the district by the *Corniferous limestone*, and the *Cauda-galli grit*; the *Onondaga* and *Schoharie beds* of the New York Reports not being distinguishable.

Owing to the fact that all the rocks are concealed by immense Drift heaps for several miles near the point where these beds thin away westward the exact place of disappearance could not be located, though it is quite improbable from several considerations that these beds extend further south-west than the western line of Hamilton township, Monroe county, twenty miles east from the Lehigh river.

The reasons for believing that the rocks of this period disappear in Hamilton township, are: 1. the sudden subsidence and disappearance from the topography, of the characteristic *ridge* made by these beds for 50 miles to the north-east, coupled with the fact that there is a coincident considerable thickening of the *Oriskany sandstone*, on which great beach-deposit the *Upper Helderberg beds* seem to thin away. Then, 2. north-east from this point, (just west from the center of Hamilton township,) these beds are visible, however abundant the Drift, and it is reasonable to suppose that their disappearance from the surface marks the south-westward limit of their distribution. And 3. I could find nothing to represent them one mile below Bowman's on the Lehigh.*

The Corniferous Limestone.

This highly characteristic series of cherty limestones immediately underlies the Marcellus beds last described,

[* Mr. Chance's section however shows 5' of chert.—J. P. L.]

though as stated on a previous page the exact contact of these two groups could nowhere be seen, in the 50 miles of outcrop between the eastern extremity of Pike county and the point where the *Corniferous* disappears in Hamilton township, Monroe county, although in two or three instances less than 5′ of rock material was concealed along the line of junction.

The Corniferous Limestone comes up out of the Delaware, one mile below Matamoras, just at the point where the river begins to execute the great bend which carries its course around from S. 30° E. to S. 65° W. In fact it is the solid wall of these beds against which the river at present beats in vain as it veers off along the strike.

This limestone is finely exposed along the southern shore of the Delaware in the vicinity of Carpenter's Point village and the long narrow neck of land projecting between the Delaware and Neversink rivers known as Carpenter's Point is entirely composed of these rocks.

The Corniferous beds have very much the same appearance from Port Jervis south-westward to their point of disappearance, so that the description of them at Carpenter's Point will answer for any other locality.

As seen along the New York shore of the Delaware (from the Tri-state corner at the mouth of the Neversink northeastward for one mile) they consist of successive layers of dark gray limestone 1′–10′ thick, in which are embedded multitudes of *black flint nodules* one inch to one foot in diameter, having no regular shape but usually longer than thick, the greatest axis lying parallel with the bedding planes. On exposed surfaces the lime has been removed by solution while the nearly insoluble *chert* stands out in numerous black projections 6″–8″ high, giving the beds a most forbidding aspect, the sharp dagger-like points being the terror of bathers. No portion of the rock seems to be free from these *flint nodules* and in some parts of the stratum they make up nearly half of its material. They are not wholly silicious, but often contain a considerable quantity of lime, and then the nodules break up and decay by atmospheric influences ; the lime being removed by solution

leaves the silicious material in such a rotten or spongy condition that it also succumbs to the elements.

The origin of these nodules by segregation is attested by the fact that they are often seen enclosing *fossil shells*, *crinoids*, *&c.*

The following analysis by McCreath and Stinson shows the composition of an average specimen of these *cherty nodules*; locality, East Stroudsburg, Monroe county:

Carbonate of Lime,	20.267	
Carbonate of Magnesia,	0.681	99.148
Oxide of Iron and Alumina,	0.640	
Insoluble residue,	77.560	
The ignited "insoluble residue" gave		
Silica,	72.430	
Oxide of Iron and Alumina,	0.770	73.605
Lime,	0.210	
Magnesia,	0.195	

Of course there are many of the nodules that do not contain so much lime as this specimen, while others contain much more, if one may judge from the readiness with which they decompose when exposed to atmospheric influences.

The limestone part or *matrix* which holds the *flint nodules* has the following composition as determined by McCreath and Stinson:

I From East Stroudsburg, Monroe county.
II From land of H. H. Campbell, Smithfield township, Monroe county.

	I	II
Carbonate of Lime,	89.014	83.750
Carbonate of Magnesia,	0.915	1.157
Oxide of Iron and Alumina,	0.380	0.480
Sulphur,	0.056	0.025
Phosphorus,	0.012	0.070
Insoluble residue,	9.860	14.470
Total,	100.237	99.952

The Corniferous limestone does not make its appearance in Pike county, at any locality known to me, since it hugs the New Jersey shore of the Delaware all along the south-eastern boundary of Pike county, the river's course being determined by the strike of these beds, since they rise from its southern margin at an angle of 20°, thus forming a barrier south of which the stream does not break until

it starts southward through Walpack ridge at the southwestern extremity of Pike.

It enters Monroe county near the mouth of Big Bushkill creek, and forms a conspicuous belt of outcrop all along the northern-foot slope of Walpack ridge, its northern line nearly coinciding with the Stroudsburg and Milford pike between Bushkill village and East Stroudsburg, where it dips rapidly under the old buried valley of Marcellus rocks.

The width of this belt is seldom more than ¼ mile and often not near so much, since the dip is always quite rapid. It is well for the agricultural interests that the belt is so narrow, since wherever these beds come to the surface they so cover the ground with enormous bowlders, and jutting cliffs of massive rock that except in favored localities cultivation is impossible. Its outcrop is frequently marked by a succession of cliffs each 10′–20′ high up the northern slope of Walpack ridge. (See wood cut section.)

Westward from Stroudsburg the *Corniferous limestone* can be followed in an uninterrupted line up McMichael's creek through Stroud township into Hamilton along the northern foot slope of Walpack ridge, being almost constantly in sight until we reach the region of Bull run School House, one mile and a half east from the western line of Hamilton township, where it is last seen, being apparently thin and very arenaceous, though the flint balls are as numerous as ever.

As stated on a previous page, I believe that this group thins away entirely before passing much beyond the western limits of Hamilton township, since it is nowhere seen west from that point and is gone entirely at the Lehigh river, 20 miles west.

The calculated thickness of this limestone at the eastern line of Pike county is as shown in Section A, 250′ while Section B from the vicinity of Stroudsburg, Monroe county, shows only about 200′.

An excellent locality for the study of the *Corniferous limestone*, is at the rock cut, one half mile below East Stroudsburg station, on the D. L. & W. R. R. The entire thickness of the series can there be seen on an overturn dip,

and also the contact with the underlying *Cauda-galli grit.* For numerous other localities at which it may be seen well exposed, the reader is referred to the detailed report on Stroud, Smithfield, and Middle Smithfield townships.

It has been burned for lime on several farms in Monroe county; but owing to the fact that the *flint nodules* were not separated from the matrix or pure limestone, the experiments in this direction have been far from satisfactory, since a very large amount of material always failed to slack, or else melted down into a silicious slag. The analyses given on a preceding page show the matrix of these nodules to be a very fair limestone for agricultural purposes, and one which should slack with no difficulty. If the farmers, when breaking the stone into small fragments for the kiln, would cast aside the *flinty nodules*, there would be no trouble in manufacturing large quantities of it into an excellent fertilizers and it would pay them to do this rather than haul their lime 5 or 10 miles further from the *No. VI beds* (as nearly all of them do,) even if half of the *Corniferous rock* should be rejected in freeing it from the *flint.*

Then, too, some of the beds are much more cherty than others, the topmost layers usually containing more of the flint nodules than any other portion of the series; so that by a judicious selection of the quarry and proper care in casting aside the *flint nodules*, the farmers of eastern Monroe ought to make this the main source of the lime they use for agricultural purposes, at a great saving in cost compared with the price of the *Lower Helderberg lime* (No. VI) when hauled a distance of 5 miles or more.

Fossil mollusks and *corals* are quite abundant in the *Corniferous limestone* at many localities, being most abundant near the top of the series. *No fish remains* were observed.

Stroudsburg and vicinity are about the best localities for collecting *Corniferous fossils*; especially one locality in a field just south from McMichael's creek and east from the road leading to the Water Gap. The following forms were recognized at this and other localities in Monroe county: *Atrypa articularis*, *A. spinosa*, *Conocardium trigonale*,

Strophomena rhomboidalis, *Strophodonta perplana*, *Platyceras sp?*, *Cyrtoceras undulatum*, *Phacops bufo*, *Zaphrentis Rafinesquii*, *Cyathophyllum sp?*, besides many species of *Orthis* and other forms not identified.

Cauda-galli grit.

Under the name *Cauda-galli grit*, I have included all the beds between the base of the *Corniferous limestone* and the top of the *Oriskany sandstone*, it being impossible to recognize the *Schoharie* as distinct in this district.

The *Caudi-galli grit* makes the north slope of Walpack ridge from Carpenter's Point just south of eastern Pike, through the north-western edge of New Jersey, and does not touch this district until it crosses the Delaware river at the eastern line of Monroe. It makes a conspicuous feature in the topography of Monroe, south-westward, along the northern slope of Walpack ridge, through Middle Smithfield, Smithfield, Stroud, and Hamilton townships, until it thins away in the western portion of the latter, coincident with the disappearance of the Corniferous limestone.

The beds of this group vary but little in physical character from the top to the base of the same, consisting at the eastern line of the district, of rather coarse, very hard, sandy slates, or sandstones, of a dark gray, or dirty-ash color, usually cleaving in coarse slabs at a high angle S. E.

Owing to its extreme hardness, it often resists the action of the elements in a remarkable manner, and covers large areas with perfectly bare rock. A fine example of this may be seen along the New Jersey shore of the Delaware, one mile below Carpenter's Point, where this rock dips 25° N. 20° W. its upper surface forming a broad bare sheet of 15–20 acres in extent. Its thickness, by calculation from the dip and breadth of its belt, is 315′ at the eastern line of the district as shown in Section A.

Followed south-westward it thins away slightly, becoming finer grained and more of a sandy slate after crossing the Delaware river into Monroe county.

Where Brodhead creek cuts through Walpack ridge south from Stroudsburg, this stratum is vertical and completely exposed, giving a thickness of 250′ as shown in section B.

Westward from this point no measurements are possible, but the rocks seem to continue in considerable force, if one may judge from the ridge they make through Stroud and Hamilton townships, until they thin away in the latter, disappearing apparently quite rapidly.

The contact with the overlying *Corniferous* is seen at several localities in Monroe, a very fine example of this being at the long rock-cut of the D. L. & W. R. R. below East Stroudsburg station. The *flinty nodules* of the upper rock are there continued sparingly into the uppermost 20′–30′ of the *Cauda-galli*.

The only use to which the rocks of this series have been put, or rather the only one for which they can be used, is the filling up of road beds, since they often break up by weathering into forms much resembling the long chips of *the Hamilton sandstones*, or "slate gravel."

Fossils are not numerous, the characteristic *fucoid* (*F. Cauda-galli*) being seen at only one locality in the district, viz: at the roadside near Place's school-house in Middle Smithfield township, Monroe county.

Strophomena rhomboidalis and *Atrypa reticularis* are quite common forms, but most of the *fossils* are generally badly preserved, and distorted.

No. VII. The Oriskany formation.

The rocks which make up the *Oriskany series* change so radically in character in passing south-west from the eastern line of the district that there is scarcely anything in common to the sections of the group at the eastern line of Pike, and the western line of Monroe.

The sandstone member of the series is entirely absent at the eastern extremity of Pike county, the only representative of the *Oriskany* there present being a bed of limy, cherty shales, weathering down into muddy looking beds holding Oriskany fossils. They are in fact a mere continuation of the *Lower Helderberg beds* up to the very base of

the *Cauda-galli grit.* These shales are seen on the Greenville pike near the toll gate, about one mile south from Carpenter's Point village, and were there estimated at 50′ in thickness as shown in Section A.

The following *fossils* occur in these *Oriskany shales* south from Carpenter's Point: *Tentaculites elongatus*, *Platyceras Gebhardii*, *P. ventricosum*, *Pterinea textilis*, var. *arenaria*, *Rensselaeria ovoides*, *Eatonia peculiaris*, *Spirifer arrectus*, *S. arenosus*, *Meristella sp?*, *Discina Jervensis.*

Several of these forms have been recognized in this rock by Dr. Barrett of Port Jervis, but were not seen by the writer.

The species of *Discina* given above is a new one described (but not figured) in the Annals of the N. Y. Academy of Sciences, Vol. I. No. 4.

A conglomeratic sandstone makes its appearance directly beneath the *Cauda-galli grit* where these beds are first exposed after they cross the Delaware river into Monroe county, from New Jersey, at the Walpack Bend; very thin at first, but growing constantly thicker and more massive when traced to the south-west from this locality; becoming 45′ thick where it crosses Brodhead creek, about 175′ at the wester line of Monroe, and fully 200′ on the Lehigh river below Bowman's.

Just how this great thickening up takes place in the *Oriskany sandstone*, from a cherty pebble bed 8′–10′ thick at the eastern line of Monroe to a massive quartz conglomerate 175′ thick at the western line of the county, is not absolutely known, but some facts brought to light render it highly probable that it originates somewhat in the following way:

Directly beneath the *Oriskany pebble bed* in eastern Monroe is a series of ashen gray sandy and calcareous shales, about 150′ in thickness, containing *Spirifer macropleurus*, and other *Lower Helderberg fossils* which ally them with the latter rocks; and I have so grouped them in the general section, B. under the name of the *Stormville shales.* Immediately below these last rocks there occurs all through eastern Monroe a calcareous pebbly conglomerate 10′–15′ thick

which I have called the *Stormville conglomerate.* At Brodhead creek it is only 10′–12′ thick and is underlaid by the limestone of No. VI in which no pebbles are seen. But on going 5 miles west to Stormville, at the edge of Hamilton township, this conglomerate gets to be about 25′ thick, while many quartz pebbles occur in 20′–25′ more of the underlying limestone. From this point westward no more sections of the *Oriskany* and immediate underlying rocks can be obtained within the district; but it will be readily seen that the inference is quite strong that the 175′ of *Oriskany conglomerate* at the western line of the of the county and the 200′ on the Lehigh river, originated from the gradual invasion of the *Stormville shale* horizon by coarse pebbly sediment, thus converting the entire interval into a pebbly sandstone. This view of the matter is supported by the fact that the *Stormville shales* as last seen in Ross township have become light gray in color and quite sandy; while on the Lehigh river there is no shale whatever to represent the *Stormville shale.* Also the *Stormville conglomerate* below, and a portion of the Stormville limestone, are unrepresented unless they should be regarded as having coalesced with the *Oriskany sandstone.*

The Oriskany Sandstone is perfectly exposed in Walpack ridge where Brodhead creek breaks through it below Stroudsburg. The rock rises out of the creek vertically or even slightly overturned, consisting of alternate layers of pebbly rock and cherty limy beds, the whole about 45′ thick, enclosed by the *Cauda-galli grit* above, and the *Stormville limy shales* below.

The Oriskany sandstone is also well exposed along the cuttings of the N. Y. S. & W. R. R. at several localities between Stroudsburg and the Delaware river; being completely exposed opposite Experiment Mills.

The following fossils were seen in the *Oriskany beds* along Brodhead creek: *Spirifer arenosus, Rennselaeria ovoides, Orthis hipparionyx, Platyceras ventricosum,* and many other fragments that could not be determined.

The alternation of pebbly and cherty layers in the *Oriskany sandstone* west from Stroudsburg is shown by the

following section (12) made in the southern slope of Godfrey's ridge overlooking Cherry valley in Stroud township.

Oriskany beds in Godfrey's ridge.

Pebbly sandstone,		10′
Alternating layers of chert and pebbly rocks,		10′
Limy and Cherty layers with pebbly streaks,		5′
Pebbly layers,	0′	8″
Chert, dark,	0′	8″
Conglomerate,	1′	0″
Chert, dark,	0′	8″
Conglomerate,	0′	4″
Chert, dark,	0′	8″
Conglomerate,	0′	4″
Chert, dark,	1′	6″
Conglomerate,	0′	4″
Chert, dark,	0′	4″
Conglomerate,	0′	6″
Chert, dark,	1′	0″
Conglomerate,	0′	6″
Chert, dark,	0′	5″
Conglomerate, fossiliferous,	4′	0″
Limestone and Chert layers,	4′	0″
	41′	11″

The uppermost member of the section has been quarried to some extent on the west bank of Brodhead, near where the D. L. & W. R. R. crosses that stream in Smithfield township. The rock is there seen extending around the hills in a long line of rectangular blocks 4′–5′ square, somewhat pebbly, calcareo-silicious, and almost as hard as granite. Were it not for the two systems of intersecting joints, it would be almost impossible to dress the blocks into shape for building purposes, except at great expense. They have been used in building abutments for bridges on the D. L. & W. R. R. and also on the N. Y. S. & W. R. R. It has also been quarried at several other localities in Monroe, but at none of them does it furnish any first-class stone, since even when it can be wrought with comparative ease, the large cavities left in it by the solution and removal of its imbedded organic remains give the stone a very rough and irregular appearance.

The old bottle-glass factory in East Stroudsburg obtains its *sand* from the *Oriskany* in Hamilton township, on Sam-

uel Shaffer's land, west from Bossardsville; while the new factory recently started (1881) obtains *sand*, from the same horizon, one mile further west. It makes excellent bottles, fruit jars, &c. but contains too much iron for window glass. *No fossils* whatever are found in the portion quarried for glass sand.

The Oriskany is always broken and shattered, from Shaffer's quarry south-westward along the entire stretch of Godfrey's ridge, no cliff outcrops whatever being seen, although the surface is covered to a great depth by the Oriskany massive bowlders. It is possible that the scattered and broken condition of this massive rock may be due to atmospheric influences, but its appearance suggests the probability that earthquake action was the agency.

At several localities along this ridge, the *sandstone* seems to be completely disintegrated, below the surface bowlders, since a bed of fine white silicious material of unknown depth underlies the surface along the *Oriskany horizon*, in the vicinity of Saylorsburg and Kunkletown. It is called *clay* by the inhabitants; but, although it contains some aluminous material, it is clearly nothing but the waste of these disintegrated sand rocks.

A sample from Samuel Lessig's farm, in Ross township, gave on analysis the following results in Mr. McCreath's laboratory:

Silica,	82.020
Alumina with a little oxide of iron,	11.000
Lime,	.280
Magnesia,	0.774
Water,	2.842
Total,	96.916

In the vicinity of Kunkletown, Eldred township, this "Oriskany waste" was once manufactured into an article called "soap," by an enterprising Frenchman. In this process the crude material was passed continuously through several vats filled with water, thus allowing the coarse grains to separate from the finer, the latter only being used.

The following analysis by McCreath and Stinson, represents the constitution of this reputed "soap:"

Silica,	72.800
Alumnia with a little oxide of iron,	18.180
Lime,	0.290
Magnesia,	1.045
Water,	3.832
Total,	96.147

The washing process accounts for the higher per centum of alumina found in this specimen.

From Hamilton township westward, the *Oriskany* contains much iron in a diffused condition.

On the Lehigh river the *Oriskany sandstone* is a coarse, reddish-gray conglomerate, 200′ thick, in which *fossils* are very rare.

No. VI. The Lower Helderberg formation.

The rocks of this period are well developed just south from the eastern end of the district, and so south-westward through New Jersey, along the northern face of Flat Brook valley, parallel with the Delaware river and one to two miles south from it. Entering Monroe county at the Walpack Bend, near Decker's Ferry, they are still in full force, and continue so on westward to the vicinity of the Water Gap. West from this the upper half begins to grow quite sandy and pebbly, and the limestone gradually disappears, being replaced by the *Oriskany coarse deposits*, so that at the Lehigh river there remains only 30′–40′ of *limestone* in the entire series.

The following sections of the *Lower Helderberg rocks*, with the overlying *Oriskany*, will illustrate this westward thinning of the former, and thickening of the latter.

The first section (13) is from the vicinity of William Nearpass's quarry, one mile and a half south from the river and about four miles south-east from Carpenter's Point:

Nearpass's quarry section.

1. ***Oriskany***, cherty, limy, fossiliferous shales, ... 50′

Lower Helderberg.

2. Shaly, calcareo-silicious beds, quite fossiliferous at top, and at several horizons, the whole representing the *Stormville shales* of Monroe, ... 150′
3. *Limestone*, massive, cherty, silicious, very fossiliferous, *Pentameras galeatus*, being most abundant, ... 10
4. Shaly, calcareo-silicious beds, mostly concealed, ... 75′
5. Massive silicious limestone, ... 8′
6. *Limestone*, massive, full of large *corals*, *Stromatopora* being very abundant, ... 12′
7. *Limestone*, blue, quarried, containing *Pentomerus galeatus*, and *Tentaculites gyracanthus*, ... 12′
8. Limestone, blackish with concretionary nodules, ... 13′
9. Limestone, shaly, curly, ... 15′
10. *Water Lime* ("Pethstone" of Prof. Cook's section, Geology of New Jersey, pages 155–160,) . . . . 5′
11. Limestone, shaly, and gray at top, more compact and blue below, with concretionary nodules, ... 12′
12. Limestone, shaly, abounding in *fossil corals*, ... 14′
13. Limestone, gray, shaly, full of *crinoidal fragments* and *corals*, 15′
14. Shales, greenish, and shaly limestone, ... 10′
15. *Limestone*, massive, bluish-gray, containing numerous *crinoidal fragments*, *corals*, *&c.*, *Chætetes* being very abundant, ... 10′
16. Shales, calcareous, containing *Atrypa reticularis* and *Chaetetes*, ... 2′
17. Limestone, slaty fracture, non-fossiliferous, much resembling in physical characters the top of the *Bossardville limestone* of Monroe county, ... 3′
18. Concealed to probable base of *Lower Helderberg*, ... 200′

Total of Lower Helderberg beds, ... 566′

Total of Lower Helderberg beds and Oriskany, ... 616′

The structure of the *Lower Helderberg* in eastern Monroe county, is shown by the following partially generalized section (14):

Generalized Section on the Delaware river.

1. *Oriskany sandstone*, consisting of alternating beds of quartz conglomerate, and calcareous chert, ... 50′

Lower Helderberg.

2. *Stormville calcareous shales*, asby, or dark gray, fossiliferous, sometimes cherty and containing limestone at base, . 160′
3. *Stormville conglomerate*, alternating beds of quartz conglomerate, and silicious pebbly limestone, ... 25
4. *Stormville limestone*, cherty, sandy, massive beds, containing numerous *fossils*, *Pentameras galeatus*, *Stromatopora*, *Favosites*, and *Receptaculites* being especially numerous, 75′

5.	*Hydraulic cement* bed ("Peth stone" of Cook) and identical with No. 10 of the preceding section,	5′
6.	Limestone, bluish, shaly, containing vast numbers of *Leperditia alta*, at top,	20′
7.	*Decker's Ferry sandstone*, a very hard, pebbly, often calcareous sandstone, filled with *fossil shells*, *Aviculas*, *Chonetes*, and others,	15′
8.	*Greenish shales*, sometimes calcareo-silicious,	15′
9.	*Bossardville limestone*, divisible into two well-marked subdivisions, (a) of 65′ and (b) of 25′; the upper (a) almost non-fossiliferous, dark blue, or almost black, splitting into slate-like, thin layers; the lowest, (b,) dark-gray, always presenting a banded or striped appearance, and often exhibiting a true *columnar structure* (Stylolites;) thickness of both *a* and *b*,	90′
10.	*Poxono Island shales*, buff, calcareous and magnesian,	200′
11.	*Poxono Island limestone*, bluish-gray, very compact, fossiliferous, extending down to the bottom of the Lower Helderberg on top of the *Clinton red beds*,	5′
	Total of Lower Helderberg,	610′
	Lower Helderberg and Oriskany,	660′

As the exposures are not good in the *Lower Helderberg*, at the western line of Monroe county, the 3rd comparative section is taken from the Lehigh river in Carbon county, 10–12 miles west from the Monroe county line, where these beds are finely exposed along the C. R. R. of New Jersey, one mile below Bowman's station, as shown by the following, (Section 15):

On the Lehigh river.

1.	*Oriskany sandstone*, a coarse, massive, reddish-gray, quartz conglomerate, nearly destitute of fossils,	200′
2.	Cherty, calcareous sandstone containing casts of *fossils*,	10′
3.	Shales, containing some cherty layers together with a few thin beds of sandstone,	60′
4.	Concealed,	20′
5.	Shales, with thin layers of reddish sandstone,	50′
6.	Greenish shales, and calcareous sandstone,	30′
7.	*Bossardville limestone*, blackish, slaty fracture, filled with streaks of calcite,	40′
8.	*Poxono Island shales*, buff, gray, and greenish, calcareous, variegated with red near the base,	225′
	Total Oriskany and *Lower Helderberg*,	635′

The dividing line between the *Oriskany* and *Lower Helderberg* is not definitely located in the above section, from 9 G⁶.

the fact that the whole *shale series* of Nos. 2, 3, 4 and 5, is a transition series probably as nearly related to one as another of those groups, though the *reddish color* of the sandstone in No. 5, would seem to ally the interval more closely with the *Oriskany*. They are perhaps identical with what has been termed the *Oriskany shale*, a series of *red beds* which underlie the *Oriskany sandstone* in central Pennsylvania. Regarding this portion of the section (Nos. 2–5, inclusive,) as belonging to the *Oriskany*, and summarizing the three sections we get the following:

	Lehigh river.	*E. Monroe.*	*East line of District.*
Oriskany,	340′	50′	50′
Stormville beds,	—	260′	295′
Hydraulic Cement bed, "*Pethstone*" of Cook,	—	5′	5′
Decker's Ferry beds,	30′	50′	—
Bossardville limestone,	40′	90′	66′+
Poxono Island beds,	225′	205′	200′?
Total,	635′	660′	616′

From this summary it will be readily perceived that the 340′ of *Oriskany* (No. VII) on the Lehigh has probably originated from the gradual conversion of the upper half (*Stormville beds*) of No. VI at the east into genuine *Oriskany rocks* toward the west; for if we add the *Stormville beds* at the eastern line of Pike county and in E. Monroe to the *Oriskany* at those localities, we get 345′ and 310′ respectively; and this approaches so near to the thickness of the *Oriskany* on the Lehigh river (340′) that the origin suggested above for the Lehigh river *Oriskany* may be regarded as highly probable; *i. e.* The *Stormville limestones* and *calcareous shales*, which at the eastern line of the district belong in the *Lower Helderberg series*, gradually change their characters, lose their fossils, and assume the typical *Oriskany character* when traced through the district to the south-west. And this shows that the *Oriskany beds* of this district at least are very intimately connected with the rocks of the *Lower Helderberg series*; in fact so intimately connected as to be coetaneous deposits; the one (*Lower Helderberg*) or at least the main mass of it, accumu-

lating as marine deposits in the open sea, while the other (*Oriskany*) was forming along the shores and beaches of the same. Of course this does not hold true for the uppermost portion of the Oriskany; for, when the *Lower Helderberg sea bottom* was elevated at the close of the period, the littoral life-forms which had previously inhabited its beaches then spread quite widely over the extensive shallows thus formed.

This intimate relation of the *Oriskany* and *Lower Helderberg deposits*, although proven strictly for only the limits of this district, seems to hold equally well for other portions of Pennsylvania, New York and West Va.; so that, looking at the matter from this standpoint, Prof. Dana's classification, which makes the *Oriskany* the closing Period of the *silurian* rather than the beginning of the *Devonian* (after Newberry and others) is preferable. We thus understand why there should be such a mingling of *Lower Helderberg life forms* in the *Oriskany deposits*; the consideration of this fact alone led Hall to place the *Oriskany beds* in the *Silurian*.

Having thus glanced briefly at the *Lower Helderberg rocks* as a whole, I shall enter into a more detailed description of the different members of the series, using for this purpose the Monroe county section, (14,) to which reference is always made in the following paragraphs unless otherwise stated:

The Stormville Shales.

These top the series in eastern Monroe, and south from Pike county in New Jersey, a succession of ashen-gray, calcareous layers, often quite cherty, and sometimes containing so much lime as to make beds of impure limestone; fossiliferous, *Spirifer macropleurus* being quite abundant near the top of the beds in Monroe; seen finely exposed along the N. Y. S. & W. R. R. and also the D. L. & W. R. R. where they pass through Walpack ridge, along the gap of Brodhead creek, and numerous other localities to which appropriate references are made in the detailed, or township report. They are also quite well exposed in the southern face of Walpack ridge, just north from the village of Storm-

ville, at the eastern line of Hamilton township, Monroe county, from which locality they have been designated; thickness about 160′.

The Stormville shales are represented at the eastern extremity of the district by No. 2 of section 13, which is there about 150′ thick and very fossiliferous in its upper portion, especially the famous "Trilobite ledge" of Dr. Barrett, which occurs at its upper limit. From this uppermost portion Dr. Barrett has collected the following species identified by Hall: *Dalmanites dentatus* Barrett, *Dalmanites pleuroptyx*, *Chonetes complanata*, *Rensselaeria mutabilis*, *Tentaculites* sp?, *Loxonema Fitchiana*, *Hyolithes centennialis* Barrett, *Pterinea textilis*, *Strophomena rhomboidalis*, *S. Conradi*, *Strophodonta cavumbona*, *Cyrtia rostrata*, *Orthis subcarinata*, *Discina Conradi*. The following species from this same horizon were identified by Dr. Barrett: *Homalonotus Vanuxemi*, *Platyceras retrorsum*, *P. Gebhardii*, *Holopea sp? Spirifer concinnus*, *S. cyclopterus Orthis oblata*, *O. perelegans*, *O. planoconvexa*, *Discina discus*, *Favosites conica*.

The uppmost layer, about 5′–10′ thick, is filled with *fragments of trilobites*, heads, pygidia, &c., and from this Dr. Barrett obtained his *Dolmanites dentatus* described in the Amer. Jour. Science, vol. XI, March, 1876.

As already stated these *Stormville shales* grow buff and sandy when traced westward from the centre of Monroe county, and as seems most probable become continually coarser until they are consolidated with the *Oriskany sandstone*.

Stormville conglomerate.

By this name I have designated a series of alternating beds of quartz pebble rock, and pebbly limestone, which are well exposed immediately below the *Stormville shales* in the vicinity of Stormville.

In the section, (Fig. 13) at the eastern line of Pike, this stratum does not make its appearance, but where these measures cross from New Jersey into Pennsylvania at Walpack Bend the *Stormville conglomerate* is present as a

thin pebble rock 5′–6′ thick. Traced further to the south-west it grows more massive and attains a thickness of 15′ on Brodhead creek, being well exposed just under the bridge across that stream, a short distance below Experiment Mills. South-west from this the quartz pebbles seem to invade the underlying limestone as will be seen from the following section (16) which represents its constitution at Stormville:

Stormville section, (16.)

1. Sandstone, calcareous, containing numerous small quartz pebbles,	10′
2. Conglomerate, very hard, pebbles small,	2′ 6″
3. Pebbly limestone,	5′
4. Sandy limestone,	5′
5. Limestone full of *Pentameras galeatus*,	10′
6. Limestone, sandy with many quartz pebbles,	15′
	47′ 6″

The Stormville conglomerate is represented only by Nos. 1, 2 and 3, of the above section, the other numbers forming a portion of the *Stormville limestone*, here invaded by quartz pebbles, but free from them east of Brodhead creek.

It seems quite probable that the *Stormville conglomerate* becomes finally connected with the *Oriskany sandstone* westward from Stormville through the intervention of the *Stormville shales* which grow coarse toward the west. In fact the 200′ feet of massive conglomeratic *Oriskany* on the Lehigh river in Carbon county seems to represent the *Oriskany*, the *Stormville shale* and the *Stormville conglomerate* of section 14.

Stormville Limestone.

The above name has been applied to a series of massive, heavy-bedded, impure limestones which intervene between the base of the *Stormville conglomerate* above and the persistent bed of *hydraulic cement* below, the whole varying in thickness in eastern Monroe from 75′ to 100′. The limestones are very *fossiliferous*, *Pentameras galeatus* being especially numerous at the top of the series, while large *corals*, *Stromatopora*, *Fovosites*, *Receptaculites*, &c., are very abundant near the middle.

In the section south from Port Jervis, at the eastern line

of Pike, (13,) the *Stormville limestone* is represented by the several beds from Nos. 3 to 9 inclusive, the whole having a thickness of 145′. The lower portion is extensively quarried at Bennett's in New York, and the Nearpass quarries in New Jersey, a short distance to the south-west.

From various horizons in this 145′, Dr. Barrett has obtained the following species identified by Prof. James Hall: *Beyrichia notata*, *Megambonia ovoidea*, *Spirifer Vanuxemi*, *S. macropleurus*, *Strophodonta varistriata*, *S. punctulifera*, *Pentamerus galeatus*, *Merista laevis*, *Streptelasma striata*, *Rhynchonella ventricosa*, *Platyceras retrorsum*, *Pterinea sp?* *Dalmanites pleuroptyx*, *Phacops Logani*, *Tentaculites elongatus*, *Fovosites Helderbergia*. The following species were identified by Dr. Barrett from the same portion of the series: *Leperditia alta*. *Tentaculites gyracanthus*, *Loxonema Fichiana*, *L. obtusa*, *Holopea antiqua* *H. elongata*, *Spirifer perlamellosus*, *S. modestus*, *S. cyclopterus*, *Rensselæria mutabilis*, *Eatonia medialis*, *E. singularis*, *Trematospira multistriata*, *Stophodonta Beckii*, *Strophomena rhomboidalis*, *Leptæna concava*, *Orthis multistriata*, *O. oblata*, *Lingula sp?* *Atrypa reticularis*, *Favosites Niagarensis*, *Stromatopora* several species, *Lichas pustulosus*.

The Stormville limestone, after crossing the Delaware river from New Jersey into Monroe county, Pa., at the Walpack Bend, continues south-westward, making the southern slope of Walpack ridge. It is seen forming a bold line of massive cliffs from where it rises out of the river above Decker's Ferry south-westward often rising to a height of 300′–400′ above the Delaware river, in massive layers 10′–20′ thick, which dip rapidly south-eastward toward the river. It is this rapid dip which gives the almost vertical outline of the southern slope of Walpack ridge. In some of these cliffs, midway in the series, very large *fossil corals* occur just like those in No. 6 of Sect. 13 at the Nearpass quarries in N. Y. and N. J. with which this portion of the series is undoubtedly identical.

This limestone is usually gray, crystalline, often somewhat silicious, hence has seldom been quarried, since the

purer *Bossardville limestone* is generally accessible wherever the former is exposed.

Mr. J. D. LeBarr has quarried the lower portion of this series, in Smithfield, and burned it into lime. Specimens taken from this quarry gave the following results when analyzed by Messrs. McCreath and Stinson:

	I.	II.	III.
Carbonate of lime,	90.785	89.821	92.364
Carbonate of magnesia,	1.241	1.513	1.362
Oxide of iron and alumina,	0.720	0.910	0.590
Sulphur,	0.045	0.095	0.094
Phosphorus,	0.005	0.015	0.006
Insoluble residue,	6.850	7.030	5.540

Two other specimens, analyzed also in the Laboratory at Harrisburg, gave the following:

	I.	II.
Carbonate of lime,	97.053	74.928
Carbonate of magnesia,	1.513	2.240
Oxide of iron and alumina,	0.340	2.560
Sulphur,	.018	—
Phosphorus,	.009	—
Insoluble residue,	1.240	19.730

I. From the vicinity of Decker's Ferry.

II. From near Stormville, Hamilton township.

The ignited insoluble residue of the Hamilton township specimen gave the following:

Silica,	16.540
Oxide of iron and alumina,	0.880
Lime,	0.080
Magnesia,	0.194

The last specimen illustrates quite well the way in which this limestone grows sandy towards the south-west; and this change is continued until at the western line of Monroe there is very little limestone left in these beds, and none whatever at the Lehigh river, where its place is represented by the *Oriskany shales* seen in Sec. 15, Nos. 2–5, inclusive. Some horizons in these beds contain considerable chert, very much like that seen in the *Corniferous limestone*; and these cherty layers are about the only portion of the *Stormville beds* recognizable on the Lehigh river, immediately under the *Oriskany sandstone*. The shaly, sandy layers next below have there a *red color* which allies the whole interval on the Lehigh, with the *Oriskany*, as already stated.

Stormville hydraulic cement bed.

Immediately below the *Stormville limestone* just described, there occurs a bed of *water lime* which seems to be quite persistent from the extreme eastern line of the district south-westward beyond the center of Monroe county, or at least as far as Stormville, from which locality the stratum in question was designated. It is seldom over 5′ thick though occasionally attaining to 10 feet. The rock is usually of a pale-buff color, and breaks with the peculiar earthy fracture characteristic of hydraulic limestones; non-fossiliferous, although just under it millions of *Leperditia alta* are found. At the eastern line of the district, this bed is represented in section 13, by No. 10, (the "Pethstone" of Prof. Cook's section,) which is an exact copy of the *Stormville cement bed* of Monroe, and undoubtedly identical with it, thus furnishing a splendid horizon for correlating the members of the N. Y. and N. J. section (13) with those of Monroe county.

This bed is seen in the steep slope of the hill facing the Delaware river near Decker's Ferry, at the eastern line of Monroe, and at numerous localities from there on, south-westward to Stormville.

The following analysis of specimens from several localities in Monroe show the composition of the *Stormville cement bed* as determined by Messrs. McCreath and Stinson:

I. Near Decker's Ferry, Middle Smithfield, Monroe co.
II. Same locality, Middle Smithfield Tp., Monroe county.
III. Land of J. DeWitt, " " "
IV. " " " " "
V. Stormville, Hamilton Tp., Monroe county.

	I.	II.	III.	IV.	V.
Carbonate of lime,	38.910	36.428	37.714	37.107	43.839
Carbonate of magnesia,	23.724	17.481	25.351	26.410	29.664
Oxide of iron,	3.357	3.285	6.290	3.357	2.607
Alumina,	4.163	7.735		3.673	3.653
Sulphur,	.065	——	.113	——	——
Phosphorus,	.038	——	.027	——	——
Insoluble residue,	27.420	28.720	29.690	28.460	17.560

The "insoluble residue" in each of the above after ignition gave the following:

	I.	II.	III.	IV.	V.
Silica,	24.150	23.940	24.850	23.970	13.630
Oxide of iron and alumina,	2.500	2.740	2.450	2.740	2.040
Lime,	0.220	0.110	0.260	0.090	0.120
Magnesia,	0.404	0.183	0.490	0.227	0.144
Totals,	27.274	26.973	28.050	27.027	15.934

The *water lime* of the N. Y. *Lower Helderberg* analyzed by Dr. Beck gave the following: Carbonate of lime 48.4, carbonate of magnesia 34.3, silica and alumina 13.85, peroxide of iron 1.75, moisture and loss 1.70.

No attempt has ever been made to manufacture *hydraulic cement* from this bed so far as I could learn; but it would seem from the composition given above that portions of this stone might be selected which would make a very fair cement. At the locality where specimens III and IV were obtained the bed is 10′ thick, so that some of it would almost certainly make *hydraulic cement.*

What are the relations of this widely persistent *cement bed* to the famous *water lime* at Kingston and Rondout is a question which naturally presents itself to the reader. It is well known that the *water lime* at Rondout, on the Hudson river, rests directly on the *Medina sandstone* there being nothing there to represent the lower half of the Monroe county *Lower Helderberg.* I am inclined to believe from all the evidence in the case that the *Stormville water lime* is identical with the *great water lime bed* at Rondout, Kingston and Rosendale, N. Y.

Decker Ferry limestone.

The Stormville water lime rests on a bluish gray, usually brecciated limestone, which contains on its upper surface vast numbers of *Leperditia alta*, the only horizon at which I have seen this fossil anywhere in the district. This limestone often becomes slaty in its lower portion, and is usually more or less sandy, thickness about 20′.

Iron Ores of No. VI.

Iron ore occurs at the horizon of the *Decker's Ferry limestone* and in the base of the overlying *Stormville limestone*, in Ross township, Monroe county, one mile and a half west from Saylorsburg.

The ore has been opened and developed to a small extent by Messrs. Nelson Le Barre, of Portland, Pa., and R. M. Jones of Bangor, the discovery of the *ore* on the land of Mr. Samuel Lessig being due to the intelligent prospecting of the former.

At the most eastern exploitation shaft a large body of "*flat ore*," or thin layers of *brown hematite* standing vertical, has been followed to the depth of 48′, the thickness of the several layers being 14′ according to the statement of Mr. Le Barre. This ore lies 5′ to 8′ above the *Decker's Ferry sandstone*, which forms a prominent ridge-like outcrop just south from the *ore*, and is thus an excellent guide to exploitation, of which Mr. Le Barre has taken advantage in his search for the ores.

Specimens collected from this horizon, and analyzed by Mr. McCreath, gave the following results:

	I.	II.
Iron,	41.500	39.425
Sulphur,	0.030	0.007
Phosphorus,	0.305	0 321
Insoluble residue,	23.500	26.730

About one fourth mile south-west from the locality just described, another large excavation has been sunk to the depth of 38′, in which a considerable body of *iron ore* and yellowish impure *ochre* has been found. This horizon is in the *Stormville limestone*, probably about 75′ above the top of the *Decker's Ferry sandstone*. The *ore* is quite silicious so far as exposed; but some of it, known as "bomb-shell" (from its rounded nodules with hollow center), seems not so objectionable in this respect.

Specimens from this last locality were analyzed by Messrs. McCreath and Stinson with the following results:

	I.	II.	III.
Iron,	29.100	39.000	31.375
Sulphur,	0.013	0.020	0.014

Phosphorus,	0.111	0.079	0.177
Insoluble residue,	44.005	27.940	38.365

From these analyses, it will be seen that some of the *ores* may prove quite valuable on further development, especially those lying down near the *Decker's Ferry sandstone.* Of the *ores* explored at the upper horizon, none are pure enough to warrant mining except the "bomb-shell," or II of the preceding analyses.

Much *ochre* is found interstratified with the iron ore at the last locality, a specimen of which yielded the following:

Silica,	57.400
Alumina,	19.033
Sesquioxide of iron,	10.107
Lime,	0.100
Magnesia,	1.740
Water,	6.458

The origin of these *ores* and *ochres* seem to be closely connected with the disintegration of the great *Oriskany sandstone*, just above (north of) them. As already stated, this greatly thickened iron-bearing sandstone is completely disintegrated into a great bed of loose sand and clay in the vicinity of Saylorsburg, and for two miles west from that village. The breaking down of this sandstone seems to have furnished the *iron* which was transferred to the layers of *No. VI* below, the most of the lime from which had been previously removed by solution, or else was removed *pari passu* with the transfer of the iron of the disintegrated sandstone above. This is proven from the fact that the *sand deposit* is entirely decolorized, while the *ore* has the same dip and stratified condition as the layers of other unmodified rock above and below. Then, too, just west from this, on the land of Mr. Lessig, the *Oriskany sandstone* is not disintegrated, the ridge rising to an elevation of 1200′ A. T., or nearly 400′ above its general elevation between Saylorsburg and Lessig's. No *iron ore* is found below the *Oriskany*, west from Lessig's, though the *sandstone* itself contains so much that some one has attempted to explore it for *ore* in the summit of Lessig's Knob.

Just south from Kunkletown, in Eldred township, the

ridge breaks down to a much lower level than it has just east and west, and the *Oriskany* is there found to be disintegrated to an unknown depth; so that it is possible that *Iron ore* might be found there by proper exploration in the southern face of the ridge.

The *Ochre beds* certainly originated by the removal of lime by solution from the layers of the impure *Stormville limestone*; in fact it is a common thing to see a coating of *Ochre* adhering to the weathered outcrops of many of the limestone layers in *No. VI*; so that it is possible the iron in the ochre analyzed represents only that already in the rocks previous to removal of the lime.

The Ochre is of a dull yellowish color, and could possibly be used in the manufacture of mineral paints, though no tests for that purpose have ever been made.

Decker's Ferry sandstone.

Just above the road leading south-west from Decker's Ferry, there occurs a low cliff of grayish-white, pebbly, calcareous sandstone, crowded with *fossil shells*. It was found to be remarkably persistent throughout Monroe and has been designated the *Decker's Ferry sandstone*. It is often seen along the Delaware river between Decker's Ferry and the Water Gap, and although not always pebbly, it is universally fossiliferous. The species are very poorly preserved however, the tests having been removed by solution, so that the only generic identifications made were of a small *Chonetes*, and a large *Avicula* with undulate margin.

This sandstone is seen forming a bold cliff along the southern face of Walpack ridge, one mile north from Water Gap station on the D. L. and W. R. R., and may be examined in the hill immediately above the Experiment Mills limestone quarry, where it juts out in a massive, pebbly cliff 10′–15′ high.

At Stormville it occurs in the field just above the Stone House, and is there a very hard grayish-white sandstone with small pebbles, filled with fossils as usual, the rock itself dipping about 75° N. 20° W.

This stratum is last seen as a massive, pebbly sandstone,

in Ross township, just west from Saylorsburg, where it is an excellent guide to the *iron ores* of No. VI, as stated above. The average thickness is about 15′, though at times it attains to 25′.

On the Lehigh river, this stratum seems to be represented at one of the limestone quarries, one mile and a half above the Water Gap, by a massive, greenish, calcareous sandstone 20′–30′ thick, though no pebbles were seen in it there. The *Decker's Ferry sandstone* has no representative at the eastern line of the district.

Decker's Ferry shale.

A bed of greenish-gray shale, often limy, underlies the sandstone above described, and as it is well exposed at the road-side, near Decker's Ferry, has been named from that locality.

The interval has an average thickness of 15′, and the greenish color seems to be remarkably persistent, since a bed of *green shale* or *shaly limestone* occurs at this horizon everywhere in Monroe county and seems to extend through to the Lehigh river in Carbon, since a *green shale* occurs above the *Bossardville limestone* on that river.

This bed cannot be certainly identified in the section at the eastern end of Pike county, though from the *greenish cast* of No. 14 in section 13, it would seem to be referable to this horizon.

A bed of water lime 5′ thick occurs in this interval near J. DeWitt's in Middle Smithfield township.

Bossardville limestone.

Just under the last described bed, there occurs a thick stratum of *limestone* which I have termed the *Bossardville limestone* from the village of that name in Hamilton township, Monroe county, where it is most extensively quarried.

All the great limestone quarries of Monroe are in this rock, and it furnishes practically all the lime burned in the county.

Its top comes out of the Delaware river just above Deck-

er's Ferry and it is quarried at the roadside on the bluff of the river west of the Ferry.

The thickness of the interval varies from 75′–100′ and is divisible into two portions, an upper and a lower, which are very unlike in aspect and composition. The upper or *quarry portion* is usually about 65′ thick, and has a prevailing dark color, sometimes almost black, the extreme upper portion excepted, which is generally gray or bluish-gray; through the dark portion especially radiate *seams of calcite*; the rock breaks with a very sharp angular fracture and has a thin flag-like bedding, and is entirely non-fossiliferous, if we except minute dark specks which may be *Beyrichia.*

This *quarry portion* of the *Bossardville limestone* is the only limestone bed of No. VI which extends through from this district to the Lehigh river. The *Bossardville limestone* has a thickness of 30′–40′ where it crosses the Central R. R. of New Jersey, one mile below Bowman's station. It possesses the same physical characters there that distinguish it in Monroe.

The equivalency of this limestone at the eastern line of the district, in section 13, is uncertain, since the base of No. VI is there concealed for 200′ or more. In the lowest exposure of No. VI at the Wm. Nearpass quarry, 3 feet of gray limestone is seen, with the peculiar, slaty, or slab-like structure so characteristic of the *Bossardville beds*; hence it is possible that the main mass of *Bossardville limestone* may be concealed in the top of No. 18, section 13.

Samples of the *Bossardville quarry limestone* were collected at several localities, and analyzed in Mr. McCreath's laboratory at Harrisburg:

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Carbonate of lime,	94.285	87 928	82.732	93.267	93.875	88.821	94.285	92.196
Carbonate of Magnesia,	1.528	1 937	2.830	1.384	1.309	2.345	2.118	2 171
Oxide of Iron and Alumina,	0 700	2 110	1.360	0.840	0.680	0.710	0.540	1 100
Sulphur,	0.056	0.229	*.895	0.118	0.153	0.207	0.207	0.154
Phosphorus,	0.014	0.019	0.007	0.010	0.010	0.013	0.015	0.020
Insoluble residue,	2.850	7.860	11.930	4.250	3.920	7.650	3.020	4.260

* Average of two determinations.

I, II. From Bossardville quarries, Hamilton township, Monroe county.

III, IV, V, VI. From C. Van Auken's quarry, Middle Smithfield township, Monroe county.

VII, VIII. From J. H. Brown's quarry, Smithfield township, Monroe county.

The limestone from this horizon burns readily into a light-gray lime, much valued for agricultural and building purposes, though it is seldom white enough to be used for plastering. At Bossardville and vicinity, several hundred thousand bushels are annually burned and hauled far and wide into the surrounding country.

The opinion prevails among the farmers that this limestone is occasionally absent for long distances, coming in again suddenly; thus for instance, no quarry of it has been opened between that near Experiment Mills, on Brodhead, and one mile west of Stormville in Hamilton township, a distance of nearly five miles; hence the farmers along this line believe it absent. The truth is that there are no *natural* exposures here because the limestone is buried by drift and surface débris, shed from the steep slope of Walpack (Godfrey's) ridge, since its line of outcrop would nearly always be found down along the northern margin of Cherry valley. Hence this valuable limestone is very probably present on every farm, but covered up. The farmers owning land along the northern margin of Cherry valley, should do some judicious digging in order to test the matter.

In passing south-westward from Bossardville, this limestone's outcrop is again covered up by the vast heaps of *Oriskany débris*, and is not seen again until we pass west from Saylorsburg into Ross township. There in the vicinity of Samuel Lessig's the *Bossardville limestone* has been quite extensively quarried, though it is not so thick as usual nor so pure, and has been so much crumpled and folded as to have a slaty cleavage and aspect, being in fact partially metamorphosed.

From the vicinity of Lessig's, this limestone is not seen again until we come to the neighborhood of Kunkletown, in Eldred township, its outcrop being constantly concealed

under surface débris, principally of *Oriskany sandstone*. West from Kunkletown, however, the great *Oriskany beds* are disintegrated, and the limestone then comes out to the surface, where it is quarried, and burned quite extensively. It is much twisted and contorted, however, so that it is difficult to decide which way the dip is going. It is of course possible that the limestone may be entirely absent in the intermediate spaces where it makes no appearance on the surface, but the probabilities are that it is present, concealed under the great heap of débris.

The lowest 25′ of the Bossardville limestone is very different in aspect from that portion usually quarried for lime, having a dark-gray color, and a peculiar banded appearance made by fine lines of lamination of different colors, gray, whitish, blue, &c. It also often possesses a genuine *columnar structure* which is finely shown at the Experiment Mill's quarry, above the Delaware Water Gap, where the rock exhibits a *prismatic structure*, like basaltic columns. This structure does not exist all through the 25′, but is confined to certain layers, the one exhibiting it most decidedly coming 7′ above the base of the stratum and having a thickness of 3′. The columns or *stylolites* are inclined to the south-east at an angle of 75′, while the dip of the rocks is only 35′ in the same direction; thus it is probable that the structure in question has originated through the action of the forces that produce *cleavage*, because the rocks which exhibit it show no traces of over heating.

The same structure is seen just below the falls at Shawnee in Smithfield township, though the limestone exhibiting it there comes higher in the series than the one at the base of the *Bossardville beds*. This stratum, in physical appearance, answers perfectly to the description of Prof. Cook's *Ribbon limestone* which is found at the base of the series in New Jersey; although many of the layers in the *Stormville limestone* often possess the *ribboned* aspect.

A specimen of the *columnar limestone*, from the Experiment Mill's quarry, had the following composition, as analyzed by Mr. McCreath:

Carbonate of lime,	73.428
Carbonite of magnesia,	2.648
Oxide of iron and alumina,	2.970
Insoluble residue,	20.240

From this analysis, one might infer that it would make a pretty fair *hydraulic cement*, and I was informed that the limestone was tested for that purpose on one occasion at Bossardville, where it shows under the quarry limestone. It is reported as having made a very good hydraulic cement.

The entire absence of fossils from this *Bossardville limestone*, having so great a thickness (90′) and so wide an extent, is quite curious, if it does really belong in the *Lower Helderberg series*. Since the structure known as *Stylolites* is quite common in the *Niagara limestone*, I was at one time inclined to believe that the *Bossardville beds* might possibly belong to that period, since Dr. Barrett claims to have found *Halysites catenulata*, and many other *Niagara forms* in the limestone of the lower portion of the section represented by Sect. 13, but there are so many obvious objections to this view of the matter that I consider it very improbable.

The Poxono Island shales.

Directly under the *Bossardville limestone*, there occurs a series of buff, greenish-gray and variegated calcareous shales, which are well exposed at only one locality in the district, viz: opposite Poxono Island, on the steep northern bluff of the Delaware river, in Middle Smithfield township; and they have been designated from that place.

They are tolerably well exposed along the Delaware river at the eastern line of Smithfield township; but only the top is seen at the Experiment Mill's quarry on Brodhead.

They are also seen along the road crossing Cherry valley to Kemmererville, one mile west from Stormville, in Hamilton township.

Just west from this Featherman's creek makes rapids and falls over the same beds.

At all these localities they are characterized by the same buffish-gray color, with often a tinge of greenish white, also varying to reddish in thin streaks; the series being entirely

non-fossiliferous, and changing much in the quantity of calcareous matter contained. The beds seem to be more or less magnesian, as the following analyses by Mr. McCreath will show:

	I.	II.	III.
Carbonate of lime,	20.714	36.285	48.392
Carbonate of magnesia,	12.259	16.164	27.091
Oxide of iron,	3.857	3.785	3.285
Alumina,	12.418	7.275	3.125
Sulphur,	0.182	——	——
Phosphorus,	0.044	——	——
Insoluble residue,	42.950	31.440	17.210

The ignited "insoluble residue" of I gave the following:

Silica,	37.170
Oxide of iron and alumina,	3.260
Lime,	0.090
Magnesia,	0.295

I, II. From J. Turn's land, Middle Smithfield tp.
III. From J. H. Brown's land, " "

The thickness of the *Poxono Island shales*, is, in Monroe county, about 200′; certainly not less than this, and possibly more; but owing to a varying dip they could not be measured with exactness.

On the Lehigh river, these beds are well exposed along the cuts of the C. R. R. of New Jersey, one mile below Bowman's station; where they are nearly vertical, and still preserve their buffish-gray and greenish-cast, though they are variegated with thicker *red bands* than eastward. The rocks of this interval have there a thickness of 225′.

These beds are referred to the *Lower Helderberg* simply because they seem to be more closely related to them than to any other group, since there is no evidence that the *Salina beds* were ever deposited in this district, though the shaly, marly and variegated nature of these rocks closely resemble some portions of the *Salina series*.

Poxono Island limestone.

The buff, calcareous, shaly beds above described are terminated below by a very hard, bluish-gray, crystalline limestone seen at only one locality in the district, viz: In the steep bluff opposite Poxono Island, hence the designation.

Whether this be a local or persistent limestone could not be determined, since its horizon is covered up everywhere in the district except at this single locality.

It is only 5′ thick, and comes in thin fossiliferous layers containing multitudes of Beyrichias, and many undeterminable fragments of *other shells*, all of which are small however.

Its composition is shown from the following analyses:

	I.	II.
Carbonate of lime,	90.178	89.392
Carbonate of magnesia,	4.313	3.254
Oxide of iron and alumina,	1.110	1.260
Sulphur,	0.251	0.267
Phosphorus,	0.010	0.013
Insoluble residue,	3.610	5.940

Both I and II are from the steep bluff opposite the upper end of Poxono Island, in Middle Smithfield township, Monroe county.

Neither this limestone nor any portion of the calcareous shales above was seen at the eastern extremity of Pike, for the reason that everything is there concealed at the horizon, and, according to Prof. Cook, State Geologist of New Jersey, remains entirely covered up through the 30 miles of outcrop in that state between its north-eastern line and the Delaware river at Decker's Ferry.

Greenish shales, about 5′ thick, underlie the *Poxono Island limestone*; and directly under them come *deep red shales* of great thickness; so that the limestone in question is certainly the lowest member of the *Lower Helderberg* series, if the last 300′ of rock really belong to that period.*

No. V. The Clinton red shale.

Red shales, of a deep dull color underlie the *Poxono Island limestone*, or rather the 5′ of green shales immediately below that limestone.

[*Prof. H. D. Rogers considered the *Niagara formation* as present in Eastern Pennsylvania along Walpack ridge, and as absent throughout the rest of the State. Mr. C. E. Hall found *Niagara* fossils mixed up with *Clinton* forms in the Juniata river region. The reports of Prof. Claypole on the fossils of Perry and Juniata counties will probably go a considerable distance towards a final classification.—J. P. L.]

The top of this series and its relations to the beds of *No. VI*, can be seen at only a single locality in the district, viz: in the steep bluff opposite the upper end of Poxono Island, where 75′ of *dull red shale* containing many greenish spots (copper?) occur immediately under the *Pocono Island limestone*, the latter coming along the top of a steep bluff, while the *red shales* continue on down the face of the same to the Delaware river and across it to the New Jersey shore. In fact the main portion of the Delaware's channel from Decker's Ferry to the mouth of Cherry creek, just at the entrance to the Water Gap, is scooped out of these soft red shales.

They extend south-westward along the valley of Cherry creek which they underlie, and, continuing on across the low divide at the head of the latter stream, pass down the valley of Aquanchicola creek to the Lehigh river just above its Water Gap.

The same soft red shale formation also makes a valley through New Jersey along the channel of Flat Brook creek from Decker's Ferry north-eastward to near its head, where crossing a low divide to the head of Mill Brook it continues the valley north-eastward to the Erie R. R. two miles south-east from where the latter crosses the Neversink river.

Since these red rocks are thus constantly found along drift-filled valleys, no exposures of them occur which can afford any reliable measurements; hence the thickness given in the general sections A, B, C, D, viz. 600′, 900′, 1200′, and 2000′ respectively are for the most part mere estimates from the breadth of the valleys these beds make at the different localities, combined with the dip of the rocks above and below (Nos. VI and IV). [See Chance's report.]

At Rondout, on the Hudson river, these beds are entirely absent, the lowest layers of VI resting there directly on grayish-green sandstones much resembling the *Medina rocks* of this district.

Not a single fossil of any description was seen in these red rocks; and their barrenness of organic forms doubtless accounts for the fact, that their *iron* is uniformly disseminated through the shales instead of being collected into *ore*

beds, as in northern N. Y., Middle Pennsylvania, Va., W. Va., and other regions where the evidence of organic life is always abundant. (See report F on the *Clinton Fossil ore-beds* of the Juniata.)

The following analyses (Survey Laboratory) shows the composition of these *red shales* from a specimen obtained 50′ below the top of the same in the vicinity of Poxono Island:

Silica,	58.240
Alumina,	19.926
Sesqui-oxide of iron,	8.214
Lime,	0.470
Magnesia,	2.623
Phosphorus,	0.038
Water,	3.700

The whole series would probably average quite as much iron as was found in this specimen; so that if all the iron in the 2000′ of red beds on the Lehigh could be collected into one mass, it would make a solid bed of metallic iron more than 50′ in thickness; hence it is not for lack of iron that no *ores* occur in these measures throughout the district, but for lack of organic life to concentrate it in layers.

No. IV. The Medina sandstone.

A series of greenish-gray sandstones often interstratified with red, sandy layers, the sandstone frequently exhibiting scattered pebbles of quartz, underlies the *Clinton red shales*.

These beds are exposed in detail at only one locality in the district, viz: along either bank of the Delaware river in its passage through the Water Gap. They there exhibit several small flexures and one of considerable size at Water Gap station. An accurate measurement of their thickness will be given in Mr. Chance's report in an appendix.

No fossils whatever were seen in this series.

The grayish-green sandstones which underlie the limestone of No. VI. at Rondout, on the Hudson river to have a lithological aspect very similar to the *Medina sandstones* of this district.

The Oneida Conglomerate.

(*Lower part of No. IV.*)

The greenish-gray and reddish sandstone of the Medina epoch, containing scattered patches of small quartz pebbles are terminated, quite abruptly, below, by the appearance of very hard, massive, gray rocks, containing vast quantities of quartz pebbles many of them quite large with no *red* rocks whatever. I am disposed to place at this horizon the dividing line between the *Medina sandstone* and *Oneida conglomerate.*

This latter series consists of layers of dark gray conglomerate, 1′–10′ thick, of extreme hardness, extending down to the *No. III slates* upon which the *Oneida beds* rest *unconformably* beyond question.

Unconformity of IV on III.—This *unconformity* is finely shown at a cut on the Erie R. R. one mile west from Otisville in New York, where the line of contact is cleanly exposed, the beds of No. III dipping N. N. W. 43°, while the *Oneida conglomerate* layers dip only 28° in the same direction. The erosion of the *No. III slates* is plainly exhibited at the line of contact, and also by the chips of black slate scattered through the bottom rocks of the *Oneida* for 300′–400′ above its base.*

In the Delaware Water Gap, the horizon of contact between these two series is covered up by great heaps of *Oneida* débris, so that no evidence either of conformity or unconformity can there be obtained. But at the Lehigh Water Gap exposures of each series are seen within a few feet of each other, and give for the dip of the *Oneida beds* 30°–32°, while those of No. III dip 45°–47° the same difference (15°) that was found at Otisville, 80 miles to the north-

[* The sudden termination of the Kittanning or Blue mountain before reaching the Hudson river may be explained by supposing an ancient shore line of No. III trending north and south; but it looks much more like one of those cross faults so common in Southern Virginia and E. Tennessee. No such coast line could furnish the materials for the conglomerate; therefore the chips of slate must be otherwise explained. The apparent nonconformability of IV on III at the Schuylkill Water Gap is so plainly a *fault*, that the same structure (*fault*) should be assigned to the alleged *nonconformability* at the other gaps.—J. P. L.]

east. Many fragments of the *black slates* of No. III are also found in the basal members of the Oneida at the Lehigh Gap, as well as at the Delaware Gap, so that the proof seems conclusive that along the Blue mountain region of this district atleast, the *Upper Silurian* rests unconformably on the beds of the *Lower Silurian.**

The Erie R. R. in passing westward from the junction of IV and III, cuts a nearly perfect exposure entirely through the *Oneida beds*, and by a very careful measurement there I make the thickness 750′.

Another measurement roughly made in the Lehigh Water Gap gave me about the same thickness, so that it may not be far out of the way to place the combined thickness of the *Medina* and *Oneida beds* through this district at 1500′, or say 750′ for each.

The *Oneida rocks* make the summit of the Blue mountains (called Shawangunk in New York) from Otisville south-westward to the Lehigh river; and their great hardness and indestructibility have preserved that range from erosion to so great an attitude (800′–1000′) above the soft measures north (Nos. V & VI) and south (No. III) from the same. The same characters have preserved the Delaware and Lehigh Water Gaps as narrow gorge-like gateways for ages, they having been but inappreciably widened except at the top, during all the lapse of time since the rivers first trenched through them down to their present channels.

Ores of Lead and *Zinc* occur in genuine fissure-veins through the beds of No. IV in the Shawangunk mountains. One of these 3′–4′ wide, running N. 70° E. & S. 70° W. has been wrought in the vicinity of Guymard, 8 miles from Port Jervis for several years. The ores are not reduced there, but shipped to New York. One of the shafts has been carried to a depth of 400′. The surface rocks are *Medina sandstone*, but the fissure very probably extends down through the *Oneida Conglomerate.*

Much prospecting has been done along the Blue mount-

[* Mr. White here uses the nomenclature of Sir R. I. Murchison, still retained by the British Survey. In the reports of the Second Survey of Pennsylvania, the terms Silurian and Siluro-cambrian are generally used.—J. P. L.]

ains from Guymard south-westward through New Jersey, and some portions of Monroe county in Pennsylvania, in search of other fissure veins similar to the one at Guymard, but up to this time the search has been entirely fruitless.*

The Siluro-cambrian system.

[*The Hudson river slate formation* No. III, underlying the Oneida conglomerate, outcrops in Northampton county on the south slope of the Kittatinny or Blue mountain.

This formation is probably 6000′ thick where it lines the banks of the Delaware river below the Delaware Water Gap. But there are difficulties in the way of measuring it exactly.

The *roofing slates* quarried along the southern foot of the mountain belong to this formation. (See Mr. Sander's forthcoming report.)

A well at Stroudsburg (or at Milford,) if sunk to a depth of 4,000′ or 4,500′ would reach the top of the Hudson River

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[*These *lead and zinc ore veins* are of the highest interest to the geologist studying the genesis of the lead and zinc ores found in the underlying *Siluro-cambrian* (*Lower Silurian*) limestones at Saucon, south of Bethlehem; in Lancaster county; in Singing Spring Valley in Blair county; at Wytheville in Southern Virginia; and in fact along the whole extent of the Great or Cumberland Valley from New York to Alabama, and in the back valleys of the Appalachian range wherever these limestones come to the surface.

Fissure veins may be filled from below or from above; in both cases by concentration from aqueons solutions; and may therefore be of any age. But the erosion of the outcrops of the veins of the Shawangunk mountain teaches that the fissures, now filled with lead and zinc ores, were formerly continued upward into and perhaps through the *Clinton* and Lower Helderberg formations which at one time covered the *Medina* of the mountain to a great height in the air. The lead ores of Missouri are in the *Calciferous* (No. II); those of Wisconsin are in the upper part of the *Trenton limestone*, (top of No. II,) just underneath the Hudson river slate formation (No. III) which underlies the Shawangunk mountain, in which these fissures were opened, probably by warp-movements.

If then the lead and zinc solution rose from the limestones of II to fill these fissures, it shows how profoundly fissured this part of the earth crust must be. As they are coincident in general direction with the cross dykes of the highlands of New York and New Jersey, now filled with trap of Mesozoic or post-mesozoic age, it is possible that the lead veins of the Shawangunk mountain have been created as recently as Cretaceous times.—J. P. L.]

Slate formation,—which underlies at various depths the whole of Pike and Monroe counties.

But a well bored any where on the great Pocono plateau would have to be 11,000′ or 12,000′ deep to reach the Hudson River Slates (No. II.)

If such a well at Stroudsburg or Milford were deepened from 4,000′ to 10,000′, it would reach the Cattasauqua limestone beds at the top of the great limestone formation of Easton and Allentown, (No. II,) probably 2,000′ thick.

At 12,000′ the Stroudsburg well would strike Potsdam sandstone (No. I,) which is only a few yards thick in this region.

Under this ought to lie the gneissic rocks of the Durham hills and Reading mountains; belonging to a different and much older age than any of the strata described in this report; consequently underlying Pike and Monroe counties as an ancient floor.

This floor must spread beneath the Pocono plateau country (northern Monroe) at a depth of say 20,000 feet (nearly four miles) more or less. J. P. L.]

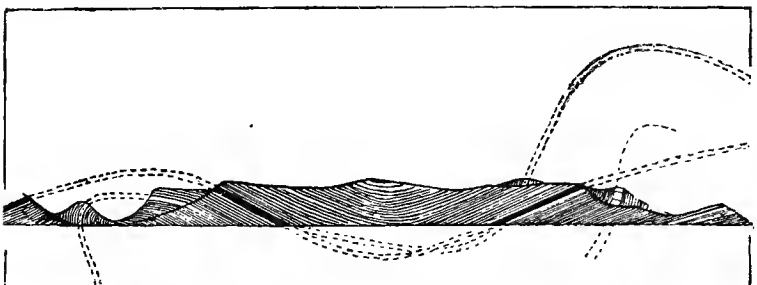

Fig. 5. Flexures at Wind Gap and at Lehigh Water Gap compared.

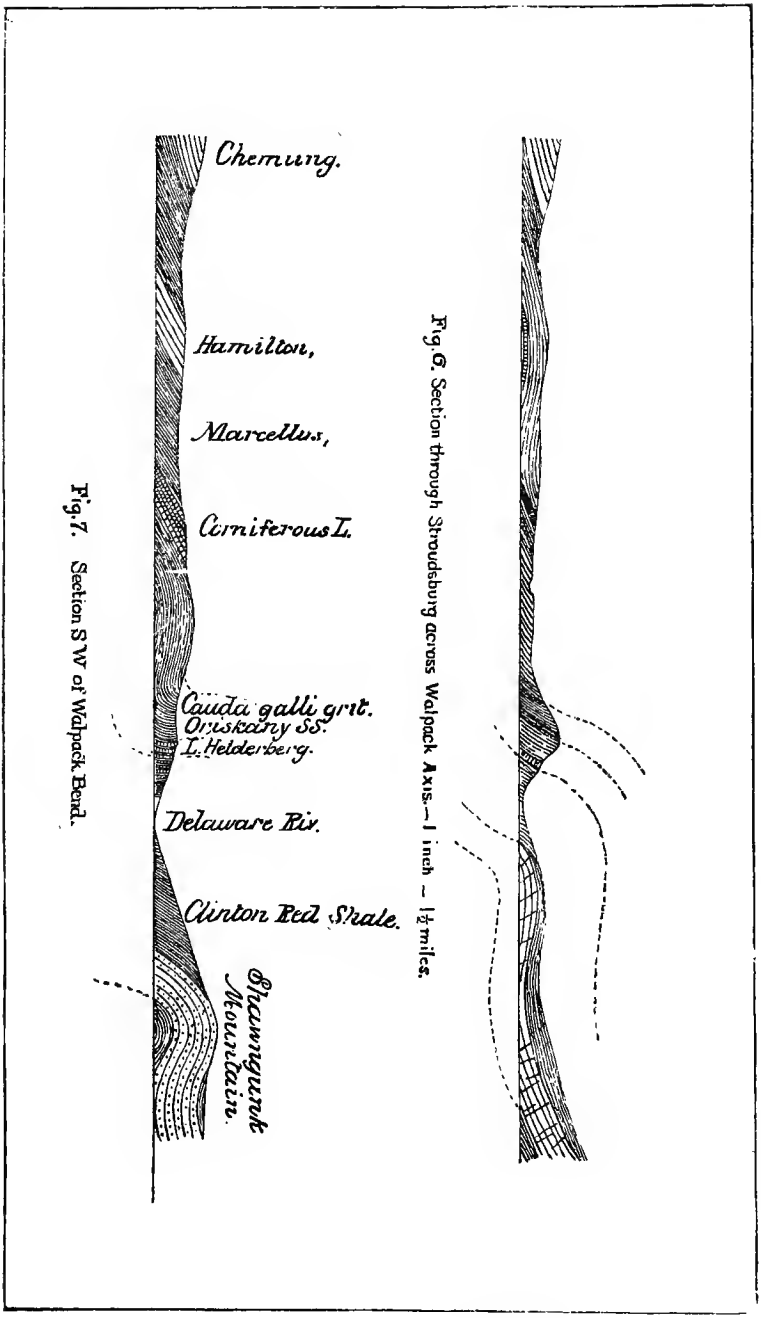

Fig. 7. Section S W of Walpack Bend.

Fig. 6. Section through Stroudsburg across Walpack Axis.—1 inch = 1½ miles.

Chapter VII.

Township geology of Pike.

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1. Lackawaxen.

This large township occupies the extreme northern point of the county; is rudely triangular in shape with the apex directed north, while the Delaware river, Wayne county line, the Milford and Owega turnpike form respectively its eastern, western, and southern boundaries.

The Lackawaxen river entering it from Wayne county, flows with many abrupt bends eastward through the same, cutting the township into a northern and southern half, and carrying all of its rainfall into the Delaware, except what goes there directly by way of Mast Hope creek in the northern part.

The interesting series of ponds and lakelets found in the northern portion of this area have already been described in the general summary, Chapter II, page 31.

The surface of this township is extremely rough and wild, there being but few cultivated farms except along the immediate valleys of the Delaware, Lackawaxen, and their principal tributaries. Back from these streams an almost unbroken forest of *Pinus rigida, Abies Canadensis* and other trees covers the surface. The reason of this wilderness condition is evident; for the great sandrocks of the *Catskill* have strewn the ground so thickly with their debris, that its cultivation except in favored localities becomes almost impossible.

The rocks of the township belong entirely to the *Catskill series*, and the section extends from the top of the *Honesdale Group* down through 600′–700′ of the underlying measures.

The Delaware and Lackawaxen river have carved deep and narrow valleys down through these rocks, and many splendid sections may be seen along the same where vertical cliffs of strata almost overhang these streams to a height of several hundred feet.

A short distance below Lackawaxen village and near the Shohola township line, the following section was obtained in descending the steep bank of the Delaware:

Lower Lackawaxen Section (17).

1. *Lackawaxen conglomerate*, (base 930′ A. T.,)	30′
2. Sandstone, grayish green,	45′
3. Concealed,	40′
4. Sandstone,	20′
5. Concealed to Erie R. R. level, (650′ A. T.,)	175′
6. Concealed to level of Delaware river,	60′
	370′

The Lackawaxen conglomerate at the top of this section, has been named from this locality, since it forms a great cliff of massive pebbly rock around the hills in the vicinity of the village, and its outcrop is very conspicuous far up the stream of the same name. Its pebbles are mostly of very white quartz ¼″–1½″ in diameter, many of them angular and exhibiting little evidence of water wear; pebbles of shale and ordinary gray *Catskill sandstone* were also observed in the matrix of coarse greenish-gray sand which makes up the bulk of the stratum.

In the bluff just south of Lackawaxen, interval No. 5, is seen to be composed largely of a dark steel-gray sandstone containing an occasional quartz pebble, many scales of mica and much pulverized feldspar; extensive quarries were once operated on it here, and the stone used in building the viaduct on the D. & H. canal across the Delaware at this locality, were largely obtained there. On the upper surface of one of these ledges, near the old quarry *Glacial striae* are seen running S. 20° W. The surface of the rock is polished quite smooth.

At the juction of the Lackawaxen with the Delaware, just above the village, we see a vertical escarpment of

Catskill sandstone, nearly 150′ feet high which exhibits the following structure:

Upper Lackawaxen Section (18).

1. Sandstone, greenish-gray, massive,	85′
2. Shales, gray,	10′
3. Sandstone, quarry rock,	50′
4. Concealed to level of Delaware river, (600′ A. T.,)	25′
	170′

The sandstone No. 3 has been quarried and used in the construction of the R. R. bridge across the Lackawaxen near by; the rock is of a dark grayish-green color, with an occasional faintly perceptible tinge of red. It comes out in good-sized blocks, and excepting its extreme hardness makes a very fair building stone.

The Lackawaxen flows over a buried channel of considerable depth at this locality since in building the piers of the viaduct for the D. & H. canal, just above here, no rock could be found at a depth of 25′ below its present surface, there being nothing but quicksand and gravel to that depth beyond which no test was made.

The Lackawaxen conglomerate and the massive sandstone both above and below, are seen making great cliffs of rock along the Lackawaxen river as one ascends that stream to Rowland's, 4 miles above its mouth. Here opposite the end of the switch, a short distance below the station, the following succession was measured in the almost vertical wall overhanging the south bank of the stream:

Rowland's Lower Section (19).

1. *Lackawaxen Conglomerate*, (base 895′ A. T.,)	20′
2. Concealed,	50′
3. Sandstone,	130′
4. Concealed to R. R. level, (695′ A. T.,)	20
5. Concealed to level of Lackawaxen river,	20′
	240′

No 3 is a solid mass of greenish-gray, current-bedded sandstone coming in layers 2′–10′ thick. The *Lackawaxen conglomerate* was not all exposed at this locality.

Only a few yards above the R. R. station at Rowland's the following section is exposed on the same bank of the stream:

Rowland's Upper Section (20).

1. *Lackawaxen conglomerate*, (base 836′ A. T.,)	60′
2. Sandstone greenish, flaggy,	3′
3. Concealed, (bench) shale?	20′
4. Sandstone greenish-gray, current-bedded,	35′
5. Sandy shales, showing much copperas on outcrop,	3′
6. Sandstone to R. R. level, (700 A. T.,)	75′
7. Concealed to level of Lackawaxen,	20′
	216′

On comparing this section with the preceding one taken only ¼ of a mile below (S. E.) it will be observed that the *dip* is here decided to the N. W. since the *Lackawaxen conglomerate* (at the top of the section) has sunk at least 20′ allowing the portion seen in Sec. 11 to have been its top instead of its bottom.

No. 4 contains a few small quartz pebbles near its center. No. 6 consists of layers of current-bedded sandstone 3′–8′ thick, separated from each other by thin beds of interstratified gray shale.

The *Lackawaxen conglomerate* is very massive, in beds 5′–10′ thick, filled with white angular quartz pebbles; near its center is a whitish layer with very large pebbles, and many pieces of shale imbedded.

One mile above Rowland's the following is seen on the south bank of the Lackawaxen:

Section one mile above Rowland's (21).

1. Sandstone, massive,	50
2. Concealed,	50′
3. *Lackawaxen conglomerate*, (base 890′ A. T.,)	60′
4. Concealed,	25′
5. Sandstone,	100′
6. Concealed to R. R. level, (720′ A. T.,)	45′
	330′

Here another great cliff rock comes into the summit of the hill 75′–100′ above the *Lackawaxen conglomerate.*

No. 5 is a vertical wall of current-bedded greenish-gray sandstone in layers 5′–20′ thick.

There seems to be a reversal of *dip* between this locality and that of the previous section, since the base of the *Lackawaxen conglomerate* is 54′ higher here than there.

At Millville, 4 miles above Rowland's, the following succession was observed in descending the rocky point just above the station:

Millville Section (22).

1. Sandstone dark gray,	15′
2. *Shale, red,*	20′
3. Sandstone, flaggy,	15′
4. Sandstone, massive,	10′
5. Concealed,	10′
6. Sandstone,	25′
7. Concealed,	60′
8. Sandstone,	20′
9. Concealed with some outcrops of flaggy, greenish-gray sandstone to R. R. level, (780′ A. T.,)	170′
10. Concealed to level of Lackawaxen,	35′
	380′

No. 3 has been quarried for flagstone at this locality; it is a bluish-green, micaceous rock separating into smooth faced layers 2″–4″ thick.

No. 8 makes a cliff along the hills.

The *Lackawaxen conglomerate* belongs somewhere in the lower half of this section, but it has lost its massive and pebbly character so as to be no longer conspicuous.

At Kimble's station, four miles above Millville, the *Lackawaxen conglomerate* regains its massive character, however, and in consequence has had a marked effect on the topography; for there we find a long narrow point composed of it projecting out across the Lackawaxen valley to the very edge of the stream at what is called the "Narrows." Here the river rushes over a rocky bottom hemmed in by vertical cliffs of massive *Catskill sandstone* 50′ high, and only 40′ asunder, thus making with the sudden bend in the "Narrows" a very dangerous passage for rafts and small crafts.

The section obtained on the south bank of the Lackawaxen at Kimble's, reads thus:

Kimble's Section (23).

1. Sandstone,	20′
2. Concealed,	40′
3. *Shale, red,*	20′
4. Sandstone small pebbles,	20′
5. A succession of greenish-gray, cliff sandstones interstratified with shales,	180′
6. Concealed,	70′
7. *Lackawaxen conglomerate,* (base 860′ A. T.,)	60′
8. Sandstone greenish-gray, hard, to level of the Lackawaxen, opposite the R. R. station, (849′ A. T.,)	55′
	465′

This is the last opportunity we get to study the *Lackawaxen conglomerate* in ascending this stream; for a short distance above Millville, a *local roll* carries it below drainage level, and when it again comes up, it can no longer be distinguished from the other greenish-gray sandstones of the Catskill.

Comparing its elevation here (860′ A. T.) with that at Lackawaxen (930′) and Rowland's (836′) we see that no strong flexures cross the measures in this township, hence in an east and west direction they are practically horizontal, since Kimble's is 12 miles by rail, or 8 miles air line due west from Lackawaxen village.

This rock at Kimble's is seen well exposed in the deep R. R. cut just above the station where its base comes within 10′ of R. R. level; quite pebbly, dark steel-gray in color, and contains many small pieces of bluish-green slate.

Quarries.—Near Kimble's many quarries have been opened on the *Catskill flagstones,* and large quantities of them are shipped both on the Erie R. R. and D. & H. canal. These quarries come at all elevations from the bed of the Lackawaxen up to the summits of the hills, 450′ above. The *flags* are 2″–5″ thick and can be obtained of almost any desirable size, the surface being quite even, and the stone nearly always of a grayish-green color. They seem to be most readily obtained where the cliff rock has been somewhat exposed to the weather, since on quarrying into the hills the flags thicken up into layers 1′–3′ thick which cannot be split into smooth layers.

About one mile above Kimble's the following section occurs where the top of the *Lackawaxen conglomerate* passes below water-level:

Section one mile above Kimble's (24).

1. Sandstone, gray,	20′
2. *Shale, red*, sandy,	10′
3. Sandstone, gray,	10′
4. *Shale*, red,	15′
5. Sandstone, flaggy to level of Lackawaxen, (835 A. T.,)	20′
6. Top of *Lackawaxen conglomerate*,	
	75′

The *dip* here is quite sharp to the N. W., but it continues for only a short distance, when the rocks become again nearly horizontal, and then begin to rise in that direction.

Three miles above Kimble's, and one mile below Hawley, the Lackawaxen valley again contracts to a very small compass, and the stream is bounded by rocky walls 50′ high on either side, and only 200′ apart.

This is about one half greater than it was before the Erie RR. on the south bank, and the D. & H. canal on the north bank made cuts through the solid rock as a passage-way for each. A very massive sandstone caps these vertical walls 65′ above river level, (870′ A. T.,) and it may possibly represent the *Lackawaxen conglomerate*, but if so, its pebbly character has disappeared.

A great bed of *red shale* extends all over the northern half of this township, at an elevation of 1150′–1250′ A. T. It is 50′–75′ in thickness and belongs to the horizon of the *Montrose red shale* of the Wayne and Susquehanna Report (G⁵). It is often seen along the hill roads, and frequently crops out along the shores of several lakelets in the northern portion of the township.

Near Mrs. Wigge's, one mile north-east of Hawley, this *red shale* is exposed along the road at an elevation of 1200′ to 1230′ A. T., and above it are seen massive blocks of sandstone, which must belong near the horizon where they are scattered so thickly.

Along the hill road, north-west from Kimble's, the rocks

are polished and striated with *glacial scratches*, going S. 30° W., M. at 1125′ A. T.

The rocks are planed off conformably with the present surface slope.

On the road leading north from Kimble's, the big *red bed* occurs at 1200′ A. T. where we see 25′ of red rock, then on above it 10′ of greenish-gray sandstone, then much more red shale on which, at 1240′ A. T., are seen numerous *glacial striae* running S. 30°–35° W.

About half way between Mast Hope P. O. and Lackawaxen, the following section was obtained in descending to the Delaware river:

Delaware River Section (25).

1. Sandstone and shales,	55′
2. Greenish-gray current-bedded sandstones separated by shales,	200′
3. Concealed to RR. level, (660′ A. T.,)	210′
4. Concealed to level of Delaware river,	40′
	505′

The *Lackawaxen conglomerate* comes somewhere in the section, as blocks of it are scattered over the surface along the base of the hill, but its proper horizon could not be discovered owing to lack of exposures. A stratum containing a few pebbles was seen at 940′ A. T. and this may possibly represent it.

On the very summit of the ridge at this locality, occurs a bowlder of rock, 2′ in diameter, composed of large quartz pebbles, chips of slate and sandstone. It looks very much like the *Mt. Pleasant conglomerate*, and must have been *transported* quite a long distance.

At Pine Grove Station, near the month of Mast Hope creek, the following succession occurs in the steep hill slope of the Delaware:

Pine Grove Station Section (26).

1. Sandstone, greenish-gray, massive,			100′
2. *Red shale*,	45′		
3. Sandstone, greenish-gray,	35′	*Montrose group*,	135′
4. *Red shale*,	55′		

5. Sandstone,	50′
6. Sandstone, massive, (Laxawaxen conglomerate,)	75′
7. Concealed to station level, (668′ A. T.,)	150′
8. Concealed to level of Delaware river,	33′
	543′

No. 1 comes at the horizon of the *Honesdale sandstone group*, while Nos. 2, 3, and 4 very probably represent the *Montrose red shale.*

The *Lackawaxen conglomerate* would then be represented by No. 6, since it is very massive, forming a great cliff around the hills, and many blocks with small pebbles are seen in the talus below it.

On Mast Hope creek, at the saw mill, just above Pine Grove, there occurs a great cliff of massive sandstone, beginning at 760′ A. T., and extending up to 825′, at which latter elevation a *flag quarry* has been operated on the land of Mr. Lebrau.

About three miles above Pine Grove, along Mast Hope creek, there is seen at the roadside a very massive, pebbly sandstone, on which, at 945′ A. T., *glacial striae* go S. 20° W. It extends to 965′ A. T., where a *red*, sandy shale comes in, on which, at 975′, *glacial striae* trend S. 25° W. This massive stratum is seen on the opposite or north side of Mast Hope, making a great cliff 50′ high, along the hills. It most probably represents the *Lackawaxen conglomerate.*

One half mile further up the stream another large bed of pebbly sandstone is seen, beginning at 1025′ A. T., and extending to 1070′, the very pebbly portion coming at 1050′. The quartz pebbles are large, white, and angular; some chips of bluish shale are also seen in the rock. It forms a bold cliff for a long distance. This may possibly be the *Lackawaxen conglomerate*, brought up by a local roll in the measures, and this seems the more probable from the fact that on passing above it to 1130′ A. T., the *Montrose red shale* comes in and is seen around the banks of Ketchall's and Simmons' ponds.

About one mile below Narrowsburg, on the N. Y. side of the Delaware, a bed of *red shale* occurs along the RR., at 710′–730′ A. T., and above it for 250′ come greenish-gray

sandstones, in which many flag quarries are operated. The rocks have a local dip to the N. W. at this locality, so that the *red bed* soon passes below the RR. level, and does not reappear until some distance north of the village.

Marsh gas rises in large quantities from a bed of buried vegetable trash below Narrowsburg, at "Big Eddy," near the Wayne-Pike line. When a pipe is driven into the sand a few feet, the gas rises through it in such quantity as to make a flame 1′–2′ high when ignited.

Blooming Grove creek enters the southern half of the township across the Milford and Owega turnpike at an elevation of 1165′ A. T., and in the four miles between this point and its mouth at Millville station, descends 420′. The creek carries a large amount of water, and it was matter for surprise that such a stream should descend at so great a rate over a constant series of falls and cascades in a narrow cañon-like valley. But on going west from it a half a mile at the turnpike, the mystery is explained; for there we come into a wide old water-way in which scarcely any water now flows, and yet the elevation of this drift-filled valley is even now 50′ lower than that of the Blooming Grove. Further observation revealed the fact that in *preglacial* times this old valley had been occupied by the latter stream which then emptied into the Lackawaxen at Kimble's, 4 miles above Millville, its present mouth; but that after the *Glacial Ice* had swept a great dam of drift across its channel in the vicinity of White Deer Lake, the Blooming Grove was forced out of its well-worn course into the new, and consequently narrow and rapid channel which it now occupies.

A great many *flag quarries* have been opened along this stream and the flags shipped on the Erie Branch R. R. at Millville. The most extensive of these quarries are in the steep hill-side, ½ mile above Millville, where the following succession is exposed.

Millville quarries section (27).

1. Sandstone in cliffs,	20′
2. Concealed,	40′
3. Sandstone,	30′

4. Concealed,	20′
5. Sandstone,	20′
6. Sandstone, quarried for flags,	20′
7. Sandstone,	10′
8. Sandstone, quarried,	25′
9. Concealed,	50′
10. Massive, pebbly sandstone, visible,	25′
11. Concealed to level of Blooming Grove creek, (785′ A. T.,)	45′
	305′

The *quarries* here in Nos. 6 and 8 are operated by Messrs. Joy & Adams, on the land of Mr. Westfall. The flags are of a bluish-green color and 1½″–5″ thick along the outcrop, but thicken up when mined into the hill. Some of the layers contain *quartz pebbles*, *chips of slate*, *fish* and *plant remains*. *The plants* are represented only by *stems* ½″–2″ in diameter and all pressed into a flat film of carbonaceous material which often contains streaks of *coal*. The stems are crossed transversely by thin septa of a bony aspect which at first glance give them the appearance of animal remains.

In passing along the road which leads from Kimble's across to Blooming Grove creek, the base of a great cliff sandstone is seen at 1070′ A. T.; it is 50′ high; 20′ above its base comes a very pebbly layer several feet thick; immediately below the cliff rock is a bed of *blood red shale* exposed for 12′ but it is doubtless much thicker.

Several *flag quarries* are operated along this road on the land of Messrs. Maxwell, Kimble, and others.

At 1110′ A. T. along the road are seen many *glacial striae* pointing S. 30° W. (M.) on the hard sandstones. At 1135′ A. T. is a very massive sandstone with a layer of *calcareous conglomerate* at the base. On above this at 1165′ A. T. the hard rock is polished off smooth and the *ice striae* point S. 35° W. (M.,) while 20′ higher they go S. 30° W. (M.)

At 1200′ A. T. a pebbly rock is seen and massive hard greenish gray sandstone continues on to the level of the flat topped hill at 1275′ A. T.

Near Taylortown, in the southeastern corner of the township, the *Montrose red shale* is seen at 1050′ A. T. and on

it at 1065′ *glacial striae* appear to point due north and south.

About one half mile west from the cross-roads at C. Woodruff's we pass over a large body of *red shale* at 1200′ A. T. and come up to the base of a very massive pebbly rock at 1270′ which extends to the crest of the hill at 1305′ A. T. where it forms a narrow "hog back" ridge. It is very probably the *Honesdale sandstone*, and the *red rock* below it would be the *Montrose red shale.*

A *calcareous conglomerate* is seen near Mrs. Walsh's Hotel at 1270′ A. T. one half mile south from the last locality, and it looks very much like the *Cherry ridge limestone* of Wayne and Susquehanna counties. It is seen along the road at the Hotel for several rods; is 10′ thick, being quite calcareous, and a perfect mass of *quartz pebbles, fish remains* and *pieces of shale*, the whole cemented into a darkish green matrix of calcareo-silicious material which weathers away on the exposed surfaces, giving them a dark brown aspect. It is quite probable that this *calcareous conglomerate*, which is very local, may come at the horizon of the *Honesdale sandstone group.* What lends some credibility to this is the fact that just west from this, and above it, another large bed of *red shale* occurs along the Milford and Owega Pike, at an elevation of 1300′–1325′ A. T. which would represent the *Cherry Ridge red shale.*

At the extreme south-eastern corner of the township a large bed of Drift is seen along the turnpike, and in it are great numbers of small bowlders of the *Oneida conglomerate*, all rounded and polished. They must have been transported a long distance.

Barometric Elevations in Lackawaxen.

(*Above Tide.*)

Forks of road at Taylortown,	1065′
Level of stream at road crossing below Taylortown,	995′
Cross-roads at C. Woodruff's,	1145′
Milford and Owega turnpike, at Mrs. Walsh's hotel,	1270′
" " " I. B. Rosencrantz's,	1270′
" " " stream near J. Roberts',	1165′
" " " Roberts' tavern,	1225′
" " " forks of road next west,	1215′

" " " summits near Mrs. Lawrence's, ... 1375
" " " level of stream next west, ... 1335'
" " " summit near C. Smasher's, ... 1400'
" " " L. Mauley's cross-roads, ... 1310'
" " " summit ½ mile west, ... 1355'
" " " where B. G. Park road turns off, . . . 1295'
" " " where B. G. Park road turns off to Millville, 1265'
" " " at crossing of Blooming Grove creek, 1075'
" " " level of old valley next west, . . 1115'
Cross-roads on B. G. creek, near W. Kimble's, ... 1025'
B. G. creek level, here, ... 1010'
Level of B. G. creek, at 1st crossing above Millville, ... 785'
" " " 2d " " " . . . . . 895'
" " " 3d " " " . . . . . 955'
Forks of road, one mile N. E. from Hawley, near Mrs. Wigge's, . . 1080'
Level of stream at road crossing near there, ... 1010'
Forks of road west from H. Garrity's, ... 1160'
Level of Baisden's creek, at crossing near H. Garrity's, ... 920'
Forks of road opposite Kimble's station, ... 880'
" " near school-house, just east, ... 905'
Level of Coryell's run, at J. Kimble's S. mill dam, ... 1070'
" Tink creek, at B. Tanney's saw mill, ... 1250'
" Big Tink pond, ... 1275'
Forks of road near B. Tanney's, ... 1255'
Level of stream at crossing next below, ... 1245'
" Tink creek at crossing near G. Grimes', ... 1120'
Forks of road here, ... 1130'
Upper forks of road near Dr. Haddon's, ... 1045'
Lower " " " . . . . . 1020'
Tink creek here, ... 975'
Cross-roads near L. Pelton's, ... 960'
Lower forks of road at G. H. Rowland's, ... 1145'
Upper " " " " . . . . . 1160'
Level of West Colang pond, ... 1120'
Forks of road at F. R. Holbert's, (near pond,) . . . . . 1125'
Next north, ... 1130'
At by-road, one mile N. W., ... 1145'
Forks of road at school-house near Mast Hope, ... 720'
Level of Mast Hope creek, at crossing above Seamon's S. M., . . . 785'
" " " " near Mrs. Seldon's, ... 825'
Crossing outlet of Wolf pond, ... 950'
Level of Mast Hope, at McIntire's Mill, (below the dam,) . . . . . 975'
" " " " (above the dam,) . . . . . 990'
Level of North Br. M. Hope Cr., at Holbert's S. mill crossing, ... 1000'
Level of Simmond's pond, ... 1160'
Ketchall's pond, ... 1165'

2. *Palmyra township.*

This is a long, narrow, irregular area bordering Wayne county next south-west from Lackawaxen. On its eastern line lies Blooming Grove, while directly south is Greene.

It is drained almost entirely by Wallenpaupack creek, which flows or rather oozes along its western boundary, (separating Pike from Wayne county) until within one mile of the Lackawaxen river when it descends by a succession of *cascades* over cliffs of Catskill sandstone, falling 260′ before it enters the latter stream. In striking contrast to this, is the course of the Wallenpaupack in the next 10 miles above the beginning of the *cascades* at Wilsonville, for in this entire distance the fall is probably less than 5 feet, only one or two "ripples" occurring, and the flow of the water is so sluggish as to be almost imperceptible. The valley of the stream is nearly a mile wide and is filled with trash to an unknown depth.

I have already in a previous chapter pointed out the cause of this curious flow of the Wallenpaupack, and showed that it now empties into the Lackawaxen, 4 miles above where it did in *pre-glacial* times; that an old deep, and wide valley in which no water now flows, leads from the Wallenpaupack above Wilsonville across the drift-covered divide below Tafton, and keeping rudely parallel to, but nearly a mile south from the present Lackawaxen valley, debouches into it at Kimble's, after receiving the tributary valley once occupied by Blooming Grove creek. That the Wallenpaupack once flowed in this old valley cannot be doubted, for the great dam of Drift thrown across the ancient channel by the *Glacial Ice* which caused all this derangement of water courses, is still to be seen. It must have formed a great *lake* along the present valley of the Paupack, nearly two miles wide, 15 miles long and two to three hundred feet deep; for we find clay deposits all along this valley and up the

sides of the hills to 200′ above the present stream. These clay beds are not connected with the Drift proper and are of exactly such character as would have been formed in a lake of such dimensions.

The rocks of this area belong entirely to the *Catskill group.*

In descending the Paupack over the falls from Wilsonville to its mouth the following section is obtained as given in the Wayne and Susquehanna Report G⁵, p. 199.

Paupack Falls section (28).

Top 1140′ A. T. instead of 1125′ as given in G⁵.

1.	Sandstone massive,	10′
2.	Shales, reddish, sandy,	20′
3.	Sandstone, pebbly, grayish-white,	25′
4.	Concealed,	30′
5.	*Paupack* sandstone, greenish-gray,	20′
6.	Sandstone, reddish, shaly,	35′
7.	Sandstone, massive, (top of first large cascade,)	10′
8.	Sandstone, shaly,	15′
9.	Shales, *red* and *variegated*,	20′
10.	Sandstone, massive, gray, (top of second cascade,)	50′
11.	Shales, dark,	15′
12.	Sandstone, flaggy to foot of third cascade, (890′ A. T.,)	35′
		285′

In releveling this section during the present year (twice with great care,) I find that my barometer makes the elevation of the surface of the water in the dam at Wilsonville 1140′ instead of 1125′ as given by the one trial in the Wayne county report, hence the total fall of the water is (1140′–880′) 260′, or 10′ greater than at first supposed.

"The uppermost member of the section together with the dam at Wilsonville make a cascade of 20′ at that locality, and then the stream descends in a series of rapids until the top of No. 7 is reached when in three successive leaps, including the rapids between, it descends a vertical height of 145′ in a horizontal distance of about 100 yards. As the Paupack carries a large volume of water at all seasons of the year, this is the finest site for water power in the county, if not in the state. Strange enough it has hitherto been allowed to run to waste, with the exception of a small modicum utilized by a tannery and flouring mill. There is now how-

ever a large silk manufactory in process of construction which takes its water-power from the top of the first cascade, and there gets the pressure of a column of water 50′ high on its turbine wheel. There is still plenty of room and power for other factories on each bank of the stream."

The Paupack sandstone, No. 7, designated from this locality, is a greenish-gray, or sometimes bluish-green rock, extensively quarried on the east bank of the Paupack one fourth mile above the first cascade. It comes in layers 4″–8″ thick and was used in building the silk factory at the Falls.

Kimball flag quarries.—These are opened in *Catskill sandstones* along Kimble's run, a stream emptying into the Lackawaxen at Kimble's Station, and one of them on the land of Mr. Curtis furnishes very excellent stone. The flags are of a bluish-green color, quite micaceous, and occasionally contain chips of dark olive colored slate which often has a *slickensided* appearance.

In passing up the Paupack valley from Tafton, a very wide stretch of level bottoms is found on either side of the stream, the valley at times being 2½ miles wide, and often marshy, so that the farming lands do not begin until the foot hills are reached, except in rare instances.

Near the forks of the road at H. D. Clark's, below Paupack P. O., a large cliff of massive gray sandstone is seen extending along the summit of the hills at 1450′ A. T. at base. It belongs most probably in the *Honesdale Group* and the *deep red shale* seen a short distance further on towards Paupack at 1320′–1340′ A. T. very probably comes at the *Montrose horizon.* Just south of Paupack P. O. *glacial striae* are seen along the road at 1290′ A. T. running S. 30° W. (M.) on a gray hard *Catskill SS.* and below this at 1260′ others are seen with the same direction, on a rock which makes a great cliff along the hills. At 1200′ A. T. an exposnre along the road shows 30′ of *deep red shale* which would represent a portion of the *Montrose horizon.*

The following partial section is exposed near Paupack Post Office:

Paupack P. O. Section (29).

1. Massive sandstone, some pebbles,	40′
2. Concealed,	110′
3. Red shale, visible,	20′
4. Concealed,	60′
5. Sandstone, massive, in cliffs,	35′
6. Concealed,	25′
7. Red shale, visible,	30′
	320′

Pottery clay occurs on the land of Thomas Burns, 2½ miles below Ledgedale, along the old valley of the Paupack, and is manufactured into *red ware* by Mr. Burns. The following succession occurs at the clay diggings:

Thomas Burns' Clay Section (30).

1. Soil, clayey,	1½′– 2′
2. Clay, gray, with no pebbles, but penetrated throughout by long decayed slender roots of plants,	15′–20′
3. Very sandy clay, the lowest explored portion of the bed,	2′
	24′

The top of this clay comes about 30′ above the stream.

Another bed of clay occurs on the opposite or Wayne county side of the Paupack at this locality, and about 200′ above the level of the stream. It is 20′ thick where explored by Mr. Burns, who mixes it with that obtained in Pike.

Near the base of the 20′ the clay is filled with black carbonaceous fragments which some have supposed to indicate the presence of *coal*; but this is a mistake, since the nearest *coal outcrop* is at least 20 miles away, and the horizon of the *lowest coal* 2,000′–2,500′ above this clay bed.

Red shale which very probably belongs in the *Montrose horizon* is seen just above Mr. Burns', along the creek road at 1175′–1185′ A. T.

About 1½ miles above Mr. Burns', we come to a place in the bed of the Paupack where a ripple reveals the bed of the stream for the first time above Wilsonville, 10 miles below; at this locality the stream has a considerable current and its bed rises 10′ between this point and the narrows under the bridge at Ledgedale, one mile above.

In descending the steep hill along the road just south of Mill Brook run to C. Degroot's, is the following section.

C. Degroot's Section (31).

1.	*Red shale*, visible,	10′
2.	Sandstones and concealed,	40′
3.	Pebbly sandstone, massive, (base 1520′ A. T.,)	30′
4.	*Cherry ridge red shale*, red shale, 50′; green SS., 15′; red shale, 30′	95′
5.	Concealed,	15′
6.	Massive conglomerate,	40′
7.	Concealed,	115′
8.	Massive pebbly sandstone,	30′
9.	Concealed to level of Wallenpaupack, (1140′ A. T.,)	75′
		450′

There can be very little doubt that No. 4 represents the *Cherry Ridge red shale* since its elevation here (top 1520′ A. T.) would be too high for the *Montrose horizon.*

No. 6 is probably the *Honesdale upper sandstone*, and here near Mr. Degroot's it makes a great cliff outcrop along the hill, 40′–50′ high, in which are numerous quartz pebbles. No. 8 is a massive pebbly sand rock, which, on coming southward from Wayne county, comes into the midst of the *Montrose red shale* horizon.

Where the ridge road crosses Egypt creek, near the eastern line of Palmyra, a great bed of *red shale* is seen exposed for a long distance. Its section as revealed along the road which descends Egypt creek is as follows:

Egypt Creek Section (32).

1.	*Red shale*, (top 1580′ A. T.,)	50′
2.	*Green sandstone*,	10′
3.	Concealed,	10′
4.	*Red shale*, visible,	10′

This, as will be seen on inspection, has the same structure as that found in the *Cherry Ridge red shale* of the previous section, and hence is identical with it, though the top of the bed here (1580′ A. T.) is 80′ higher than there, but as this locality is 2½ miles due east of the former, this is no evidence of non-identity.

As we pass along the road toward Jones' Lake, the *Cherry Ridge red beds* is frequently seen making long stretches of red outcrop.

Lake Jones is a large body of water several hundred acres

in extent, 30′–40′ in depth, and having only one small inlet. It is the source of Blooming Grove creek, and has an elevation of 1500′ A. T. Its basin is excavated in the *Cherry Ridge red shale*, since a broad band of this material is seen extending around its shores to 30′ above the water level.

Much drift is also seen around the margin of Lake Jones.

On the summit, one mile west from *Jones' Lake*, a massive pebbly sandstone occurs at 1550′ A. T.

Barometric Elevations in Palmyra.

(*Above Tide.*)

Level of Wallenpaupack ck. above Wilsonville dam,	1140′
Forks of road at Tafton,	1185′
" " Kimble's run, 1½ miles east,	1025′
Kimble's run, at crossing of Milford and Owega pike,	1020′
Milford and Owega pike, at forks near J. Degroot's,	1200′
Forks just south of Palmyra Hotel,	1220′
Level of Bingham's run, at road crossing,	1190′
Forks of road near H. D. Clark's,	1390′
" at Salem road, in Paupack village,	1290′
" of road near A. A. Killam's,	1185′
Level of Mill Brook there,	1165′
Forks of road at M. N. B. Killam's,	1175′
" " near Burns' Pottery,	1160′
By-road to C. Masker's,	1475′
Cross-roads, one mile S. E. of L. Phelps',	1725′
Forks next S. E.,	1720′
" " north,	1700′
Level of Egypt creek, at crossing next north,	1550′
Forks of road just north,	1555′
Cross-roads near F. Frank's,	1630′
Level of Lake Jones,	1500′
Inlet to Lake Jones, at road crossing,	1520′
Level of Bingham's run, east of F. Smith's,	1520′
Summit at F. Smith's,	1540′
Branch of Bingham's run, near J. Simon's,	1490′

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3. Greene Township.

This township adjoins Palmyra on the south, and is separated from Wayne county at the west by the south branch of Paupack, while on the south it borders the Monroe county line. Its shape is an irregular triangle, with the base rest-

ing on Paupack creek, the apex pointing eastward against the western boundary of Porter.

The central and eastern portions drain their rain-fall northward by way of Paupack creek along the Wayne county line to the Lackawaxen at Hawley, through which it goes to the Delaware; the extreme eastern portion reaches the Delaware through Big Bushkill, going southward; while the middle-southern portion goes into Brodhead creek and eventually gets into the same river, just above the Delaware Water Gap.

The high *escarpment of the Pocono plateau* extends along the southern margin of this area, and with the possible exception of High Knob in Blooming Grove township, it contains the highest land in the county, the general level of the Pocono plateau along the Monroe-Pike line ranging from 1900′–1950′ A. T.

The township is everywhere sheeted by a vast thickness of *morainic débris*, so that it is only along the principal valleys of erosion, that the rocks crop out to-day. Enormous *bowlders* of a very *white conglomerate* cover the surface along the upper portion of Bridge Brook, being packed in so closely at one point in a long line around the hillside, as to closely resemble a cliff outcrop at a distance. They are fragments of the *Mount Pleasant Conglomerate* whose place is 300′–400′ in the air above where the huge bowlders now lie.

The line of the New York, Susquehanna and Western R. R. now building (1881) passes across the Pocono platean through this township, crossing from Goose pond, at the Monroe line, to Bridge Brook, and following down that to the Paupack. The line of the road goes through a great *gap in the Pocono plateau* cut down 300′ lower than the general level of that range, since the summit is reached at only 1681′ A. T., (J. W. Schermerhorn, C. E.)

A continuous sheet of Drift fills this old channel, and it is possible that this immense rift in the Pocono range is due largely to *glacial erosion.*

The rocks of the township belong entirely to the *Catskill series.*

At Ledgedale, the Paupack flows between vertical walls of very pebbly sandstone 20′ high, and only 30′ apart, and from this locality on up the stream its fall is quite rapid, in striking contrast to its course along Palmyra; for, in the 17 miles (of meanderings) between Ledgedale and the N. & S. Pike, the South Branch falls (1800′–1155′) 645′, while in the 12 miles from Ledgedale to Wilsonville the fall is only (1155′–1140′) 15′.

The following section (Fig. 33) of the rocks in the vicinity of Ledgedale is taken from G⁵, page 205, Fig. 58:

Ledgedale Section (33).

1. Sandstone, massive pebbly,	20′
2. Concealed,	25′
3. Sandstone,	15′
4. Concealed,	100′
5. Sandstone, gray, pebbly,	25′
6. Concealed, with some outcrops of massive sandstone,	110′
7. Sandstone, dark gray pebbly to level of Paupack,	25′
	320′

This section is just across the Pike line in Salem township, Wayne county.

The top of No. 1 is grooved with *ice scratches* going S. 12° W.; it very possibly represents the *Honesdale Upper sandstone* instead of *Cherry ridge* as stated in G⁵.

In passing south from Ledgedale toward Mr. S. Simon's, a great many huge bowlders of *calcareous breccia* are seen, blackened on the exposed surfaces. They have doubtless come from the horizon of the *Cherry Ridge limestone.*

On the summit of the ridge, near T. Simon's, there is seen the outcrop of a great pebbly stratum with some *calcareous breccia* near its base at 1475′ A. T., and there can be little doubt that it represents the *Honesdale Upper sandstone* of Wayne county.

In passing down to the Paupack on the other side of this ridge, a great many *calcareous breccia* bowlders, some of them 8′–10′ in diameter, are seen scattered over the surface.

Just north of the forks in the road at T. Smith's, a ledge of conglomerate is seen with *calcareous breccia* at its base,

4′–6′ thick, while immediately below the latter is a bed of *red shale* of which 40′ is exposed, base of breccia 1500′.

Glacial striae are seen along the road ½ m. S. E. from T. Smith's going S. 15° W. at an elevation* of 1550′ A. T.

Near the forks of road at A. Distill's, the outcrop of a *red shale* is seen at 1615′–1635′ A. T. It probably belongs in the horizon of the *Cherry Ridge Group.*

Just south of Wynooska, at 1650′ A. T. the outcrop of a dark, pebbly, massive, cliff rock was observed. Many bowlders of *calcareous breccia* are also seen scattered over the surface here.

Along the road leading from Wynooska southward, the surface rises to 1800′ A. T. and is covered everywhere with Drift, there being much coarse sand and gravel in its composition. Many *bowlders* of a whitish conglomerate are also seen, which have doubtless come from a much higher horizon.

In decendimg to Bridge Brook along the Canadensis road, a line of great whitish conglomerate *bowlders* is seen on either side of the stream, and 100′ above the same. They are imbedded in the drift deposits at an elevation of 1600′ A. T. and have probably come from the horizon of the *Mt. Pleasant conglomerate* 200′–300′ higher.

Two miles north from this near Hanesville the most elevated summits are covered with the same whitish bowlders, at 1830′ A. T. their plane of outcrop would probably come at about 1900′ A. T.

A *bed of red shale* is seen near Laureldale lake where the road crosses its outlet, at an elevation of 1700′ A. T. It is much broken by *glacial action* and the materials scattered through the drift.

In the eastern portion of the township, is a cluster of lakelets among which are lakes, Laura, Ernest, Belle, and Mud, Elich's and Goose ponds. Elich's pond is the head of Bridge Brook, a stream which empties into Paupack and along which the N. Y. & W. R. R. passes. The elevation of this pond (according to Mr. Schermerhorn of the R. R.

* Half a mile west of Correyville.

engineers) is 1754′ A. T. Goose pond is at the Monroe Pike line and has an elevation of 1476′ A. T. (Schermerhorn.)

Barometric Elevations in Greene.

(*Above Tide.*)

Paupack creek at Ledgedale,	1155′
Cross-roads at Greentown, just south of last,	1195′
Forks of road near S. Simon's,	1400′
Summit of road at T. Simon's,	1500′
Paupack (south br.) near I. A. Grant's,	1250′
Forks near S. Hopp's,	1400′
" " Mrs. Craft's,	1280′
" " T. H. Gilton's,	1320′
Level E. Br. Paupack, at road crossing here,	1320′
Forks at I. Brink's,	1390′
" near J. Burrows',	1558′
" " T. Smith's,	1440′
" " C. Cramer's,	1640′
" " A. Distill's,	1550′
Level of Meadow run, at crossing near last,	1500′
By-road near J. Carlton's,	1580′
Level of Bridge Brook, at road crossing next east,	1560′
Forks near J. Rose's,	1640′
Birch creek, at road crossing near J. C. Blake's,	1670′
Forks one mile S. E. from E. Osmer's,	1780′
Bridge Brook, at road crossing next north,	1565′
Summit of road north of Hanesville,	1830′
East Branch Paupack, at crossing of road at Laureldale, (top of dam,)	1700′
Stream at road crossing just south of Hanesville,	1730′
Leves Branch creek, at crossing of Stroudsburg turnpike,	1800′
Summit of Pocono plateau on Stroudsburg pike next south, near Monroe-Pike line,	1900′

The following instrumentally determined elevations I owe to the kindness of Mr. J. P. Schermerhorn, one of the engineers on the survey of the route for the N. Y. S. & W. RR.

Instrumental levels in Greene.

(*Above Tide.*)

Goose Pond,	1476′
Dark Hollow summit, (between Paupack and Brodhead waters,)	1681′
Elich's Pond,	1754′
Crossing of Canadensis road,	1625′
Level of East Br. Paupack 200 feet above its junction with Bridge Brook,	1387′
South Br. Paupack, at crossing about two miles above Ledgedale,	1226′

4. Blooming Grove township.

This township lies directly east from Palmyra, and is separated from Lackawaxen on the north, by the old Milford and Owega turnpike.

It is an elevated area, forming as it does the common heading ground for all the larger streams of Pike county.

From it, Bushkill goes south, Shohola, east, Blooming Grove, north, and the tributaries of Paupack west, thus radiating, like the spokes of a wheel to almost every point of the compass. In this respect it much resembles Preston township Wayne county, and like it, too, is a township famous for the number of its lakelets, for there are no less than ten of these within its area while half as many more lie just without its borders.

With the exception of a narrow belt running east and west through the center of the district, all of it is a wilderness in which deer, bears and other wild animals still find a retreat.

The Blooming Grove Park Association, a company of gentlemen from N. Y. city, owns several thousand acres of this wild land, including all the principal lakes. These they have stocked with fish. A considerable portion of their lands is enclosed by a high fence, so that their deer and other game are protected.

The rocks of Blooming Grove belong entirely to the *Catskill series*, and to that portion of it between the top of the *Cherry Ridge group* and the *Delaware river flags*.

The Cherry Ridge conglomerate is found only as a coping to the elevated North Knob and South Knob in the southwestern corner of the township.

The section obtained on the southern slope of the South Knob is as follows:

South Knob Section (34).

1.	Concealed, (top 2010′ A. T.,)	10′
2.	Sandstone, gray, current-bedded,	25′
3.	*Cherry Ridge conglomerate*,	65′
4.	Sandstone, shaly,	35′
5.	Sandstone, pebbly at base,	25′
6.	Sandstone, and concealed,	70′
7.	*Red shale*,	20′
8.	Sandstone, reddish-gray,	20′
9.	*Red shale*,	10′
10.	Concealed,	45′
11.	Sandstone, massive, current-bedded,	30′
12.	Concealed,	50′
13.	*Red shale*, visible,	10′
		415′

South Knob is known as High Knob and is the culminating point of Pike county. It rises like a pyramid 500′–600′ above all the surrounding country except the other "Knob" just north of it which is only 100′ lower. These elevated points are in the same range with Pocono mountain to the south west and are in fact the north-eastern remnants of that range left as monuments of the erosion to which Pocono owes its origin.

From the lofty summit of High Knob, the observer is well repaid for the toilsome ascent of two miles through thickets of underbrush, over large piles of rock debris, and up the faces of almost vertical cliffs, infested with rattlesnakes; for from this elevated position one of the grandest views in the State spreads out before him.

To the south, the long blue crest of the Kittatinny stretches away from the Lehigh Water Gap almost to the Hudson river. To the east, the Catskill mountains of N. Y., loom up throughout their whole extent like heavy cumulus clouds low down on the horizon. To the north the view looks over the Moosic range to North and South knobs of Susquehanna county, and taking in Ararat and Sugar Loaf peaks, in Wayne, continues on into N. Y. for at least 100 miles. While to the west the Pocono range stretches away toward the Lehigh river. The whole of Pike, Monroe, and Wayne counties lies at one's feet, and in no direction is the observer's horizon less than 30 miles distant, while in others the limit is over 100 miles.

On the very crest of the knob lies a large *bowlder* of white conglomerate, several feet in diameter, which must have been transported by the ice, since it is rounded and polished to some extent, hence the *Glacial current* flowed over the summit of this knob.

The *Cherry Ridge conglomerate*, No. 3, makes a bold vertical cliff 60′–75′ high, along the entire southern face of the knob, so that the ascent can only be accomplished on the south-west side, where the cliff breaks down somewhat. This great cliff is a conspicuous object from several miles away, and it is to this immense mass of hard pebbly sandstone that the knob owes its preservation from *erosion* to so great an altitude above all the surrounding country. The rock is quite pebbly throughout; but in the uppermost 30′ it is a mere mass of large quartz pebbles, rounded pieces of sandstone, and blue sandy shale, all cemented into a matrix of coarse, greenish-gray sand.

I identify this with the *Cherry Ridge conglomerate*, because of its position above the *Cherry Ridge red shale*, which was seen a short distance east from the line of this section, and 350′ below the base of the conglomerate.

The *Cherry Ridge group*, of Wayne county, expands very rapidly when followed south from the type locality, so that here in High Knob, instead of finding it 200′ thick, as in Wayne, the thickness is nearer 500′, the sandstone portion being very much increased by the introduction of several new elements, as seen in Section 33.

The exposure in this section does not extend quite down to the *Cherry Ridge red shale*; but it is seen well exposed along the road at the forks, near the eastern end of the high Knob; its top comes at 1540′ A. T. and nothing but *red shale*, and red sandy layers occur down to the level of the little stream at 1500′ A. T. It has there been quarried and used for filling up the road bed along the Canadensis and Blooming Grove road.

Just across the creek, below the village of Blooming Grove, the following succession is seen in descending the steep hill-side:

Blooming Grove Section (35).

1.	Sandstone and concealed from top of hill,	50′
2.	*Cherry Ridge red shale*,	70′
3.	Concealed,	10′
4.	Sandstone, pebbly, Honesdale SS.,	35′
5.	Concealed to level of Blooming Grove creek, (1400′ A T.,)	10′
		175′

The *Cherry Ridge red shale* has here been quarried quite extensively for use on the public roads; it is quite sandy in some portions and makes an excellent bed for the roads, preventing both dust and mud when used liberally. Its top as seen here comes at 1525′ A. T. or several feet lower than the same horizon 2 miles west, on Egypt creek, in Palmyra township.

The *Honesdale Upper sandstone* is very probably represented by No. 4, which is very massive and pebbly, there being a line of cliffs wherever its outcrop can be followed.

At the forks of the road, ½ mile west from Blooming Grove P. O. the *Cherry Ridge red shale* is exposed in a bank near Mrs. Decker's. The road is here 1490′ above tide, and the top of the shale is concealed. It has been dug out, for use on the roads, to a considerable extent.

The same *shale* is also seen finely exposed along the road near Egypt where it is 100′ thick with a bed of *green sandstone* 15–20′ thick below its center. All around the Blooming Grove region is a wide *marshy* surface, plainly due to the presence of the *Cherry Ridge red shale* which disintergrating easily formed wide valleys with little slope, and these are now filled with Drift.

The upper portion of Blooming Grove creek has a very gentle fall, and it is bordered on either side by wide stretches of *marsh* land. It is possible that the upper waters of this stream may once have issued through Lake Giles into Shohola creek, since this lake is now separated from Blooming Grove creek by a bank of Drift only 50′ high, while all appearances lead to the belief that a *buried valley* leads under these deposits to the Lake. Otherwise it would be difficult to account for the erosion of the basin in which Lake Giles is now found; for there extends more than half way around

its banks an almost vertical escarpment of massive sandstone rocks extending to nearly 200′ above its level; yet the lake has no inlet whatever, being fed entirely by subterranean springs which rise from its bottom.

A red shale is seen outcropping around the southern shore of Lake Giles and 25′–30′ above the same.

Along the road which passes south of the lake, a pebbly sandstone occurs with black looking fragments imbedded in its upper portion. They appear to be *fish remains*; its top is polished; *ice scratches* run S. 32° W. (Magnetic.)

The Park Association club house is built on the bluff overlooking Lake Giles at an elevation of 125′ above the Lake or 1500′ A. T. Along the new road leading from the Club House to the Milford and Owega Pike, immense cliffs of massive pebbly sandstone surround the northern half of Lake Giles rising one above the other like tiers of seats in an amphitheatre.

Near Lord's Valley P. O. a well was once bored to a depth of 300′ in search of oil. Genuine *petroleum* found floating on the water, in the midst of a large swamp, led to this enterprise, but it was subsequently learned that the "*oil signs*" had found their way to the surface not through the earth, but through the bung of a barrel brought there on purpose to "salt" the land and effect a sale at high figures. It is safe to state that no oil could be found at Lord's Valley by any boring however deep.

On the Dingman Turnpike, at the eastern line of the township, occur small *bowlders* of *Oneida conglomerate* transported there by the *ice*. Further west they disappear.

Near J. McConnell's along the Dingman road, there occurs a great cliff of pebbly sandstone, at 1270′ A. T., looking very much like the *Lackawaxen conglomerate* which it doubtless represents.

On the summit of the hill further west, at F. Cochen's, the *Montrose Red shale* comes into the pike at 1275′, and then the road hitherto rough becomes smooth and the rough hills give place to broad gentle valleys with splendid farms. The same *red shale* is frequently seen along the Blooming Grove road between Lord's valley and the Mil-

ford and Owega turnpike, and wherever it occurs the fact is at once evident in the smooth road, free from stones.

Just north of Mrs. Walsh's Hotel, about one mile, the high peak south of the township rises to an elevation of 1450′ A. T., and is capped by a massive pebbly sandstone 35′ thick; it very probably represents one of the *Cherry Ridge sandstones.*

Barometric Elevation in Blooming Grove.

	A. T.
Forks of road near Jane Decker's above B. G. P. O.,	1435′
Level of Blooming Grove creek here,	1425′
Road at Blooming Grove P. O.,	1420′
Forks near E. Miller's,	1410′
Level of creek here,	1400′
Forks near L. Westbrook's,	1365′
Creek here,	1360′
Blooming Grove creek at M. C. Westbrook's,	1325′
Forks at Blooming Grove Club-House road,	1420′
Level of Lake Giles,	1375′
Level of Beaver Lake,	1400′
Cross-roads at Lord's Valley P. O.,	1275′
Level of Shohola creek near D. Hatten's,	1225′
Branch of Shohola creek near J. McConnell's,	1220′
Next br. east on Dingman road,	1285′

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5. *Shohola township.*

This lies north-east from Blooming Grove township, (which it touches for only a mile at the Milford and Owega turnpike,) and extends to the Delaware river which meanders along its north-east boundary for nearly ten miles.

This latter stream therefore drains the entire area, receiving in this township the tributaries Shohola, Big and Little Pond creeks.

An insignificant area from the southern portion sends its waters to the Delaware by way of the Sawkill.

There is very little land under cultivation in this township, and it is a wild rocky region covered with the original forest of *Pinus rigida.*

The surface everywhere gives evidence of extreme glaciation, and this has rearranged the water courses to a considerable extent.

Shohola creek does not now empty into the Delaware where it did in pre-glacial times, for then it left the present channel about two miles above Shohola, and keeping to the east entered the Delaware about one mile below its present mouth; but a great dam of Drift was thrown across its channel by the ice, which compelled it to make a new cut through the solid rocks at the "Glen."

There is also evidence that a large stream once crossed the Milford and Owega pike, near N. Blackmore's and keeping eastward, emptied into the Delaware through Little Pond creek; for, a wide Drift-filled valley in which no water now flows crosses the turnpike at this locality, 150′ below the general level, and extends eastward into the valley of Little Pond creek, as well as southward of the turnpike to an unknown distance. It may possibly have been connected with the Rattle Snake branch of Shohola in that direction.

Two very large ponds, Big Brink and Little Brink, the former covering about about 1,500 acres, owe their origin to the Drift; for, great banks of it extend all around them. Little Brink has neither inlet nor visible outlet, and is 40′ in maximum depth. It is most probably connected with Big Brink by a subterranean stream through the sandbanks which separate them. The Big pond is only 25′ deep.

The rocks of the township belong entirely to the *Catskill series*, and extend from the *Honesdale Sandstone Group* down through about 1500′ of rocks, since the rise of the strata to the south-east along the Delaware now becomes decided, bringing up the *Delaware flags*, on which the Erie R. R. runs for its entire extent through this township, often on a mere shelf cut into them, 75′ vertically above the Delaware, while great cliffs of the same frown *flags* overhead to the height of 100′–200′.

Near the north-western corner of the township, on the Delaware, 1½ miles below the village of Lackawaxen, the following succession was obtained in the steep hill-side.

Section one and a half miles below Lackawaxen (36).

1.	Sandstone, gray and concealed,	50′
2.	*Montrose red shale* and *red SS.*,	70′
3.	Sandstone, massive,	20′
4.	Concealed,	35′
5.	*Lackawaxen conglomerate*, (base, 980′ A. T.,)	45′
6.	Sandstone, and concealed,	40′
7.	Sandstone, gray, massive,	20′
8.	Concealed, with many layers of sandstone,	240′
9.	*Red shale*,	10′
10.	Sandstone, greenish-gray to RR. level, (650′ A. T.,)	20′
11.	Concealed to level of Delaware river,	65′
		615′

The crest of the hill is here capped by the gray coarse sandstone of No. 1, and it doubtless represents a sandy portion of the *Montrose red shale.*

The latter makes a broad and almost level bench around the hill, just below the summit of the Knob, and is of a deep, blood-red color, the lower portion being rather sandy.

The Lackawaxen conglomerate is quite massive and very full of quartz pebbles; makes a very bold cliff outcrop along the hill, and many huge bowlders from it cover the slopes below.

Many layers of greenish-gray, current-bedded sandstone occur in No. 8, and are from 10′–20′ thick, apparently separated by shale.

A short distance further down the Delaware the following succession occurs:

Section on Delaware River below Lackawaxen (37).

1.	Sandstone, and concealed,	50′
2.	*Montrose red shale*,	40′
3.	Sandstone, in layers, 3′–10′ thick,	30′
4.	*Laxawaxen conglomerate*, (base 1005′ A. T.)	55′
5.	Sandstone, and concealed,	40′
6.	Sandstone, massive, whitish,	40′
7.	Sandstone, gray,	30′
8.	Concealed,	30′
9.	Sandstone,	25′
10.	Concealed,	100
11.	Sandstone, gray, flaggy,	15′
12.	Concealed,	50′
13.	Sandstone, gray, to R. R. level, (650′,)	25′
14.	Concealed to Delaware river,	65′
		595′

From this section we learn that the 240′ concealed interval of the previous section consists largely of grayish-green, current-bedded sandstones.

No. 6 is weathered whitish on the outside, but when freshly broken is seen to possess a blnish-green color within.

Just at this point a local roll passes across the measures, and they *dip* to the S. E. along the RR. track for 75 feet at an angle of 40°, when they suddenly become horizontal again, or nearly so; but as we go south-east, down the river toward Shohola, they dip gently, and the *Lackawaxen conglomerate* comes down to within 60′ of track level in the cut just above Shohola; thus showing that the crest of the low *Lackawaxen anticlinal* crosses near the locality of the last section.

Opposite the 109th N. Y. M. P., where the rocks are dipping S. E., the following beds are seen passing below track level, going down the Delaware:

Section on Erie RR., opposite 109th M. P. (38).

1. Gray, flaggy sandstone,	20′
2. Reddish-gray sandstone,	10′
3. *Red shale*,	40′
	70′

These beds would have come in the 100′ concealed interval of the previous section in the reverse order from that here given.

In descending the high hill to the Delaware, opposite the Suspension bridge, at Shohola, this succession was obtained:

Shohola Bridge Section (39).

1. Sandstone, gray,	30′
2. *Sandstone, red*,	20′
3. Sandstone, gray,	20′
4. Concealed,	35′
5. Sandstone,	20′
6. Concealed,	15′
7. Flaggy sandstone,	80′
8. Concealed,	20′
9. Sandstone, gray,	15′
10. Concealed,	25′
11. *Red shale*, visible,	25′
12. Concealed,	60′

13. Sandstone, grayish-green,	10′
14. Concealed,	55′
15. Sandstone, gray,	10′
16. Concealed,	40′
17. *Lackawaxen conglomerate*, visible, (base 708′ A. T.,)	25′
18. Sandstone, gray,	30′
19. Sandstone, flaggy,	20′
20. Concealed to RR. level, (648′ A. T.,)	10′
21. Concealed to Delaware river,	73′
	638′

In comparing this section with the previous one, we see that the *Lackawaxen conglomerate* has dipped down to the S. E. 300′ in the distance of two miles between these localities, thus showing the *anticlinal* axis passing across the Delaware near the former.

No. 7 is one of the *flag quarry* rocks of the Catskill, and has been largely operated for flagstone here on the land of Mr. Chauncey Thomas; in fact there have been quarries at nearly every horizon in the section above the base of the *Lackawaxen conglomerate*. These greenish-gray cliff rocks look quite massive on their outcrop, but when quarried they are found to split quite smooth and evenly into layers 2″–6″ thick, of most any desirable size.

It was from the lower half of this section at Barryville, in N. Y., just across the river from Shohola that the monster flag 25′×15′×8″ was quarried for the pavement in front of Vanderbuilt's new mansion in New York city.

The Lackawaxen conglomerate makes a very bold outcrop in the hills and has been quarried to some extent for building the piers of the suspension bridge connecting Shohola with Barryville. It is a very hard, steel-gray rock, containing many large, white, and rose-colored quartz pebbles. One half mile south from the station it is seen in a great perpendicular cliff 80′ high, the lower 60′ of which is quite pebbly. Its base is there 50′ higher than in section 38, showing that the bottom of the syncline is at Shohola station.

About one mile south from Shohola, the creek of that name passes through a deep narrow gorge hemmed in by vertical cliffs of Catskill sandstone. The locality is known

as *the Glen* and is much visited by excursionists. The rocky channel is only 40′ wide and on the west bank the cliffs rise almost perpendicularly to a height of 200′, the *Lackawaxen conglomerate* being seen near the top in a great pebbly cliff. On the east bank, the rocks rise vertically for 25′ and then slope gently back from the stream. The "Glen" is several hundred feet long and was doubtless formed by the stream having been turned out of its former course by a *Glacial dam*; for, one mile above, near Geo. Hess', this gorge suddenly widens out into a wide level valley from which an old channel is seen passing one half mile east of the Glen into the Delaware. This old channel is now choked up with 250′ of Drift, however, and except for the sudden expansion of the Shohola gorge into a wide valley while in the same kind of rocks would escape detection.

Glacial striae running S. 10° W. are seen along the road which leads up the east bank of Shohola just opposite the Glen at 775′ A. T., and 125′ above the water in the same.

One mile south from this, however, and at an elevation of 940′ A. T. the *striae* go S. 30°W.

Just below the R. R. crossing of Shohola creek the strata suddenly *dip* S. E. at an angle of 25° and the following section is there exposed in a R. R. cutting:

Shohola Creek Section (40).

1. Sandstone, gray,	40′
2. Concealed,	5′
3. Sandstone, greenish-gray,	35′
4. Shale, red, sandy,	10′
	90′

After No. 4 comes down to track level the rocks again become nearly horizontal, and then the dip is gently reversed to the N. W.

About one mile and a half below Shohola station, the following section was obtained in descending the steep bluff to the Delaware:

Section one and a half miles below Shohola (41).

1. *Lackawaxen conglomerate*, visible, (base 895′ A. T.,)	45′
2. Concealed,	55′

3. Sandstone, flaggy,	80′
4. Concealed,	65′
5. Sandstone, to track level, (645′ A. T.,)	50′
6. Sandstone to level of the Delaware,	80′
	375′

The *Lackawaxen conglomerate* is very pebbly at this locality, and makes a bold cliff along the crest of the hill, its base being nearly 200′ higher than at Shohola station.

The R. R. runs here on a narrow shelf cut into the face of a cliff of greenish-gray sandstone which rises above the track perpendicularly to a height of 150′.

As we continue down the Delaware from this point, the rocks rise continuously to the S. E. and at the 105th N. Y. mile post 100′ more rock have come above track level, thus making the base of the *Lackawaxen conglomerate* there, (645′+350′=) 995′ A. T.

Here along the RR. we see a very massive bluish-green sandstone, which has been *quarried* to a considerable extent for building stone, the RR. across Shohola creek having been constructed of it.

Just above Carr's Rock, the massive cliffs of greenish-gray *Catskill sandstone* rise perpendicularly 150′–200′ above the RR., and midway in them a bed of *reddish shale* is seen, 3′ thick, 60′ below which is 5′ of *red sandstone.*

About one half mile below the 203d N. Y. mile post, a sharp *roll* crosses the measures, and they suddenly *dip* S. 10° W. 45°, but only continue so for a few yards, when the normal rate of 200′–250′ per mile N. N. W. is regained, though for the one mile N. W. from here about 275′ of rock come above track level.

At the 100th N. Y. mile post the horizon of *Lackawaxen conglomerate* would be 1100′–1200′ above the RR. since that amount of rock comes up on a north-west dip between there and Shohola, 7 miles above. These beds are nearly all greenish-gray sandstones in which flag *quarries* occur at most every horizon, and constitute what I have elsewhere termed the *Delaware river flags.*

At Pond Eddy, near the south-east corner of this town-

ship, the following succession is seen in descending the steep hillside:

Pond Eddy Section (42).

1. Sandstone, hard, gray,	25′
2. Concealed,	30′
3. Flagstone,	80′
4. Concealed,	25′
5. Grayish-green sandstone, flags,	250′
6. *Red sandy shale*, (to RR. level 571′ A. T.,)	25′
7. Concealed to Delaware river,	61′
	496′

The *Delaware flags* have been largely operated on here for flagstones, and a large amount of stone is shipped to N. Y. and other cities for pavements, side-walks, &c. The principal *quarries* come at the horizon of No. 3, but they also occur at all elevations above the *red shale*. The paving stone for the front of the new Vanderbilt mansion in N. Y. city, 10′×15′×6″, were obtained at this locality. Beers & Co. and Killgore are the principal operators. The flags are greenish-gray, quite smooth, and of very even thickness. The layers get thicker, or rather the division planes disappear, as the rock is quarried into the hill, so that the quarries are always situated along the prominent cliff outcrops, where the rock has been exposed to the weather. The rock contains some *mica*, and the crevices, when small, are filled with *amorphous quartz*, but when an inch or so apart, the walls on either side are lined with long, slender *quartz crystals*.

Just opposite the depot at Pond Eddy, the *red bed*, No. 6, comes up, but immediately pitches N. E. under the RR. to come up again on a *reversed dip* a short distance below and opposite the 99th N. Y. mile post, where a sudden *roll* brings up another *red bed*, 10′ thick 40′ below the one seen at Pond Eddy. This S. W. roll continues at an angle of 40° *dip* for about 100′, bringing up 40′ of greenish-gray sandstone, when the dip suddenly flattens and the rocks are almost horizontal.

In the vicinity of the Brink Ponds, many *bowlders* of *Oneida conglomerate* are seen scattered over the surface in the general drift débris.

A cliff of gray pebbly sandstone is seen skirting the eastern edge of Big Brink pond, at 1300′ A. T., and is very possibly the *Lackawaxen conglomerate.*

In the vicinity of the Walker Ponds, many large *bowlders* of very pebbly *Catskill sandstone* are seen scattered over the surface, and they appear to come from a bluff at an elevation of 1225′ A. T. They most probably represent the *Lackawaxen conglomerate.*

This latter rock is seen in a cliff 70′ high along the Shohola creek valley near Mr. N. Shield's, 2½ miles above Shohola village, and its base is there 760′ A. T. Great *bowlders* from it are seen all along the Shohola valley, though its outcrop is concealed by the heavy covering of Drift.

Where the Milford and Owega pike crosses Shohola creek, that stream emerges from a wide swampy valley filled with Drift, in which the stream has a very gentle flow, and cutting down to the massive *Catskill sandstones*, plunges in four cascades over the cliffs of Shohola Falls, descending 50′ vertically in as many yards. Then it passes on for four miles in a very narrow gorge, bounded on either side by massive walls of rock.

The elevation of the stream at the head of the Falls is about 1115′ A. T.

One half mile west from this, along the Milford pike, a great bed of Drift occurs at the roadside, and in it are many rounded *bowlders* of *Oneida conglomerate.*

Barometric Elevations in Shohola.

	Above Tide.
Level of water in mill-dam at Shohola Glen,	650′
Delaware river at mouth of Shohola creek,	570′
" " at Pond Eddy,	510′
Forks of road just south of Shohola,	665′
Forks ¾ m. above, at Lackawaxen road,	820′
Forks of road near Geo. Hess',	715′
Where road crosses Gulf Swamp brook,	905′
Grassy brook, at road crossing,	915′
Shohola creek there,	905′
Brook at C. Croon's,	925′
Taylortown creek at crossing near twp. line,	975′
Shohola creek at Milford and Owega pike,	1115′
Level of Old Valley, near N. Blackmore's,	1275′

Summit on M. & O. pike, near J. O. Stidd's,	1475′
Forks of road near (½ mile S. E.) J. O. Stidd's,	1375′
Level of Red brook, at road crossing,	1350′
Branch of Raymondskill, near C. Gable's,	1325′
Level of Savantine creek Br., near Kline's,	1315′
Big Brink pond,	1285′
Little Brink pond,	1285′
Big pond creek, at crossing W. of C. Carey's,	1225′
Stream at road between Great and Little Walker ponds,	1185′
Great Walker pond,	1165′
Little Walker pond,	1200′
Forks of by-road near C. Sweezey's,	1270′
Forks S. of J. Wolfreth's,	810′
Forks at A. C. White's S. H.,	700′
Forks S. W. of Woodtown school-house,	1235′

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6. Westfall Township.

This township adjoins Shohola on the S. E. and occupies the extreme eastern angle of the county and State, formed by the great elbow which the Delaware river makes in the vicinity of Port Jervis. Thus its area is more than half surrounded by the Delaware, which, flowing in a sinuous course south-eastward along its northern boundary, turns abruptly on encountering the Neversink Valley, and thereafter flows about S. 65° W. along its southern border, veering around more than 100°, thus making an acute angle with its former course.

The Neversink river enters the Delaware from N. Y. just as the latter stream completes this famous bend, uniting with it at what is known as Carpenter's Point, a long narrow ledge of *Corniferous limestone*, separating the two streams by only a few rods for nearly a mile, and then ending at the junction in a sharp wedge-like point on the extremity of which is the Tri-State Corner, as it is usually called, or the separating point of the New York, Pennsylvania, and New Jersey State lines.

The Delaware river carries off all the rainfall of the township, receiving from it only small tributaries which rise on the high bluffs two or three miles back from the same, and

descend with a very rapid fall, or more frequently in high *cascades*.

About 3½ miles above Port Jervis the Delaware river emerges from the cañon of No. IX, in which it flows from Deposit at the northern line of the State, 90 miles above. The change in topography at once announces the presence of a different rock formation; for in the 30 miles between Saw Mill Rift and the northern line of Pike county, at Narrowsburg, the banks are mere shelves a few rods wide on either side and frequently nothing except rocky walls which rise perpendicularly from the bed of the stream to a height of 600′. Below Saw-mill Rift, however, the stream enters No. VIII, and then the hitherto narrow gorge expands into a beautiful valley, nearly a mile in width.

A great bed of Drift trash fills this valley 20′–50′ above the present level of the water, and extends down below its surface to an unknown depth. It was penetrated 63′ below the river level at Port Jervis without reaching the bed rock.

The section of the rocks in this township owing to the strong N. W. dip (10°–15°) extends from about 1000′ above the base of IX down to within 500′ of the base of VIII; the lowest rock being the Corniferous limestone, which comes up to day along the southern shore of the Delaware at Carpenter's Point.

The following is the succession that rises to view along the Delaware river between the western line of the township, near Pond Eddy, and Carpenter's Point, 10 miles below, in an air line. (See lower portion of Sect. 1:)

General Westfall Section (43).

(*Above Tide.*)

1.	*Delaware Flags,*	400′
2.	*New Milford red shale* and red rock,	75′
3.	*Starrucca flags,* (base of IX.)	600′
4.	*Chemung flaggy sandstone,* (including Portage,)	1850′
5.	*Genessee slate,*	200′
6.	*Hamilton sandstones,*	1375′
7.	*Marcellus shale,*	800′
8.	*Corniferous limestone,*	250′
		5,550′

The *Delaware* and *Starrucca flags* are extensively quarried along the Delaware river where they crop out in lofty cliffs between Pond Eddy and Saw-Mill Rift.

There are several large quarries at a place called Stairway, operated by Kilgore & Co. Very large and beautiful flagging stone are shipped from this point to New York and other cities.

The *Starrucca flags* are seen finely exposed along the Delaware river, on the N. Y. side, for 2½ miles above the Erie R. R. bridge, rising almost vertically from the bed of the D. & H. canal to an elevation of 600′, in which nothing is seen but a continuous succession of grayish-blue and greenish-gray flaggy sandstones, no red rock whatever occurring.

The *Chemung rocks* rise from the Delaware about 300 yards above the 92nd N. Y. mile post on the Erie R. R. This is about ½ mile above the Erie R. R. bridge and 4⅛ from Port Jervis.

The line of demarcation between the *Chemung* and *Catskill* is quite sharp, there being a total change in the lithological character, the greenish-gray, hard sandstones of the latter giving place to bluish, shaly beds filled with *fossil shells* no traces of which occur in the *Catskill* above.

These blue, shaly, fossiliferous layers continue rising above water level, as we descend the Delaware, at an angle of 10°–12° until opposite the 90th N. Y. mile post. The lower half seems to be more sandy than the upper, but aside from this no distinction can be made out since the *Chemung fossils* continue on down through it until the top of the *Hamilton* is reached at the 90th mile post. There a dark sandy slate comes up at an angle of 11°, and in it occur *Spirifer mucronatus*, *Athyris spiriferoides* and a form much like *Tropidoleptus carinatus*; so that there can be no doubt about its representing the *Genesee slate*. It is seen along the N. Y. bank of the Delaware for about ¼ mile, when the gray and more sandy rocks of the *Hamilton* proper rise from the river, the rapid dip 10°–15° soon carrying them into the summits of the hills. These latter rocks make the high bluffs of bare rock seen along the northern

wall of the Delaware valley from Port Jervis to the western line of the township.

This escarpment of *Hamilton rocks* facing the Delaware is almost perpendicular in many places to a height of 600′ or more. The steepness is due to the fact that all the Hamilton beds exhibit *cleavage structure* in a very rude way; and as the cleavage planes dip S. E. at an angle of 60° here, the hills frequently have that slope. Along the foot of these cliffs, there are great piles of talus consisting of small, long, angular fragments of Hamilton rock, broken up and fallen away from the cleavage planes by the action of frost. This is locally called "slate gravel," and is largely used in the repair of the roads, being excellent for that purpose, since it is already broken into fragments small enough to apply directly to the roads.

The *Marcellus beds* are not visible along the Delaware in this township since a wide valley of erosion begins above Matamoras (opposite Port Jervis) and extending S. W. along the Delaware, the underlying rocks are everywhere concealed by the terrace deposits, except at a single point, just above where the Delaware veers around to the S. W.; there a ledge of hard, gray *Marcellus slate* is seen extending across the Delaware, cleaving at a high angle to the S. E. On beyond this at the New York shore of the Delaware, the *Corniferous limestone* rises from the water at an angle of 20° and continues along the shore to the extremity of Carpenter's Point, ¾ mile below. The great masses of cherty material stand out in rough and jagged nodules from the body of the limestone which has been largely removed from around them by solution.

Black slate is said to be visible along the New Jersey shore of the Delaware, four miles below Matamoras. Mr. DeWitt informs me that some parties once dug into it with the expectation of finding *coal*, but it represents only the carbonaceous portion of the *Marcellus beds*, and of course could furnish no *coal*.

The cliffs of *Hamilton sandstone* which overhang the Milford road in this township, are covered with *cactus plants*

of the species *Opuntia Vulgaris*, the discovery of which is due to Dr. Barrett, of Port Jervis.

In these same rocks there also occur several fissures filled with crystals of quartz, and this fact has led many people to suspect the presence of valuable minerals; but the fissures are too narrow and irregular to warrant such conclusion.

Some traces of *Lead*, *Zinc* and *Copper*, however, may be found, but never in sufficient quantities to warrant mining. *Black Oxide of Manganese* is also present at times in considerable quantities, but is always so disseminated through the rocks as to render its mining impossible. An attempt was once made to search for *Manganese* on Quick's Mill run, but nothing came of it.

The *Catskill rocks* come into the summits of the hills 2 to 2½ miles back from the Delaware river and along the road that ascends Quick's run they may be seen near H. M. Sheuston's, forming great cliffs from 1040′ up to 1100′ A. T.

Barometric Elevations in Westfall.

(*Above Tide.*)

Forks of road near F. A. Rose's, Jr.,	455′
" at Old Half-way House,	440′
" at C. L. DeWitt's lane,	1150′
" near J. Quick's,	1260′
Level of Delaware at Erie R. R. Bridge,	440′
" at Matamoras,	420′
Milford road through Matamoras,	440′
Delaware at Junction with Neversink,	415′

7. *Milford Township.*

This township lies directly west from Westfall, and like it is bordered by the Delaware river on the south. It drains into the Delaware through Sawkill and Vandemark creeks.

Between the mouths of these streams at Milford there is a wide and beautiful terrace whose top comes 100′–120′ above the level of the Delaware river, and makes the site of Milford, the county seat. It is a great bed of rehandled morainic debris and is seen along the river in an almost vertical

mass 100′ high, in which occur bowlders of *Oneida conglomerate*, *Corniferous limestone*, *Hamilton sandstone*, *Chemung* and *Catskill rocks*, together with much fine sand and gravel.

The Drift materials occur all over the township, and rounded *bowlders* of *Oneida conglomerate*, 1′–2′ in diameter, are of common occurrence everywhere.

The Drift has exerted a not inconsiderable influence on the topography of this area, since a great dam of *moraine* thrown across the ancient channel of the Sawkill near Mr. G. Hamilton's, 2½ miles above its mouth, caused it to seek a new outlet to the Delaware over the cliffs of the *Hamilton sandstone*, and thus resulted in producing the "Sawkill falls," where the stream passes over the high escarpment of the Delaware hills.

In *pre-glacial* times, the Sawkill waters instead of going over the present falls, passed by a channel now buried with Drift, which runs from where the Milford and Owega pike crosses that stream, south-eastward to the old valley in which the Milford water-works are situated, and then continuing along this old valley it received the Raymondskill near Milford, the combined streams finally emptying into the Delaware directly under the present site of that town.

This is known to be true (1) because the "divide" of Drift which now separates the Sawkill from the old valley is only 25′ high, and (2) because the only water carried in the old valley comes from two or three springs; and yet, this valley is cut down more than 100′ below the level of the top of Sawkill falls through the same series of rocks, while the bed rock is still concealed by an unknown thickness of Drift. It is simply impossible that a feeble stream such as now flows in it, could ever have cut out such a deep wide valley; and on the other hand it is equally improbable that the large volume of water carried by the Sawkill, could rush over its steep descent for untold ages without cutting its channel down to a depth at least as great as that of small streams like Vandemark and Quick creeks, just above.

The rocks of this township extend from several hundred feet above the *Catskill series* down to the base of the Ham-

ilton, since the *Corniferous limestone* still hugs the southern shore of the Delaware as it did in Westfall.

The Catskill rocks come into the hills in this township, about 3 miles N. W. from the Delaware river, and then cover all the rest of the area, rendering it a rocky, desolate region with only a few scattering cultivated farms.

In passing up the present channel of the Sawkill from the Delaware river, (380′ A. T.,) there occurs a succession of *cascades*. The first one is ¼ mile above the mouth of the stream and begins at 410′ A. T. The rock is a dark sandy slate, (*Marcellus*,) and a dam thrown across its center gives a fall of 20′ for the mills situated just below.

On above this the stream meanders through a dense grove bounded on either side by steep banks of Drift. This part of the Sawkill channel is known as the "Glen," and it forms a delightful retreat for the summer boarders who throng Milford every year. At the head of the Glen, and directly opposite the main street of Milford, the Sawkill makes a second plunge of 18′ over a dam, and the dark-bluish, sandy slates of the *Marcellus*, dipping N. 25° W. 13°. The channel below the dam is a gorge only 30′ wide, with vertical walls of slate, but on above this the channel widens out into a considerable valley, the ancient course of the Sawkill.

About one mile above the mouth of the Sawkill, and just below where the road crosses it, a gray, coarse, and somewhat massive-looking sandy rock comes down, dipping 12°–14° N. 20° W. Its bedding planes exhibit numerous irregular layers with curly or twisted structure and it belongs to the *Hamilton* proper, since, just above, many bold massive beds dip under water at an angle of 15° N. 25° W.

One mile and a quarter above the mouth of the Sawkill the base of the 3rd fall is reached at an elevation of 510′ A. T. or 130′ above the Delaware. This is a constant succession of cascades 1′–20′ high through a vertical distance of 50′; and seen from below, is one of the most fascinating views on the stream. At the top of this "Bridal veil" fall, as it is called, the stream has cut a narrow channel through the rock 10′ deep but only 5′ wide at top, so that one can easily

step across the channel even when it is much swollen. The rocks, bluish-gray sandy beds, dip N. 20° W. 16°.

About 1¾ miles from the Delaware, one comes to the Sawkill falls proper, the level of the water in the pool at its base being 600′ A. T.

The structure of this *fall* is sufficient evidence to any one that the Sawkill has not always flowed over its walls.

Beginning ¼ mile up the stream from the main falls, we find the Sawkill flowing between banks of Drift, which it here cuts through, and rapidly excavates a long narrow cañon out of the *Genesee shale.* This trench is 110′ deep where the Falls begin, only about 50′ wide at top and 10′–15′ at the bottom.

The first descent is a fall of 20′ in two cascades over the *fossil coral bed* at the base of the Genesee; then the stream spreads out on a broad gently sloping platform of gray *Hamilton rock*, to fall into the great abyss below in a vertical plunge of 60′. Leaving the pool at the base of the huge amphitheatre here excavated, the water passes through a channel only 2½′ wide, with a fall of 15′ down into a chasm only 2′–10′ wide but overhung with rocky walls 75′ high.

The *fossil coral bed* at the top of the large fall is a dark-blue slaty rock filled with *corals*, and also many *fossil shells.*

A short distance (½ m.) above the Sawkill Falls, the Milford and Owega pike crosses the creek, and following it north-westward, we find the *Catskill cliff rocks* coming into the hills, about one mile from the Sawkill bridge, at an elevation of 900′–1000′ A. T.

A great bed of *Drift* containing many *Oneida* bowlders, and some *Lower Helderberg limestone*, is seen near Mr. Darr's, at an elevation of 940′ A. T.

Just north of the by-road to J. H. Newman's, the outcrop of a grayish-green *Catskill sandstone* occurs in the road, at 1070′ A. T., dipping N. 25° W. 12°–15°. The same bed also makes a line of *cliffs* along the hills.

One mile further north from here, more *Catskill cliff rocks* are seen at the roadside, dipping N. 25° W. 15°, and

have been quarried for flagstone by J. Stiehler, just south from the pike.

All along the pike, near Wm. McCarty's, there are large beds of Drift, in which many small rounded bowlders of *Oneida conglomerate* are to be seen.

Some *nodules of iron ore* are seen in the *Marcellus dark shales*, one mile above Milford, at a cutting along the Port Jervis road. They come in a nearly continuous layer, 2″–3″ thick; elevation 520′ A. T.

At the upper limit of Milford, Vandemark's creek makes a series of cascades over the *Marcellus beds*, giving fine water power to the mill below.

Barometric Elevations in Milford.

(*Above Tide.*)

Court house in Milford, (street in front of,)	495′
Cross-roads at Crissman House, in Milford,	490′
Bridge across the Sawkill, near its mouth,	410′
Sawkill creek, at road crossing near D. Wells',	500′
" " crossing of Milford and Owega pike,	775′
Milford and Owega pike, at by-road to J. H. Newman's,	1050′
" " " " Stiehler's quarry,	1110′
" " " Stark's S. H.,	1225′
Next fork north,	1210′
" " of last,	1250′
Delaware river at Milford,*	380′

8. *Dingman township.*

This large township lies between the Delaware river on the south-east and Shohola creek on the west, being separated from Milford and Shohola townships by the Owega turnpike and Sawkill creek.

The western portion is drained by Shohola creek north-

* Confirmed by transit levels of J. J. Coon's, made on the old Lehigh and Eastern RR. survey.

Foot of Sawkill Falls,	600′
Top " "	695′
Milford and Owega pike, at crossing Br. of Sawkill, near L. B. Quick's,	1110′

ward into the Delaware, while the central and eastern portions send their waters through Raymondskill southward to the same river.

In the extreme south-western corner a small area drains into Big Bushkill.

The cultivated land of all this area is in two quite narrow strips: one, a narrow shelf along the Delaware bottoms under the *Hamilton cliffs*; the other, a belt of *Hamilton* and *Chemung* about one mile wide west from the *Hamilton sandstone cliffs*. The rest of the township is in the condition of the original wilderness, covered with a forest of *Pinus rigida*, and *Abies Canadensis*, in which bears, deer, and other wild animals still live.

The effects of the *Glacial moraine* in changing the course of streams is also plainly marked in this township; for the evidence proving that the Raymondskill once emptied into the Sawkill above Milford is complete.

The Raymondskill creek now empties into the Delaware three miles below Milford; but in pre-glacial times, it left its present channel, about 2½ miles west from the Delaware and going north-eastward, descended the present valley of Mott's run, uniting with the ancient Sawkill somewhere under the present site of Milford. That the Raymondskill once took this course is certain, because an old drift-buried valley leads across from the Raymondskill near J. Brink's to the Sawkill at Milford; and at no point does it rise higher than 20′ above the bed of the Raymondskill at Brink's. The character of the present Raymondskill channel below Brink's, is also proof of its recent origin, for it descends about 450′ in two miles, being a constant succession of rapids and falls with one grand leap (at Raymondskill Falls) of 125′.

The rocks outcropping in Dingman, are the same as those in Milford. The *Corniferous limestone* still hugs the New Jersey shore of the Delaware, whose valley is excavated from the *Marcellus shales*, while the *Hamilton* still forms a ridge of vertical cliffs overlooking the Delaware river and 500′–600′ high. Then come the *Chemung rocks* whose northern outcrop is about 3 miles from the river. Here the

Catskill sandstones begin and cover all the rest of the township with their cliffs and huge piles of débris. We thus get three ridges facing the Delaware, viz: the *Hamilton SS. ridge*; the *Chemung ridge*; and the *Catskill*, the latter of course leading up on to the general *Catskill plateau.*

In ascending the Raymondskill from its mouth to the foot of the Raymondskill Falls, one mile above, the ascent of the stream is only 100′ above the Delaware. The stream, however, has cut a deep, narrow cañon out of the soft *Marcellus slate* all the way from the foot of the Falls until its channel debouches into the Delaware valley.

The *Raymondskill Falls* is a spot of surpassing scenic beauty. The stream has there cut a deep narrow gorge through the *Hamilton ridge*, and at the bottom of this it descends through a vertical distance of 125′ in two successive leaps, excavating a beautiful glen, overhung with vertical walls of pine clad rock 200′ high, into whose depths the sun never shines. The upper is known as "High Falls," and the lower as "Bridal Veil." The water first makes a plunge of 80′ over the High Falls into a deep pool, and passing out of this in a narrow channel worn into the rock, descends 45′ vertically over the "Bridal Veil."

The bed rock is a hard bluish-gray *Hamilton sandstone*, and dips N. 25° W. 15°–17°. Owing to its delicious coolness in the hottest weather, this locality is a favorite resort of pleasure parties, and many thousands visit it during the heated term.

From the top of the Raymondskill Falls up to where the road crosses it, the descent of the stream is quite rapid, and cascades are frequent, the elevation at the bridge being 675′ A. T.,—a fall of 310′ in the one mile and a quarter from this point to the Delaware.

Continuing on up the Raymondskill, we come to a great bed of *Drift* near Lareaux's School-House, which fills a buried water-way extending north-eastward from the valley. Here the dark shales of the *Genesee* are reached, and a short distance above where the road up the creek crosses the Raymondskill, they sink below water-level, the *Chemung* coming in as surface rock. Very little of the latter is

seen in place, however, since the Drift débris covers up everything for two or three miles along this portion of the stream. Even the *Catskill rocks* are not seen *in situ* until we reach Mr. Galloway's, five miles above the mouth of the Raymondskill; but the base of this series must come down to water level, at least one mile below there. Just opposite Mr. Galloway's, on the north bank of the creek, the following succession was observed in a ravine.

Galloway's Section (44).

1. Sandstone,	10′
2. Concealed,	5′
3. Sandstone, grayish-green, (to 920′ A. T.,)	25′
4. Concealed to level of Raymondskill,	20′
	60′

Both Nos. 1 and 3 are hard, greenish, current-bedded sandstones peculiar to the *Catskill series*; and the latter forms a bold cliff, over which the little stream makes a vertical plunge of several feet. The dip is here about 15° N. 25° W.

Much Drift is seen in this vicinity, and in it many rounded and polished *bowlders* of the *Oneida conglomerate.*

Leaving the Raymondskill here, and passing over the hills to G. Geyer's, no *Oneida bowlders* were seen along the road; but from Mr. Geyer's on north to the Owega pike they are quite abundant, a very white one, 3′ in diameter, being seen just south of Geyer's.

Sawkill Pond, just south of the Owega pike, is an oblong body of water 15′–20′ deep, and occupies an old Drift-filled valley. The Pike county map represents it as having no outlet, but this is wrong, as it empties by a small stream into Sawkill creek.

Great heaps of Drift occur all along the Owega pike, from Sawkill pond to Shohola creek, and in them occasional *Oneida bowlders*, even on the highest summits, a few having been seen at 1475′ above tide, near J. O. Stidd's.

The Dingman turnpike runs N. W. & S. E. across the south-western corner of this township for about five miles. The elevation varies between 1225′ and 1375′ A. T., but everything is covered up with Drift except occasional cliffs of

Catskill sandstone. The *Oneida bowlders* are seen sparingly all along this pike in Dingman.

The *Log Tavern Ponds* are situated at the source of the Raymondskill, near the center of the township. The Big Pond is 1½ miles long, with an average width of ½ mile, and depth of 20′–30′. It is separated by the Little Pond by a long narrow ridge about 150′ high, and from the summit of which both ponds are visible. The latter has a maximum depth of 85′, according to the statement of Robert Drake, who has sounded it. The Big Log Tavern Pond has an elevation of 1270′ A. T., and the little one is a few feet lower.

The Big Pond occupies a portion of an *old Drift-filled valley* which extends northward from it toward the Owega turnpike, and it is possible that the Frenchtown branch of Raymondskill which crosses the Owega pike at 1325′ A. T. and now veers off one mile east from the Big Pond may once have passed through this old valley. Many Drift heaps are seen in the vicinity of the Log Tavern ponds and southwest from them, in which small *bowlders* of *Oneida conglomerate* occur.

On the Chucktown road, leading down the south bank of the Raymondskill, the *Catskill cliff rocks* are frequently exposed, and at Mrs. D. M. Case's the *base of the Catskill* is reached, three miles from the Delaware river. A large cliff of grayish-green current-bedded sandstone is there seen at 1025′ A. T., and a few feet below it the bluish-gray fossiliferous shales and sandstones of the *Chemung* make their appearance, extending on south to near the State road, where the top of the *Hamilton* begins in the dark blue *Genesee slate*, seen just north of J. McCarty's, dipping N. 20° W. 15°.

Just south of the cross roads at Loreaux's School-House, *Hamilton rocks*, are seen along the State road planed smooth by *glacial action*, conformably with the dip which is there 13° N. 25° W. *The striae* go S. 40° W. at an elevation of 900′ A. T.

Taking the road which leads S. E. from the Owega Pike

at Stark's School-House, we soon come to a great cliff of *Catskill sandstone* extending around the hills at 1185′ A. T., and on its surface see *glacial striae* trending S. 65° W.

Just south of the cemetary, near W. Baum's, a cliff of Catskill grayish-green sandstone, occurs at 1170′ A. T., dipping N. 30° W. 10°.

The Hamilton sandstone makes a line of cliffs along the Delaware in this township, just like those in Milford, only they are higher and more precipitous. One of these, called Utter's peak, one mile below Milford, rises to about 800′ above the Delaware, and from its summit the river valley is visible for a distance of 30 miles.

Barometric Elevations in Dingman.

(*Above Tide.*)

Forks of road near H. S. Mott's,	675′
Bend in road at T. Bowhanon's tannery,	780′
Forks at N. Grari's,	795′
Next fork S. W. from last,	810′
" " highest point in old valley leading from the Raymondskill to Sawkill creek,	830′
Level of Raymondskill at road crossing next north-west, ($\frac{1}{2}$ mile,)	810′
Cross roads near Loreaux's school-house,	850′
Raymondskill just west from last,	820′
" at Galloway's, two miles above,	900′
Forks of road at Galloway's saw-mill,	925′
" at J. Freadrich's,	1275′
" at G. Geyer's,	1250′
" at next north,	1240′
Level of Frenchtown branch of Raymondskill at crossing S. W. from G. Geyer's,	1240′
Big Log Tavern pond,	1270′
Little Log Tavern pond,	1260′
Level of Big Log T. outlet at road crossing,	1225′
Forks of road near R. Drake's,	1240′
Forks at Dingman pike next S. W.,	1250′
Dingman pike at A. P. Gerike's,	1350′
Level of Rattlesnake creek next worth,	1300′
Level of Dingman pike at Bear creek, near J. Picot's,	1245′
Level of Raymondskill west from M. Gaget's,	1075′
Summit of Chucktown road, one mile south of last,	1200′
Forks at by-road to J. Cornwell's,	1075′
" to J. Kilsby's,	950′
Forks at by-road to M. Chatillon's,	910′
" near J. McCarty's,	880′
" next S. W. of last,	895′

Forks at J. Kilsby's,	940′
" near H. Van Etten's,	970′
Level of Raymondskill at the road crossing above the falls,	675′
Level of Raymondskill at top of the falls,	595′
" " at foot "	470′
Raymondskill at crossing of Millford road,	400′
Forks just above,	410′
" of road near W. Baum's,	1065′
" " near C. & E. Quinn's,	850′
Sawkill pond,	1175′
Level of Sawkill pond outlet at W. Newman's,	1125

9. Delaware township.

This township lies directly south from Dingman, and its eastern line borders the Delaware river for about eight miles.

It is drained directly into the Delaware, principally through Adams, Dingman and Hornbeck's creeks, though the extreme western corner is drained by Little Bushkill to the same river through Lehman township. All of these streams pass over the *Hamilton sandstones* with great *cascades*, and although their ancient courses are not so clearly marked out as those of Sawkill and Raymondskill, yet there is little doubt that the present channels, at least from above the falls, date from the close of the *Glacial Epoch.*

The rocks of this township are exactly the same as those in Dingman, the *Corniferous limestone* being the lowest stratum, still occupying the New Jersey shore of the Delaware, while westward come in succession the *Hamilton*, *Chemung* and *Catskill* the latter extending to the western line.

The *Hamilton sandstone* still forms a line of cliffs along the Delaware, while west of it come in proper succession the *Chemung* and *Catskill ridges.*

In passing up Dingman's creek from the Delaware river one enters a narrow valley cut down through the *Marcellus shales.* The bed of the stream rises gradually until the *High Falls* is encountered 2 miles from the river, where the elevation is 515′ A. T. Here Dingman's creek descends 130′

in a very short horizontal distance, the lower portion being a nearly vertical plunge of 100′. The top of the Falls has an elevation of 645′ A. T. and there the hard bluish gray *Hamilton sandstone* dips N. 30° W. 12°. Two cascades of 10′ and 20′ each lead down to the top of the main falls, at whose base the rock dips N. 25° W. 10° and the joints run N. 60° E.

Just above the crossing of the old State road is the *Deer Lick Falls*, where the stream takes a plunge of 40′ over a cliff of *Chemung sandstone* whose top is 750′ A. T.

On above this ¾ m. and, just below Fulmerville the *Fulmer Falls* of Dingman's creek occur near the old woolen-mill. The stream descends in a cataract from 890′ A. T. to 850′, and then leaps from a narrow platform of sandstone through dark shaly rocks perpendicularly to 800′ A. T.

Chemung fossils occur in the dark shales but none are seen in the more massive bluish-gray sand rocks above; so that this is near the limit of the *Chemung*; for on above the upper falls 50′, there is seen the base of a massive grayish-green current bedded sandstone which is in the *Catskill;* it makes a cliff along the hills.

Many *Oneida bowlders*, all rounded, occur in the vicinity of Fulmerville.

Much drift débris is seen on up the valley to its source in *Silver Lake*, which is surrounded by low banks of drift gravel; elevation of Silver lake 1270′ A. T.; reported depth 100′. The lake has no inlet being fed by springs which rise from its bottom.

The State road runs along on a glaciated surface of rock near the dividing line between the *Genesee* and *Chemung*. The *striae* go S. 30°–40° W. and the rock is always smoothed off conformably with the bedding planes, which dip 10°–15° toward the north-west.

On the Dingman road ½ mile north from Albright's corners, *glacial striae* are seen on the *Catskill sandstone* going S. 25° W. at an elevation of 1060′ A. T. The rock is planed off smooth and furrowed with parallel grooves ⅛″–¼″ deep, and ⅛″–1″ broad.

Where the State road crosses Adams' creek, several *cascades* are seen 1′–5′ high, at an elevation of 910′ A. T. and in descending to the Delaware, its course is frequently interrupted by falls 10′–20′ high, while passing through the *Hamilton sandstone.*

In the vicinity of Dingman's, there is a broad *terrace* running back a half mile from the Delaware, and extending to 40′ above the same. Along the Bushkill road this terrace has been much eroded by some stream in the past, probably Dingman's creek, which may once have emptied into the river a mile or so below its present mouth. The wide valley through the terrace deposit, may however have been made by the Delaware itself during periods of floods when overflowing its banks an arm of the same extended west from the terrace deposit.

The *Corniferous limestone* is seen at Dingman's Ferry below the village extending along the New Jersey shore of the Delaware and dipping N. 25° W. 20°.

Barometric Elevations in Delaware.

(*Above Tide.*)

Forks of road near Conashaugh Cr.,	445′
Level of Conashaugh at crossing of road,	425′
Forks of road near Mrs. Van Gorden's,	400′
Adam's creek at road crossing near its mouth,	380′
Hotel in Dingman village, (road,)	405′
Level of Dingman's creek at road crossing,	385′
Cross-roads just south of creek,	400′
Forks of road at J. J. Case's,	390′
Levels of Delaware at Dingman's Ferry,	350′
" little stream at road near A. S. Dingman's,	370′
" run at road near M. V. C. Shoemaker's,	435′
" Hornbeck's creek at road crossing,	370′
Forks of road near G. Broadhead's,	820′
Hornbeck's creek just opposite,	815′
Forks on opposite side of creek,	840′
Level of little stream N. E. of L. P. Van Gorden's,	825′
Forks next east,	870′
" near Mrs. J. Angle's,	800′
Cross-roads near D. Burrell's, (State road,)	980′
Adam's creek at crossing next south,	910′
Forks north of A. Smith's,	895′
Cross-roads at Albright's Corners,	910′
Forks of road at Mrs. S. Fuller's, (above Dingman,)	455′

Creek just opposite,	440′
Forks near F. Elenwein's,	600′
" J. W. Kilsby's,	715′
Stream here,	700′
Forks near P. Reaser's,	785′
" north of S. Rozenoranz's,	830′
" next north,	850′
State road at S. Cole's cross-roads,	865′
Dingman's creek at crossing of State road,	710′
Forks of road near Fulmerville,	945′
Dingman's creek at road crossing above Fulmerville,	1000′
" " next " "	1020′
Nichecronk creek at road crossing near mouth,	1050′
Forks of road just above,	1055′
Level of Digman's cr., at mouth of little stream, ¾ m. above last,	1120′
Dingman's creek at E. Sheperd's dam,	1145′
" " crossing near G. Jolly's,	1190′
" " " below Silver lake,	1260′
Silver lake,	1265′
Forks near J. Shepherd's,	1360′

10. Porter township.

This township lies west from Delaware, having Dingman and Blooming Grove on its northern boundary, with Monroe county at the west and south.

It is drained by the several branches of Bushkill, (Big, Little, and Middle or Saw creek) southward into the Delaware at the extreme south-western corner of the county.

It is a wild, barren region, covered for the most part with its original forests. The nature of the country is sufficiently indicated from the number of persons living in the area in 1870, which was only 102, although the township is the third in size within the county.

Its geology is a sufficient reason for this lack of cultivation; for the great cliff rocks of the *Catskill* make up the underlying strata at every point of its surface, which is so littered up with their débris as to render farming impossible except in favored localities.

The lowest rock exposed in this township is the *New Milford red shale*, or the *first red bed* which occurs above the

base of the Catskill series, while the highest extend up to the level of the *Cherry Ridge red shale* at the extreme north-western corner of the area.

The *New Milford red shale* is seen along the Factory road at the township line, just west from Silver Lake, and is of a brick red color, several feet thick (20′ being seen) quite sandy; many rounded *bowlders* of it occur in the Drift.

Just west from where the Factory road crosses the inlet to Porter's lake, *glacial striae* are seen on a hard greenish-gray sandstone, trending S. 25° W. at an elevation of 1335′ A. T. Much drift is heaped up over the surface in the vicinity of Porter's Lake, but only one *Oneida bowlder* (the only one seen in the township) was observed. It is 2′ in diameter and lies at the roadside on the south-west shore of the lake.

Porter's lake contains 650 acres of surface, with an average depth of 15′, the bottom being covered with dark-green carbonaceous ooze, which doubtless extends to a great depth. The elevation is 1300′ A. T., and it empties into Big Bushkill.

Just north from Rocky Hill creek, a massive greenish-gray *Catskill sandstone* makes a vertical *cliff* 20′ high around the hills at 1310′ A. T., and just north from it some *red sandstone* and *shale* occur in the road at 1335′ A. T.

On the east bank of Big Bushkill, near Peck's saw-mill, the *Catskill sandstones* are seen forming a succession of vertical *cliffs* 15′–25′ in height, for 150′ above the level of the creek. They most probably belong in the *Honesdale group*.

Along the road which leads from Porter's lake to Bushkill village, a long *cliff* of gray sandstone is seen just north from Middle Bushkill, at 1360′ A. T. Also, just south of this stream, and 20′ above it, there is another cliff rock at 1270′ A. T.

Barometric Elevations in Porter.

(*Above Tide.*)

Level of Little Bushkill at F. Mercer's saw-mill,	1240′
Middle Bushkill, near its head, at crossing of Factory road,	1315′
Crossing of inlet to Porter's lake,	1335′

Porter's lake,	1300′
Forks of road just west,	1305′
Rocky Hill creek, at crossing next west,	1280′
Crossing of Bushkill, near Peck's saw-mill,	1310′
Forks of road, near H. A. Rheinhart's hotel,	1305′
" " one mile S. E. of last,	1400′
Level of Middle Bushkill, (Saw creek,) on Bushkill road,	1250′
Level of Mud pond,	1280′
Forks of road next south,	1320′
Crossing of Whitmore's Br. of Saw creek,	1260′
" Ladlee run,	1210′

11. Lehman Township.

This township adjoins Delaware on the S. E., and extends along the Delaware river to the Monroe county line, at the mouth of Big Bushkill, thus forming the extreme southern corner of Pike.

The drainage is all south-eastward into the Delaware, principally through Middle Bushkill (Saw creek,) Little Bushkill, Tom's, and Mill creeks.

The section of the rocks in this township is exactly the same as that exhibited in all those bordering the Delaware river between Bushkill and Matamoras.

The topographical features are, consequently, the same as those of the townships lying north, the same steep high ridge of *Hamilton sandstone* overlooks the Delaware, while back from it come in succession the *Chemung* and *Catskill ridges*, separated from each other by erosion valleys in the softer rocks at the top of the *Hamilton* and *Chemung*.

A large portion of this area is deeply buried by Drift, and *ice scratches* are numerous, generally running S. 25°–30° W.

A well was dug 20′ through the *Drift*, near the western line of the township, on the land of Mr. Laughlin, without reaching bed-rock. The elevation is 1300′ A. T., and the material passed through was principally sand, with an admixture of clay, gravel, and bowlders, mostly rounded.

Glacial striae going S. 25° W. occur on a hard *Catskill sandstone*, at the roadside, on the land of Mr. J. Acker, elevation 1160′ A. T.

Just south of Acker's a *cliff* of *Catskill sandstone* is seen at 1155′ A. T., and on below it several others, a very massive one occurring at 1115′ A. T.

Chemung sandstones are seen in the bed of Little Bushkill, where the Pine ridge road crosses that stream near R. M. Cook's; they dip N. 20° W. 14°; are quite hard and flaggy.

Further up the stream nothing is seen along the bed of the creek except Drift, which also covers the hillsides with a deep coating of trash.

The *Bushkill Falls* begin about ¾ mile below the road crossing at R. M. Cook's. The stream (Little Bushkill) cuts a deep narrow channel through the *Genesee dark slate*, falling 50′ in a series of gentle rapids, until the creek cuts down to the *Hamilton sandstone*, when it descends 75′ vertically into a deep pool with a large amphitheater excavated all around it; then, passing out through a narrow channel, the water descends in another vertical plunge of 50′ through a very narrow chasm to the deep, dark, and narrow cañon below.

This is probably the most attractive "Falls" in the county on account of its wildness and grandeur, as well as for the refreshing coolness always to be found in its shadowy depths. It is much visited by pic-nic and pleasure parties during the hot season. The top of the 75′ fall has an elevation of 700′ A. T.

It is very probable that the Little Bushkill once emptied into Middle Bushkill through some *old channel* now choked up with Drift since the lower portion of its course is evidently of comparatively recent origin.

North-west from the Falls, about 2 miles, is an *old valley* extending through to Middle Bushkill in which we now find a chain of several *ponds*, whose outlet is into Little Bushkill just below the Falls. A fall of considerable height also occurs at the outlet of these lakelets called *Pond Run Falls*.

Glacial striæ going S. 30° W. are seen on the hard *Hamilton sandstone*, ½ mile below Mr. H. Westbrook's at an

elevation of 600′ A. T. The rocks dip N. 25° W. 17° and they are planed off smooth conformably with the dip.

The Big Bushkill cuts through the hard *Hamilton sandstone* along the south-eastern line of the township without making any "falls" while Saw creek (Middle Bushkill) although it carries less water than Little Bushkill, has a fall of only 15′ in cutting through the Hamilton.

At the Middle Bushkill Falls, 1½ miles above where the stream empties into Big Bushkill, the following section is exposed:

Middle Bushkill Falls Section (45).

1. *Genesee slate,*	50′
2. Sandstone, dark, hard, (falls,)	15′
3. *Fossil coral bed,*	30′
4. *Hamilton sandstone* seen in cliffs for 1 mile S. E. dip 10°–15°.	
	95′

The *Genesee* No. 1 is here a dark sandy slate and is finely exposed along the bed of M. Bushkill. I could not get to the top of it owing to the deep gorge cut in it by the stream.

No. 2, is the lowermost portion of the *Genesee*, the rock over which the stream makes a fall of 15′ in a sloping cascade. The rock is quite sandy, hence its hardness.

No. 3 marks the dividing line between the *Genesee* and the *Hamilton* proper. The whole 30′ is one mass of *corals* penetrating in every direction the dark bluish matrix. Many of the corals have been dissolved and leave the surface of the enclosing rock honey-combed and pitted in every manner conceivable. The species are very numerous and the individuals simply countless. This stratum doubtless marks the horizon of the *Tully limestone* of N. Y.

Under it come the gray coarser beds of the *Hamilton sandstone series* dipping N. 25° W. 10° and making great *cliffs* along the stream south-eastward for more than a mile.

The *Marcellus shales*, dark-blue in color, are seen along the Delaware river road about two miles above Bushkill village.

Near the head of Schoonover's run, that stream makes a considerable *cascade* on the upper portion of the *Hamilton sandstone.*

The dark, slaty, *Genesee rocks*, dipping N. 30° W. 18° are seen along the road leading from W. Dickson's at the head of Schoonover's run, to Tom's creek.

On the old Ridgeway road, the *Catskill rocks* come into the hills at 1000′ A. T. near Mrs. Skyler's, where much débris from the Catskill cliffs is scattered over the surface.

Glacial striae are seen on Mill creek just opposite Mr. S. Fowler's, going S. 40° W., the dip of the Hamilton rocks being here N. 45° W. 16°.

The old State roads runs on a shelf of *Hamilton sandstone* between the forks of road near George William's, and the northern line of the township at J. Elenwein's. This solid rock road-bed is often grooved by glacial action, the *striae* running S. 30°–40° W.

Barometric Elevations in Lehman.

(*Above Tide.*)

Rafferty's run at crossing of River road,	380′
Forks of road at Brisco's hotel on River road,	370′
Level of Mill creek there,	360′
Forks of road at C. Swartout's,	390′
Crossing of Swartout's run on River road,	375′
Forks of road at Egypt Mills P. O.,	380′
Level of Tom's creek at crossing there,	365′
Crossing of small stream near Bonnical pond,	355
Schoonover's run at crossing of River road,	350′
Bridge across Big Bushkill,	360′
Creek there,	350′
Forks of road near H. Westbrook's,	730′
Top of High Falls on Little Bushkill,	700′
Little Bushkill at road crossing near R. W. Cook's,	860′
Base of Middle Bushkill Falls,	450′
Schoonover's run at first crossing of road above its mouth,	360′
" " second " " "	450′
" " third " " "	485′
" " fourth " " "	540′
" " fifth " " "	605′
" " sixth " " "	715′
" " seventh " " "	765′
Forks of road near W. Dickson's,	780′
" opposite sixth crossing,	745′
" near J. Bensley's,	700′
" near H. Stewart's,	650′
" near F. Everett's, on Tom's creek,	750′
Cross roads near P. Pierce's,	830′
Forks just east of George William's,	900′
Forks near F. Hornbeck's,	850′

Chapter VIII.

Township geology of Monroe.

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12. Middle Smithfield.

This township borders the Delaware river on the south, and Pike county on the east, so that it adjoins Porter and Lehman of that county, which have just been described.

The rainfall is carried into the Delaware river eventually, though it gets there by quite diverse routes. Big Bushkill flows south-east along the eastern line of the township, and drains that area directly into the Delaware at Walpack bend. The western and central portions are drained by Marshall and Pond creeks south-westward through Smithfield into Brodhead creek, a short distance above where that stream empties into the Delaware, above the Water Gap. Shawnee creek carries the water from the south-eastern portion to the same river through Smithfield township.

At the eastern extremity of this area, the Delaware river suddenly veers out of the course (S. 65° W.) that it holds in the 26 miles along Pike county, and first flows south 50 rods; then north-east (nearly parallel in a reverse direction to its Pike county course) for 200 rods; then south 50 rods; when it again veers around to S. 65° W., which direction it maintains all along this township. The double ox-bow bend thus made is called the Walpack Bend, and the curious shape is explained by the geological structure.

In Pike county the river flows in a valley excavated out of the *Marcellus shale*, while the *Corniferous limestone* borders its southern (New Jersey) shore, and just beyond, the underlying *Cauda-galli grit* forms a conspicuous ridge, separated from the Shawangunk (Blue) mountain by the valley of VI and V in which Flat Brook flows for 20 miles

in New Jersey parallel to the Delaware river, and often not more than one mile away from it. At the Monroe county line the Delaware, having found a low place in the *Cauda-galli ridge*, leaves the *Hamilton shale rocks* and cuts across to the valley of Flat Brook, which it reaches at Decker's Ferry, and flows across it to the *Medina sandstone.* Here, forced westward along the strike (S. 65° W.) it continues to wash the steeply dipping Medina layers until it starts southward, through the same, to enter the Water Gap.

It is possible that in ancient times the Delaware may have continued on down the Marcellus valley; for there is an old *buried channel* that continues on through this township, and Smithfield, in a direct line with the Delaware in Pike county, and is always bordered on the south by the *Corniferous limestone* and the *Cauda-galli hills.* But as stated elsewhere * the probability is that it owes its origin to other causes. The Big Bushkill strikes this old valley at Shoemaker's mill, where, being met by Willow creek, it turns abruptly eastward and follows it down to the Delaware at the point where the latter stream leaves it.

Drift occupies this old valley throughout its entire course, and is of unknown depth. Near its center in this township, are two lakelets, called Coolbaugh and Echo ponds. .

Echo Pond is at the head of Willow creek, from whose waters it is separated by a high ridge of Drift, though the maps wrongly exhibit it as emptying into the latter stream. It has in fact no visible outlet anywhere, except in very rainy weather, when it overflows the low swampy ground connecting it with Coolbaugh pond. It is fed by springs which have their source in the Drift covered regions around, come up under its surface, and usually find an exit for the surplus waters by a subterranean channel through the Drift into Coolbaugh pond, and thence into Pond creek, a stagnant, sluggish stream which occupies the lowest portion of this old valley south-westward from the ponds. The surface of Echo lake is 500′ A. T., and its maximum depth 35′; and as this is the highest point in the old valley between Bushkill and Stroudsburg, we know that it is cut down to

* See summary, page 54.

at least 400′ A. T.; for the valley is so wide here that the Drift trash under the bottom of the lake could not well be less than 65′ deep. It is more probably 150′.

Coolbaugh pond has about the same elevation (500′ A. T.) as Echo lake, the difference being inappreciable with the aneroid.

Hitherto our section of the rocks along the Delaware, has extended only to the *Corniferous limestone*; but, owing to the southward cut of the Delaware previously referred to at Walpack Bend, a large addition is made to this lower end of the column in this township, the same being extended from the *Corniferous* limestone down through the rest of VIII, VII, VI, and V, to the *Medina sandstone* (No. IV,) along the southern shore of the Delaware, which now flows in the soft *Clinton red shale* between the *Medina* SS. and No. VI, instead of the soft *Marcellus shale* which it had previously occupied between Port Jervis and Bushkill.

Hence the topography of this township, and others bordering the Delaware in Monroe county, is much more complex than that of those similarly situated in Pike; there being an addition of several *ridges* and intervening valleys, to which appropriate reference will be made under the description of the *rock formations* of the township.

The section of the strata exposed in this area extends from the lower portion of the *Catskill* down to the top of the *Medina sandstone*, at the southern shore of the Delaware. The channel of the river is excavated for the most part, out of the soft red rocks of No. V, and consequently the beds of this series are not well exposed, since at one locality only do we obtain a view of any portion of the *red beds*. This occurs at the upper end of Poxono Island, where the Delaware bears slightly southward, and *Clinton* rocks, V, coming into the hill along the northern shore are exposed in a deep ravine which enters the river there on the land of Mr. I. Turn. Here directly below the basal members of VI, are seen 75′ of a dark, or dull red shale, in which occur many traces of *copper* in scattered patches of green, and also traces of *zinc blende*.

The Lower Helderberg rocks, (No. VI,) crop out along the northern shore of the Delaware, and make the steep slope of the hill surface facing the river between Decker's ferry and the southern line of the township. The lowermost beds extend out under the bed of the stream, except at the one locality already mentioned in vicinity of Poxono Island, where No. V forms the northern shore.

Where the Delaware cuts through No. VI above Decker's ferry, the following section is exposed:

Decker's Ferry Section (46).

1.	Very fossiliferous shales, visible,	20′
2.	*Limy, cherty shales*, fossiliferous, with some pebbles,	35′
3.	*Pebbly layers*,	5′
4.	*Very massive gray limestone*, } *Stormville*, {	20′
5.	Concealed, (limestone,) } {	75′
6.	Limy sandstone, with pebbles of quartz and many fossils, *Decker's Ferry Sandstone*,	20′
7.	Shales, gray, calcareous, (*Decker's Ferry*,)	15′
8.	Limestone, (*Bossardville*,) slaty fracture, visible,	15′
		205′

On above No. 1 of this section, occur hard, grayish, sandy beds whose place in the series could not be definitely determined, owing to poor exposure and the fact that I was unable to collect fossils from No. 1; since, occurring as it does in the bed of the Delaware, separated from the shore by a deeper channel, I was unable to reach it at the time of my visit to this locality, though the fossils in it were so numerous that they could be readily discerned at the distance of several yards. I am inclined to consider No. 1 a portion of the *Stormville shale*, since I have never seen any portion of the *Cauda-galli grit* in which the fossils were anything nearly so abundant.

Nos. 2 and 3, however, look very much like the *Oriskany cherty shale* and pebbly layers found in that formation; so that should No. 1 not represent the *Stormville conglomerate*, as supposed, it would be the lower portion of VIII, in the bottom layers of the *Cauda-galli*.

No. 4 is a very massive stratum, forming a great cliff of bluish-gray limestone along the hill facing the river, from which many bowlders 10′ or more in diameter, have broken

away and now line the shore, being smoothed and rounded by the river action during high waters. Many *fossil corals* (*Stromatopora* and allied forms) are seen in this stratum together with *Pentamerus galeatus* and other common *Lower Helderberg* forms.

The thickness of rocks in No. 5 was obtained partly by measurement and partly by calculation from the dip, which is here N. 30° W. 40°.

The Decker's Ferry sandstone, No. 6, was named from this locality. It is a greenish-gray, fossiliferous rock containing considerable lime, and many small quartz pebbles in several of its layers, especially near the top. The most abundant fossil is a small *Chonetes* which when the lime is dissolved from the test often leaves the enclosing matrix in a very rotten or honey-combed condition. No *characteristic Lower Helderburg* forms are seen in it.

The Bossardville limestone, No. 8, is exposed only for 15′ in its upper portion at Mr. J. Grube's quarry, along the road to the Ferry. It is a bluish-gray rock, in thin layers, which break with a slaty fracture, and is *non-fossiliferous*, excepting some minute organisms which look something like *Beyrichia*, and some small fragments too indistinct for determination. This limestone is quarried near the Ferry by Mr. Grube and burned into lime for agricultural and other purposes.

About one mile below Decker's Ferry, and near Mr. J. VanAuken's, the following section was obtained in the steep bluff of the Delaware:

J. Van Auken's Section (47).

1. *Stormville shales*, visible,	10′
2. Cherty, limy shales, with some pebbly layers, (*Stormville conglomerate*,)	20′
3. *Limestone*, massive, bluish-gray, (*Stormville*,)	75′
4. *Water lime*,	5′
5. Bluish-gray, brecciated limestone,	5′
6. *Decker's Ferry sandstone*,	25′
7. Concealed to level of Delaware river,	100′
	240′

No. 2 is well exposed at this locality, and it covers most

of the concealed interval in the preceding section. Owing to the cliff-like exposure at Van Auken's, this interval could be measured with greater precision, and the result (75′) renders it probable that the concealed interval, (75′,) obtained by calculation for the preceding section, is a little too great

Many *fossil corals* are seen in No. 3, some of which have fallen out of the weathered vertical cliffs, and now lie in large masses over the ground.

No. 4 is a drab-colored rock of an earthy aspect, which much resembles in physical appearance the famous *water-lime* at Rondout, New York. Specimens taken from it for analysis gave the composition shown on page 136.

The *Decker's Ferry sandstone* forms a bold cliff outcrop along the hill at this point, and many quartz pebbles are seen in it.

On below J. Van Auken's, about one mile, the Drift materials have been eroded from the northern shore of the Delaware, and in its steep bluff near J. C. DeWitt's the following is exposed:

Delaware River Bluff Section (48).

1. *Decker's Ferry sandstone*, visible,	20′
2. *Bossardville limestone* to level of Delaware river,	60′
	80′

The Decker's Ferry sandstone makes the top of the bluff, and is apparently more pebbly than in the two preceding sections. A narrow terrace extends on its upper surface, as a shelf, back to the bounding hill.

The Bossardville limestone is fully exposed for 60′ in the vertical bluff, and several feet more extend beneath the Delaware. It has been extensively quarried here and transported across to the New Jersey side for burning. The upper portion is bluish-gray, but the middle and lower is of a bluish-black aspect, and traversed with veins of calcite. For analysis of specimens collected here, see summary, page 142.

The portion seen in the bed of the Delaware at this locality is very probably the *Columnar limestone*, since it seems to have the banded structure peculiar to that stratum, so

far as can be made out from the appearance of the rock submerged under two feet of water.

Steeply dipping rocks are also seen on the New Jersey shore of the Delaware at this locality, probably belonging to the beds of No. V.

Near the school-house below J. C. DeWitt's, the following section is exposed between the road and the Delaware.

J. C. DeWitt's School-house Section (49).

1. Limestone, bluish-gray,	6′
2. *Water lime*,	5′
3. Limestone, bluish-gray, brecciated,	5′
4. *Decker's Ferry sandstone*,	30′
5. Concealed to Delaware river,	40′
	86′

No. 1 contains immense numbers of *Leperditia alta*, and is seen along the road in a cliff for some distance.

The *Water lime* layer, No. 2, is the same bed as the one found in the section 46, from J. Van Auken's. It also seems to be identical with the "*Peth rock*" of Prof Cook, in the sections of these same measures at Wm. Nearpass' quarry, near Port Jervis, 30 miles N. E. from this locality. The rock has a buffish-gray, dull color on weathered surfaces, but on fresh fracture is a bluish-gray, with the characteristic aspect of *Water lime*.

The *Decker's Ferry sandstone* makes a vertical cliff, 25′ high, in the vicinity of the school-house, and extends along the Delaware bluff just below the road.

The Bossardville limestone is quarried again on the land of Mr. J. DeWitt, about one mile and a half below the locality of the last section, where the following succession was obtained in descending the hill road to the river road at the limestone quarry:

J. DeWitt's Section (50).

1. *Stormville shales*, visible,	30′
2. *Stormville conglomerate*,	20′
3. Concealed,	65′
4. *Limestone*, massive, fossiliferous,	25′
5. Concealed	10′

6.	*Water lime*,	10′
7.	*Limestone*, blu.sh, brecciated, fossiliferous,	10′
8.	Concealed, (with some shaly limestone, visible,)	20′
9.	*Decker's Ferry sandstone* and shale,	35′
10.	*Water lime*, impure,	5′
11.	*Bossardville limestone*,	60′
		290′

The Stormville shales, No. 1, look very much like the *Cauda-galli grit* having an ashen hue; but they are not; for on going further north they dip under, and the *Oriskany sandstone* is then seen coming into the section.

The *Stormville conglomerate* caps the hill; and a short distance to the north-east is seen forming the summit of an isolated knob, overlooking the Delaware river almost vertically and 300′ above its level. There is more pebbly sandstone in its composition here than further eastward.

The concealed interval, No. 3, is exposed one and a half miles N. E. from the line of section and consists largely of massive bluish-gray, impure, crystalline limestone, very full of characteristic *Lower Helderberg fossils*.

The Water lime layer, No. 6, which is the same as that given in the preceding sections, is here much thicker than usual; is of a dull buffish-gray color and on its weathered surface is converted into *ochre* by removal of the lime.

Leperditia alta is very abundant in the top and upper half of No. 7, their seed-like bodies covering its entire upper surface in many places.

The *Decker's Ferry sandstone* is somewhat limy here, and very fossiliferous, *Chonetes* being the most abundant. *Glacial striæ* are seen on its top going S. 60° W.

A second layer of water lime makes its appearance in this section, below the *Decker's Ferry sandstone;* it is very earthy, however, and of no economical importance.

The *Bossardville limestone* has been extensively quarried along the river road by Mr. J. C. DeWitt, and burned into lime for agricultural and other purposes; the rock is of a bluish-black color, except near the top where it is gray; contains much calcite in irregular streaks and veins, and dips N. 15° W. 40°.

Keeping on south-west from this locality the Delaware

veers south of the line of *strike* and cutting over against the steeply dipping *Medina sandstone* along the *Jersey shore* leaves the *red shales* which come above the latter rock and the *buff shales* at the base of No. VI standing out in a steep bluff and wide terrace along the north bank of the river. The section obtained here, opposite the upper end of Poxono Island on the land of Mr. J. Turn is as follows:

Poxono Island Section (51).

1. *Stormville conglomerate,*	25′
2. Limestone, impure, massive,	75′
3. Concealed,	40′
4. *Bossardville limestone,*	75′
5. *Poxono Island shale,*	200′
6. *Poxono limestone,* bluish-gray, crystalline,	5′
7. Greenish, shales,	5′
8. *Clinton red shale,*	75′
9. Concealed to level of Delaware river,	45′
	545′

This is the only locality in Monroe county, or in fact anywhere between the New York State line and the Lehigh river, where the succession between the *base* of the *No. VI limestone* and the *No. V red beds* can be satisfactorily made out, since everywhere else these measures are deeply covered by debris from the rocks and soil above. Prof. Cook, of the New Jersey survey, could not find an exposure of this interval in the entire extent of *No. VI* through that State; and this is the principal reason why my section of No. VI and its associated rocks differs so much from his. For this fortunate exposure we are in debt to a deep cut made in the nearly vertical bluff by a small stream, and to a cutting along the river road which lays bare the most of the *Poxono Island shales*, bringing the section up to the limestone bluff at the foot of the steep hill which everywhere borders the Delaware river along this township.

This is the locality to which reference has already been made as containing the lowest rocks exposed above water level in the township.

The upper portion of this section needs no comment since it is simply a repetition of the same rocks that occur every-

where along the Delaware river between here and Decker's Ferry.

Nos. 1 to 4 make the steep slope of the hill, the foot of which does not begin until nearly one half mile back from the Delaware river, from which it is separated by a broad terrace made by the *Poxono Island shales.* The highest portion of the terrace is 240′ above the river, or about 555′ A. T., while other shelves occur at 530′ and 490′ A. T., the latter seeming to represent the elevation of the principal portion of the terrace.

The Poxono Island shales are exposed along the river road from the upper extremity of Poxono Island to the forks at J. Turn's. They dip N. 25° W. 20°–30° and are largely composed of buffish-gray shales often interstratified with calcareous layers. Occasional bands of red or variegated shales are also to be seen, while much of the buffish rock is tinged with a pale greenish hue.

The genuine *limestone bed* No. 6, at the base of the *Poxono Island shales*, should probably be included in the latter, since this is the only locality in the county or district where it is seen, and it may possibly be local; but as exposures at this horizon are rare, the fact of its seeming absence elsewhere is really no argument against its general distribution. I have termed it the *Poxono Island limestone* from the fact that it juts out of the bluff overlooking the island of that name in the Delaware. It is bluish-gray crystalline; breaks with sharp conchoidal fracture, and contains some minute fossils all of which are too fragmentary for determination. For its analysis, see page 147.

The Poxono Island shales are partially exposed along the ravine which puts into the Delaware near the Lutheran church, one mile below the locality of the last section, where we see 75′ of buffish shales interstratified with thin beds of *red material*, and some layers of impure limestone.

The Oriskany sandstone (*No. VII*) makes but little show in this township, and was seen at only three or four localities. This is owing to the fact that it has not yet thickened up to a regular conglomerate. It rapidly grows massive and pebbly however toward the southern line of the

township, Shawnee creek exposes it by erosion, near J. Mosier's, for only a short distance, where its top forms a broad flat along the road. A low swell or anticlinal also assists in bringing it up at Mosier's. Followed north-eastward from this point out of the Shawnee valley it is soon buried under the overlying *Cauda-galli grit*, and only comes out to day on the northern flanks of the mound-like ridge which runs parallel to the Delaware, with the *Stormville conglomerate* in its southern face, and the *Stormville shales* occupying its summit.

On the road leading from J. Woolbert's up on to Walpack ridge past Mr. J. Hanna's, the *Oriskany sandstone* is seen coming up in a cliff 15′–20′ high, near the township line; elevation 950′ A. T. The rock is quite pebbly and fossiliferous. Below it come the *Cherty shales* of the *Stormville series.*

Where the next road passes over the Walpack ridge, two miles north-east from this last one, the *Oriskany sandstone* is seen just south of M. H. Dimmick's, in a ledge of massive conglomerate, 15′ high, dipping rapidly (20°–25°) to the north-west under the *Cauda-galli grit.* On above, the *Stormville shales* cover the summit of the ridge, and its cherty, ashen-colored layers are well exposed at the forks of the road above Mr. Dimmick's.

The next road across the ridge is about two miles further to the north-east, passing from T. Schoonover's across to the Delaware, opposite Van Campen's island. Along this road the *Oriskany Sandstone* is seen in the field just north from the summit of the ridge, though there are so few pebbles in it here that it does not make a cliff.

The Oriskany passes below the Delaware river about one half mile above Decker's Ferry, though owing to the precipitous character of the bounding banks at this place, I was unable to reach the locality.

The Caudi-galli grit, (under this name I include all the beds between the base of the Corniferous limestone and the top of the Oriskany,) outcrops in a broad band across the entire south-western portion of the township, parallel

with the Delaware river, and next north from the *Oriskany sandstone.*

The rock is a hard, dirty-looking, gray, slaty sandstone, with very fine grain, and nearly always exhibiting coarse cleavage planes at a high angle to the south-east, which causes it to look very frequently as though dipping in that direction, when in reality the true dip is toward the north-west. *The cleavage structure* is well exhibited along the Shawnee valley near Mr. H. Overfield's, where a high bluff of *Cauda-galli* juts out immediately above the *Oriskany sandstone.*

The only fossil seen in this formation within the township is the *Spirophyton cauda-galli*, whose abundance in New York has given name to the rock. This (of which only one specimen was observed) occurs at the roadside near Place's school-house.

Owing to the fine grain, and very hard nature of this material, it is excellently fitted for preserving *glacial scratches*, and hence we find its surface scored with *striae* whenever it is uncovered. The rock is occasionally found *moutonné*, a very fine example being seen at the roadside, one mile south-west from T. Schoonover's, where the *Spirophyton* was observed.

A few rods further down the road, the *Cauda-galli grit* is ground off to a fine polished surface, and cut away much steeper than the dip; the very fine *striae* run S. 40°–50° W. Magnetic.

Just beyond the Cartright school house, the *Cauda-galli grit* is planed off conformably with the dip (16° N. 25° W.,) and a large surface has been uncovered along the road, on which the *glacial scratches* trend S. 60° W. (M.)

A very high hill of the *Cauda-galli grit* extends along here, running of course the same direction as the strike (about S. 65° W.) and this very probably accounts for the unusual *westward* trend of the *striae*, the hill of *Cauda galli* having acted as a groove to force the ice into a direction nearly parallel to the strike. The road leading from Bushkill to Decker's ferry passes across a high ridge of *Cauda-galli grit*, 600′–700′ above the level of the Delaware

river, and here this rock series crosses the latter stream into New Jersey.

No opportunity was found for measuring the thickness of the Cauda-galli in this township, but from its rate of dip (seldom less than 15° and often 25°), and the breadth of its outcrop, it cannot well be less than 300 feet.

The *Corniferous limestone* is the next (upward) succeeding of the rock formations in Middle Smithfield.

Its *northern outcrop* enters the county across the Delaware from New Jersey, where the river first begins to veer southward near the mouth of the Big Bushkill, and keeping south-westward parallel with the Milford road, it follows the road to where the latter leaves the township; never further away than 300–400 yards, but only in two places does it touch the road, once just south-west from Shoemaker's corners and again as the Milford road leaves the township, near S. C. Augle's.

The southern outcrop is a very undulating line averaging about ⅛ mile south from the northern, but occasionally broadening out to ½ mile, or even ¾ mile, and again contracting to ¼ mile, when the dip is very rapid. This belt of *Corniferous limestone* was undoubtedly nearly twice as broad in pre-glacial times as now. It was entirely stripped off of the long sloping hill of *Cauda-galli*, except in a few favored spots which remain to attest its former extent. The rock is everywhere filled with masses of *black chert*, from the size of a hen's egg up to one foot in diameter. It has been burned only to a small extent in this township, since it requires great care in excluding the *cherty portions*, or the lime will not slake. Just opposite Echo Lake it has been quarried and burned to a small extent by the owner of Echo lake Cottage. The uppermost portion only was used and it is quite fossiliferous.

The dip of the rock varies wonderfully in short distances at times being 25°–30° to the N. 25° W., and then suddenly flattening to almost nothing or even reversing. This irregularity of dip causes frequent ledges of the rock to be exposed in vertical walls 10′–15′ high, rendering the sur-

face over which its outcrop extends exceedingly rough and almost always untillable, except in small isolated areas.

It is frequently broken into blocks of immense size which are occasionally heaped together.

The *grinding action* of the ice is often discernible on the *Corniferous limestone*; but it is rare that any *striae* have been preserved in this township, except when they cross the nodules of flint.

Owing to the very irregular dip of the *Corniferous Limestone* its thickness in this township could only be rudely estimated, and this would make it somewhere between 200′ and 250′ thick, with the probabilities in favor of the latter figure.

The dip of the *Corniferous limestone* is nearly always 15°–20° where it passes under the *Hamilton rocks*, but further southward near the southern outcrop it is reduced to 10° or even less.

The *Corniferous limestone* has its best exposure in this township along the road which leaves the Milford pike at A. Miller's and goes south past S. Walter's. Here it covers many acres with its immense roughened bowlders, and long lines of cliffs.

The Hamilton belt averages about 1½ miles wide.

The exact contact of the *Marcellus beds* with the *Corniferous* beds was not seen in this township owing to want of exposures at this particular horizon, yet in two or three places the concealed interval between them is reduced to a maximum of only 5 feet, so that the character of the rock at the line of contact can be inferred without much uncertainty. This is everywhere (within this township) a bluish-gray, sandy slate, or often more properly a slaty sandstone; it is seen at many places in cuttings along the Milford pike; and especially at J. V. Coolbaugh's, where in excavating for a building foundation it is cut away for several feet just above the outcrop of the *Corniferous Limestone*, which occurs in the road only 5′–10′ below the lowest layers of the *Marcellus shale*. The bluish-gray rocks at this locality show cleavage planes at a high angle (70°) to

the south-east, and are interstratified with layers of light buff rock 2″–4″ thick at intervals of 4′–5′. The whole mass disintegrates very readily. How much of this lowermost portion of the Hamilton consists of the *gray slate* in this township, it is impossible to know, since it dips rapidly down under an old *drift-buried valley* and is speedily lost from view; when the northern wall of the valley is reached, we find the dark, bluish-black shales of the *Upper Marcellus*.

The Marcellus outcrop in Pike county is occupied largely by the bed of the Delaware river and the adjacent valley, its upper portion only extending north of the Milford pike for a very short distance under the overhanging cliffs of the *Hamilton* proper. But when the Delaware turns south and leaves it at the eastern corner of Monroe Co., an old *buried valley* keeps straight onward, its continuation being occupied in this township by Willow creek (flowing north-east) and Pond creek (flowing south-west) with Lakes Echo and Coolbaugh separating them at the highest level of the buried valley.

The outcrop of the bluish-black *Upper Marcellus shales* is frequently seen along the road which runs parallel with Willow creek and ¼ mile north from it. Just north from M. Overfield's, a *cliff* of these blackish, sandy shales, 200′ high, rises almost perpendicularly from the old valley. Some fossils are seen in them, but they were so badly preserved as to be indeterminable.

From the known dip of the *Marcellus* (15°–18° N. 25 W.) its entire thickness in this township cannot be much less than 800′ of which probably 500′ belong in the *upper* division.

The *Hamilton proper* consists in this township, as throughout Pike county, of very hard sandy beds which always show a rough cleavage to the south-east, and make massive looking *cliffs* and high bluffs. The summits of these bluffs are generally reached at an elevation of about 800′ A. T. and then a gentle slope of *Genesee* brings us up to the outcrop of the *Chemung*. A fine specimen of *Gram-*

mysia bisulcata was obtained in the top of the Hamilton group, at the roadside near Hoffman's school-house; and in the bed of Marshall's creek, one half mile above the township line, many specimens of *Spirifer Hamiltonensis* and *S. granuliferus* were observed. At this last-mentioned locality the creek makes rapids over the *Hamilton sandstone* which dips 16° N. 25° W.

The fossil coral bed was not seen in this township, since both it and the *Genesee slate* are almost constantly concealed under the huge piles of debris which have come down from the *Chemung ridge* above, and beneath Drift heaps which cover up everything that would otherwise be revealed.

The rocks of the *Hamilton series* dip about 15° N. 20°–25° W. in this township, and their thickness is about 1200′, with *Genesee* probably 200′, thus making the whole *Hamilton series* about (800′+1200′+200′) 2200′ thick.

The *Chemung beds* form a narrow belt, only ½–⅝ mile wide, across the township, next north from the *Hamilton outcrop*.

The top of the series is seen along the road 1¼ miles south from Ressaca, where a few feet are exposed at the base of the Catskill, and this is the only locality in the township where I saw any of these rocks uncovered, except along Marshall's creek, in the vicinity of Miller's saw-mill, where the creek makes a fall of 8′ over them, and great cliffs of the same are seen near the crest of the hill, just below.

The Big Bushkill must give a very fair exposure of *Chemung*, as well as the upper part of the Hamilton, below, but owing to the cañon-like character of its channel it was found inaccessible at the time I visited the region, though doubtless during a very low stage of the water it would be possible to pass along the bed of the stream between the Falls at Ressaca and the mouth of Saw creek. This ought to expose nearly everything between the *Catskill* and the top of the *Marcellus*, if anything can be judged from the character of the channel, as seen from the nearest road, (½ mile away.)

The northern outcrop line of the *Chemung* extends from about the western angle of the township, near J. Cramer's, north-eastward, crossing Marshall's creek ¼ mile above the mouth of Dead Man's run, and Big Bushkill, below the Falls of Ressaca.

The *Catskill rocks* cover all the rest of the township north from this line, and the entire region (about ⅞ of the township) thus covered is almost a complete wilderness, there being not more than one dozen farms in the whole area. A large portion of it is deeply covered with *Drift*, and several extensive swamps occur in the western and northern portions. Among these are *Bear*, *Palmer*, *Long*, and *Kennad swamps*. They come at the horizon of the *Montrose red shale*, and this has, doubtless, had much to do with their origin, though they seem to be everywhere covered with *Drift*.

The lowest beds of the Catskill come down to water-level on Marshall's creek, near the old saw-mill, one half mile above Mr. H. Miller's, and there make long lines of cliffs 20′–30′ high, dipping 20° N. 25° W. The rock is a coarse, greenish-gray sandstone, much current-bedded, and apparently destitute of fossils.

About ¼ mile above the old mill, *the lowest red bed* of the Catskill comes down to water-level, on a dip of 25° N. 25° W., and makes a broad red outcrop across the road. It is a deep, dark-red, somewhat sandy, and about 75′ thick. This would represent the *New Milford red shale* of Susquehanna and Wayne, the 500′–600′ of steep dipping sandstone beds immediately under it corresponding to the *Starrucca gray shales*.

A *flagstone quarry* has been operated to a considerable extent, 150 yards further up the creek, on both sides of the road, by Mr. J. Chambers. Its horizon is in the *Delaware flags*, or what is the same as the *New Milford sandstone group* of Wayne and Susquehanna. The rock is greenish-gray, and comes in smooth layers 2″–4″ thick, dipping 30° N. 25° W. Excellent flagging of small size (3′×4′) can be obtained here; elevation of both this and the *red beds* about 800′ A. T.

The *New Milford red bed* is seen crossing the Coolbaugh road, one mile south of Ressaca, at an elevation of 900′ A. T.; 60′–75′ thick, and dipping 27° N. 25° W.

The Big Bushkill Falls are at the village of Ressaca, where the stream makes a vertical plunge of 40′ over massive cliffs of *Catskill sandstone.* A short distance below this is situated the old Ressaca tannery, which received its water-power from the head of the falls through a waterway cut from the dam at the head of the falls around the bank, through solid rock. In this cutting, *thin streaks of coal* $\frac{1}{8}''$–$\frac{1}{4}''$ thick were encountered, and considerable prospecting has since been done in this region, with the hope of finding valuable beds of the same. It is, of course, hopeless to expect anything of the kind, since it is absolutely certain that no *workable bed of coal* exists east of the Lehigh river.

No better locality for water-power could be desired than the abandoned site of Ressaca tannery, since the Big Bushkill furnishes an unfailing supply of water, and the fall can be increased to any extent. The top of the Falls has an elevation of 790′ A. T.; the rocks dip 12½° N. 25° W.

About one half mile above Ressaca, the Big Bushkill makes another *fall* of 30′ over the hard cliff sandstones of the Catskill.

Along the extreme northern line of this township no outcrop rocks are to be seen; for there, except along Big Bushkill, everything is covered up with great heaps of Drift. In these heaps, near Mr. Smith's, at the Pike county line, two *bowlders* of *Oneida conglomerate* were observed at an elevation of 1100′ A. T.; one a foot in diameter, and the other two feet—both polished and water-worn.

Barometric Elevation in Middle Smithfield.

(*Above Tide.*)

Big Bushkill at crossing of Milford road,	350′
Forks at Maple Grove Hotel, "	380′
Cross-roads at Shoemaker's Post Office,	450′
Forks at J. V. Coolbaugh's,	500′
Milford road at Echo Lake Cottage,	530′
Echo lake, (Seeley's pond,)	500′

Milford road at J. Coolbaugh's, ... 505′
" " Coolbaugh P. O., ... 515′
Coolbaugh pond, ... 500′
Milford road at forks near Jas. Places', ... 515′
" " " S. Wolf's, ... 515′
" " " A. Miller's, ... 520′
" " " J. J. Augle's, ... 540′
" " " S. C. Augle's, ... 500′
Pond creek at road near Jas. Places', ... 510′
Forks at E. Harman's, ... 520′
" H. Overfield's, ... 500′
Level of Shawnee creek at crossing just south, ... 480′
Forks near J. Woolbert's, ... 625′
" L. Strunk's, ... 685′
By-road to a Treible's, ... 750′
Forks ¼ mile south of M. H. Dimmick's, ... 805′
Forks near Geo. N. Michael's, ... 415′
Delaware river an Poxono island, ... 315′
Forks of road near J. Turn's, ... 435′
" " " J. DeWitt's, ... 430′
" " " S. DeWitt's, ... 380′
" " just on the hill above, ... 525′
Delaware river at Decker's Ferry, ... 325′
Forks near T. Schoonover's, ... 555′
Forks east from J. Colville's, ... 635′
Level of stream at " . . . . . 600′
Forks east from M. Places', ... 60⁵
Forks near Cartright's school-house, ... 590′
Big Bushkill at mouth of Willow creek, ... 405′
Willow creek at crossing opposite Shoemaker's P. O., ... 425′
Forks south of M. Decker's, ... 490′
Forks ½ mile west of " . . . . . 645′
Big Bushkill at mouth of Saw creek, (Middle Bushkill,) . . . . . 435′
Forks of road at Ressaca, ... 810′
Top of Big Bushkill falls, ... 790′
Forks ¼ mile south-west of school-house, ... 880′
" ½ mile south of J. Hoffman's, ... 775′
" near J. Clark's, ... 590′
" " J. Mosier's, ... 585′
Pond creek near E. G. Mosier's, ... 540′
Forks next west from G. W. LeBar's, ... 530′
Pond creek at crossing near S. Wolf's, ... 495′
Cross-roads at Levi Hoffman's school-house, ... 825′
Forks of road on Marshall's creek.
Forks just north of J. Ransparger's, ... 630′
Road crossing of tittle stream ¼ mile west, ... 705′
By-road to Mrs. P. Pifer's, ... 860′
Forks near C. W. Lander's, ... 880′
Forks north from A. Smith's, ... 920′
Sambo creek here, ... 860′
Marshall's creek at mouth of Dead Man's run, ... 700′
Forks of road near Halstead's saw-mill, ... 830′

Marshall's creek at mill-dam here,	820′
" " road crossing next above,	840′
By-road to B. J. Strunk's,	1025′
Crossing of small stream next north,	1030′
" " " of last,	1050′
Forks near Wm. Smith's,	1100′
South road at Drake's near western line of the township,	1200′
Crossing of stream next south,	1100′
Forks near there,	1120′

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13. Smithfield Township.

This township borders the Delaware river next south-west from Middle Smithfield, until that river, after turning southward makes its exit into Northampton county, through the Blue mountain at the Delaware Water Gap. The extreme southern line borders Northampton county for two miles along the crest of the Blue (Kittatinny) mountain, and the western line runs nearly due north and south along Stroud township.

The drainage is all into the Delaware river, the principal streams entering which are: *Brodhead* which pours into it a large volume of water just where the river veers southward toward the Water Gap; *Cherry creek*, draining the extreme southern portion and entering the Delaware just below the mouth of Brodhead; *Shawnee creek*, draining the eastern portion and emptying into the Delaware at the upper end of Great Shawnee Island; and *Marshall's creek* entering the township from M. Smithfield, midway of its north-east boundary and flowing nearly south, with only one or two insignificant tributaries, except Pond creek, empties into Brodhead ¾ mile above the mouth of that stream.

The surface geology of this township is most varied and interesting; for, aside from the fact that it contains the great breach made through the mountains by the Delaware river, its topography has been in many ways modified by *Glacial* action, filling up ancient valleys and changing the course of preëxisting streams.

For example, it is very nearly certain that Marshall's creek, in pre-glacial times, turned south-westward after its junction with Pond creek and, keeping down the great *buried valley* which extends from the mouth of Pond creek to Stroudsburg, emptied into Brodhead somewhere near the present mouth of Sambo creek. But the retreat of the north-eastern glacier, left a considerable *moraine* across the old channel below the mouth of Pond creek; and the combined waters of the latter with that from the north (Marshall's creek's) found a lower outlet southward across a low point in the *Cauda-galli ridge*. The recent origin of that portion of Marshall's creek between its present mouth and the junction with Pond creek is sufficiently attested all along its course; but especially so at the "Butter Milk Falls," one mile above its mouth, where a sharp fold of *Corniferous limestone* forms a natural dam athwart its course, 30′ high upon which the erosive action of the stream has made but little impression. It would seem impossible that this dam of *limestone* could still exist if the stream had flowed over it in pre-glacial time.

Cherry creek flows in a deeply *buried valley* in a direct continuation of the Delaware valley before that stream turns south, which is about S. 65° W., or the same direction as the strike of the strata. The origin of this old valley is considered at page 56.

The Delaware itself flows along the township over a *buried valley* of unknown depth. The piles driven for the piers of the N. Y. S. & W. R. R. bridge across it just above the mouth of Brodhead found no rock bottom at a depth of 30′ below its present bed and two miles below this the water is 50′ deep where the river escapes through the Blue Ridge in the Water Gap. I was informed by a reliable man that the water was formerly 70′ deep in the gap, but the depth at which the bed rock would be reached is not known.

Very fine *Terraces* are seen along the Delaware in this township, and especially about the mouth of Brodhead creek. The *first* forms the flood plane of the Delaware, and is only 20′ above the river bed; the *second* rises, at first, abruptly, and then gradually to the height of 50′ above the

Delaware, where we find a broad level exposure covered with rounded cobble stones, gravel and coarse sand; the surface slopes up sharply from the top of the *second terrace* to a broad level exposure at 100′ above the Delaware or 400′ A. T. The sides and top of this uppermost terrace are covered with rounded *bowlders*, coarse sand and gravel, among which are seen many fragments derived from the *Oneida Conglomerate.*

The rocks of this township extend from the base of the Catskill down to the top of the *No. III slates* in the lowest rocks above drainage at the Monroe-Northampton line, in the Water Gap. True, none of these *slates of No. III* is exposed, since the outcrop is entirely concealed by the deep beds of talus from the great overhanging *Oneida conglomerate* above; but if these surface deposits could be stripped off, we know that *No. III* would be seen in Monroe county. There is thus a large addition made to the section in this township over that in Middle Smithfield; and of course the topography and geology are so much the more varied as will appear in the following detailed description of the rocks beginning at the south and coming north, or what is the same thing, beginning with the oldest.

Concerning *No. III*, I have nothing to say in this report, except that valuable slate quarries occur at Bangor, and other localities just across the Monroe county line; so that if its outcrop were uncovered along the Delaware there is no reason why *slate beds* might not there be found, since a quarry was operated at one time on the New Jersey side, nearly opposite the place where the Monroe county line leaves the river.

The *Oneida Conglomerate* forms the crest and upper flank of the Blue (Kittatinny) mountains along the southern boundary of the township, and is finely exposed on both sides of the Delaware, (best on the New Jersey side,) where the river cuts through it at the Water Gap; it there consists of massive plates of hard, grayish-white conglomerate, in layers, 1′–5′ thick, dipping N. 25° W. 40°–50°. A rude estimate made by the use of pedometer and clinometer gave

about the same thickness here as I found at Otisville, N. F. at the eastern line of Pike county, viz: between 700′ and 800′, certainly not less than the former number, and it cannot well be larger than the latter.

The lower portion of the *Oneida* is more massive than the upper, and the pebbles are larger, some being seen fully 3″ in diameter, they being invariably composed of white quartz usually rounded and water-worn. The lower portion also contains many chips and fragments of the *No. III Black Slate*, thus showing that the latter formation was subject to erosion at the time the *Oneida* was deposited.

I fix no definite line of division between the *Oneida* and *Medina*; but I have regarded the *Oneida* as ending where the rocks begin to grow reddish and the quartz pebbles have mostly disappeared, since these two characters most generally appear together in ascending from the *Oneida* to higher rocks.

The average height of the crest of the Blue mountain in this township is between 1400′ and 1500′ A. T. The range on the New Jersey side is about 1600′ A. T., at its crest.

For several hundred feet near the crest of the Blue mountain the slope is very steep, and as the rocks dip never less than 30°, and often as much as 50°, the surface is nearly always covered with a great heap of debris which has been broken up by the frost, and accumulated over the steep slope by sliding and rolling down the dip. Thus it happens that very little outcropping bed rock is seen on ascending the mountain, back from the Water Gap, though any quantity of bowlders and loose fragments, often of large size, may occur.

The Medina sandstone, as I have limited it in this district, begins with the first appearance of *reddish sandstone* containing few or no pebbles, about 750′ above the base of the *Oneida Conglomerate*, and extends upward until the *sandstone* ends, and the *red shale* begins. It is quite well exposed along both banks of the Delaware in passing from Water Gap Station southward. As it appears here (which is by far the best exposure in the district,) the series consists of alternate beds of bluish, or greenish-gray, and red-

dish-gray sandstones, with occasional intercalations of *red shaly sandstone.* The gray beds often contain quartz pebbles as may be seen in a cut at the very top of the series, 350 yards above Water Gap Station, where the rocks dip N. 20° W. 30°–35°. Just below the station, is seen the crest of the *Kemmererville axis*, which makes the long ridge through the southern portion of the township, parallel with the Blue Mtn. and separated from it by a synclinal valley of No. V. This *anticline* makes a hoist of several hundred feet in the *Medina beds*, probably about 500′, and between it and the top of the *Oneida* are two or three minor folds or rolls. Owing to these I could not measure the thickness of the *Medina* with any near approach to accuracy without an instrumental survey, which would have required more time than I could spare from other work.* The thickness of these *Medina sandstone beds*, according to the best estimate I can make, with due allowance for the anticlinal and subordinate rolls, is between 700′ and 800′, or putting these with the *Oneida beds* at the Water Gap, I should place the whole of No. IV at 1500′, leaving out the *Red shale beds* above the Medina sandstone proper.

The Clinton red shale beds come next above the *Medina sandstone* and make a broad level valley along Cherry creek just north from the uppermost beds of *Medina*, and in a direct continuation (S. 65°–70° W.) of the Delaware river channel, which is excavated in them between the mouth of Brodhead and the western extremity of the township. As the Cherry creek valley is an ancient buried waterway, no outcropping rocks of *No. V* can be seen anywhere within this area; and as the Delaware too flows over a deeply buried ancient bed not a single outcrop of *No. V* is to be seen in the township; hence the thickness of the series is to be conjectured. That a *red shale* occupies this concealed interval is certain, for 75′ of its top is seen in the township just east from this, and as much of its base is also revealed in the one next west (Stroud); and in both cases the

[* Such an instrumental survey, made by Mr. Chance in 1874, is given in an appendix to this volume.—J. P. L.]

rock is a *deep red*, while the *valley* along their line of strike is sufficient proof of their *shaly* character.

The breadth of the valley composed of these *red shale beds* varies between one third and one half mile, and if there could be any assurance of constant dip a close approximation to the actual thickness could be obtained; for just above the Water Gap station the lowest layers of VI dip N. 25° W. 30°, while on the other side of the valley ⅝ mile away, the top of the *Medina sandstone* comes up dipping N. 25° W. 30°–35°. Assuming the average dip at 30°, this would give a thickness of about 1000′. But it is quite possible that there are local rolls like those in the *Medina* just below the Water Gap station, and their effect might be to reduce this apparent thickness.

The Lower Helderberg series, (*No. VI*,) continues to make the steep slope of Walpack ridge, facing the Delaware river, on south-westward from the Middle Smithfield township line, through Smithfield until the river veers southward from the line of strike at the mouth of Brodhead creek, and then it still maintains its place in the southern face of Godfrey's ridge, overlooking the old, buried Cherry Creek valley.

The following is a nearly complete section of No. VI, obtained along Brodhead creek, in the vicinity of Experiment Mills, one mile above its mouth:

Experiment Mills Section.

1.	CAUDA-GALLI GRIT, visible		15′
2.	*Oriskany sandstone*,	*Massive pebbly silico-calcareous sandstone*, 5′ *Limy, cherty layers, with many fossils*, 38′ *Quartz conglomerate*, 1′	44′
3.	*Stormville shales*,	*Dark sandy shaly limestone, fossiliferous*, 50′ *Dark-blue sandy limy shale*, 75′ Concealed, 25′ Limestone, massive, cherty, 10′	160′
4.	*Stormville conglomerate*,		10′
5.	*Stormville limestone*, massive, cherty, visible		25′
6.	Concealed, (containing the rest of the *Stormville limestone*,) about		75′

7.	*Decker's Ferry sandstone,*		10′
8.	Greenish shales,		12′
9.	*Bossardville limestone,*	(*a*) shaly sandy layers, 20′	110′
		(*b*) bluish-black massive limestone quarry-rock, 65′	
		(*c*) bluish-gray, impure limestone, in banded laminæ, and exhibiting *columnar structure,* 25′	
10	*Poxono bluff limy shales,* 5′ visible, but extending down under concealed interval to the top of the *red shale,* (No. V,) at least		200′
			661′

This gives an interval of about 600′ from the base of the *Oriskany* to the top of *No. 5 red shale.*

The Poxono shales are seen for only 5′, immediately under the *Bossardville limestone,* at the great quarry of Mr. Croasdale, near Experiment Mills. They are quite limy, and of a bright-buff color, the residue left after the lime is dissolved out, being a kind of impure ochre.

The *Bossardville limestone* is completely exposed at Mr. Croasdale's quarry, where the strata dip S. 25° E. 35°.

The sub-division (*c*) is a very peculiar stratum, consisting of thin laminæ of alternate blue and gray sandy limestone, giving the whole stratum much the appearance of the *Ribbon limestone* of this series, described by Prof. Cook, in New Jersey. But the most singular thing is the appearance of a regular *columnar structure* all through the stratum, while a layer 7′ above the base, and 3′ thick, exhibits the structure in almost as much perfection as it is found in basalt. These *Stylolites*, as they have been termed, seem to have originated as a consequence of the folding to which these measures have been subjected; for the shaly portion of this stratum has a semi-schistose aspect, as though it had been subjected to heat. The rock is totally destitute of fossils, so that nothing of that kind is found capping the columns which could explain this structure, as suggested by Marsh. The columns slope south-east at angle of 75°, while the dip is only 35°.

The main Bossardville limestone, or division (*b*,) has been quarried for many years near Experiment Mills on the land of Mr. E. T. Croasdale; and, as it has been followed

back into the hill for several rods, a great cliff of it, as well the upper and lower divisions, are there exposed. It is for the most part a very hard, dark, and bluish-black limestone, seemingly destitute of fossils except small indeterminable fragments. There are many narrow seems of *calcite* running through the layers in every direction, and often from a large mass of this material filling a cavity veins are seen radiating away like the spokes of a wheel. The rock turns into a very good grayish-white lime, highly prized for agricultural and building purposes, being hauled from here a long distance northward.

The uppermost division (*a*) of this limestone is too silicious and shaly to burn and is rejected, though it has to be removed from the top of (*b*) in order to give the quarrymen access to that stratum. It probably contains 60–70 per cent. of *carbonate of lime*, and is destitute of fossils so far as seen.

Greenish limy shales, 12′ thick, occur above the last stratum; and they also seem barren of fossils.

The Decker's Ferry sandstone caps the high cliff at the Croasdale quarry, in a ledge of pebbly calcareous sandstone 10′ thick. It is quite *fossiliferous*; and the small whitish quartz pebbles are so numerous as to constitute it a *conglomerate* rather than a *sandstone*.

The dip here is rapid to the south-east, but between this and the old Croasdale quarry 300 yards south the bottom of the *synclinal* is crossed and then the strata have a rapid dip to the north-west.

The Stormville limestone is concealed at this locality all except 25′ of massive cherty fossiliferous layers at its top. These are seen cropping out along the east bank of Broadhead creek, just below the covered bridge, above the mouth of Marshall's creek, where the rock is very full of *fossils*, *Pentamerus galeatus*, and *crinoidal stems* being very abundant, while a layer 3′ thick, at the base, is composed almost entirely of *Pentamerus* specimens.

The Stormville conglomerate is seen just under the covered bridge already mentioned, and also comes into the

road on the east bank of Brodhead, just below the bridge; it is 10′ thick, consisting of alternate layers of pebbly conglomerate ½′–1′ thick, separated by limy silicious layers of about equal thickness, the whole being fossiliferous.

Just above the latter stratum comes a bed of massive, *cherty limestone* 10′ thick, fossiliferous, but the shells too badly preserved for identification.

The Stormville shales are finely exposed in a cutting for the N. Y. S. and W. R. R. along the east bank of Brodhead just above the covered bridge. The rocks dip there at an angle of 50°–60° to the north-west and the exposure for 125′ is very complete. *The shales* have a dirty-gray color as a whole and resemble the *Cauda-galli* layers so much in general aspect that they might readily be mistaken for the latter, if this section did not exhibit the true succession in a manner so unmistakable. Unlike the *Cauda-galli* however they are quite *fossiliferous*. The upper portion is so full of shells as to render it an impure limestone though all are so broken and triturated as to be indeterminable.

Whatever doubt may hang over the question as to the true place of the *Stormville shales* and *conglomerate*, there can be none with regard to No. 2 of our section, for it undoubtedly belongs to the horizon of *No. VII*, since directly above it comes the unmistakable *Cauda-galli grit* and the cherty, pebbly, calcareo-silicious layers of rock itself are filled with the characteristic fossils of No. VII the large coarse *spirifers* and *Rensselaerias* being quite numerous.

The Cauda-galli grit No. 1, is seen in complete exposure at the line of contact with the *Oriskany*, along the R. R. cutting, where rusty, limy layers, 5′ thick and fossiliferous, are seen immediately on top of the Oriskany, on above which come the hard bluish gray, almost non-fossiliferous, beds which make up the great mass of the *Cauda-galli grit*, much of which is seen on above this along the creek opposite Experiment mills.

Sections of VI and VII anywhere along the Delaware valley in this township would be but a repetition of that just given from the vicinity of Experiment mills.

The Poxono shales come so low down that they are usually concealed along the northern shore of the Delaware, except at the very eastern edge of the township, where on the land of J. Treible the following section was taken descending the steep bluff to the Delaware:

J. Treible Section (53).

1. *Stormville conglomerate*,	20′
2. Concealed,	65′
3. Cherty, limy, fossiliferous beds,	40′
4. Concealed,	60′
5. *Bossardville limestone*, visible,	30′
6. Concealed to base of Bossardville limestone, probably about	10′
7. *Poxono buff shales*, visible,	150′
8. Concealed to Delaware river,	50′
	425

The *Stormville conglomerate* consists here of alternate layers of *pebbly rock* and impure fossiliferous limestone layers.

No. 3 makes a great cliff along the hills, and its layers dip rapidly toward the Delaware river; it represents in part the *Decker's Ferry Sandstone.*

The *Bossardville limestone* is quarried on the land of Mr. Treible, just above the river road, where 30′ of bluish-black limestone is seen, streaked with calcite.

The Poxono shales are finely exposed for 150′ along a little rill which puts into the Delaware above Mr. Treible's, just at the township line. For the most part they are a creamy-buff color, often approaching a greenish-white, and containing frequent layers rich in lime, also two or three bands of *red shale.*

In this vicinity a very well marked terrace occurs 40′ above the Delaware river at 350′ A. T. One mile below Mr. J. Treible's, or about 1½ miles from the eastern line of the township three beautiful terraces are seen in the following succession.

	Above Delaware river.	*Above tide.*
Top of third Terrace,	150′	460′
" second "	100′	410′
" first "	25′	335′

The third Terrace has a wide exposure and is covered with

rounded *bowlders* from every series between the *Oneida* and *Catskill.* Along its outer or river front runs a kind of rise or higher portion, giving the top of the terrace a slope away from the river, in a manner similar to the flood plain of all large streams. The escarpment of this terrace is quite steep down to the level of the next.

The second Terrace is not so broad nor level as the third, its upper surface undulating between 100′ and 110′ above the Delaware. Its river escarpment is almost precipitous, descending at an angle of about 60′ to the top of the *first Terrace.* Rounded bowlders of every description are seen on its top, and in the escarpment of this terrace, together with some that are angular.

No bowlders are seen in the *first Terrace* and it seems to be made up entirely of river sand and silt. The outer rims of both this and the *second* one also, slope backward away from the river.

A small stream puts into the Delaware below J. Treible's, near the school-house at the forks of the road, and along it the limestones of VI are well exposed; here the dip is south-east at a very high angle, since a layer of limestone is seen curving up over the steep slope as fast as the surface of the ground.

Just opposite the middle portion of Depuy island, near Mr. P. Albert's, the *Stormville limestone* is seen forming a great *cliff* along the river hill, beginning 150′ above the Delaware and extending up 75′ almost vertically. The lower portion is largely composed of *fossil corals*, *Stromatopora* being especially abundant, of which specimens were seen more than a foot in diameter. This is undoubtedly the horizon of the *stromatopora bed* of the Newpass quarry in New Jersey, at the south-eastern corner of Pike county.

Just above Mr. Albert's this *Stormville limestone* is seen beginning at 110′ above the Delaware and extending in a lofty cliff to 300′ above the same. The dip is here very rapid toward the river (south-east) so that the great cliff is made by only 40′–50′ of limestone strata which the strong south-east dip renders nearly vertical.

At Shawnee village, the creek of the same name, makes a fall of 15′ over the top of the *Stormville limestone*, and the *Stormville conglomerate* is partially exposed just above.

A *limestone quarry* has been operated to some extent just above Shawnee at the Presbyterian church. The opening is not large ; and it could not be determined whether the quarry was situated in the upper (blue) portion of the *Bossardville limestone* or the lower portion of the *Stormville.*

In passing up Shawnee creek from the village, the *Stormville shales* come down to the road, and the Shawnee valley is excavated out of these through its entire length in this township, except near the Middle Smithfield township line where the *Oriskany sandstone* comes down to the level of the stream.

About half way between Shawnee and the township line a high cliff of *Oriskany sandstone* is seen jutting out of the hill-side south of Shawnee creek and 100′ above the same, 600′ A. T. The rock is quite pebbly, 20′ thick, and rests on 30′ of impure cherty shally limestone (*Stormville shales*) in which is seen *Spirifer mascropleurus.*

This same stratum (Oriskany) forms a line of cliffs along the northern slope of the Shawnee valley above this point for nearly a mile, and at the road forks near J. Mosier's comes in a broad table along the road, quite pebbly and calcareous, its top being polished and *striated* by glacial action, the grooves pointing S. 50° W.

Between Shawnee creek and the Delaware river is a long high ridge capped with the *Cauda-galli grit*, and about midway between Shawnee village and the township line it culminates in a high peak known as Mosier's knob, at an elevation of 865′ above the Delaware river or 1175′ A. T. From this summit a wide view of the Delaware valley from Decker's Ferry to far beyond the Water Gap can be obtained. The outlook in other directions is also very extensive and the locality is frequently visited by those in search of scenic beauty.

The *Oriskany sandstone* is seen forming a cliff at the roadside ¼ mile south-west from the knob, at an elevation

of 900′ A. T. and dipping rapidly down in a north-west direction.

Where the road starts across Walpeck ridge from Shawnee to Marshall's creek the *Stormville limestone* is quarried and burned by Mr. J. D. LeBarr. The following section is seen at this locality:

J. D. Le Barr's Section (54).

1. *Stormville shales*, visible,	50′
2. Concealed,	50′
3. *Stormville limestone*, visible,	30′
4. *Water Lime*,	5′
5. Concealed,	20′
6. *Decker's Ferry sandstone*,	25′
7. Greenish limy shales and concealed to road below the lime-kiln,	20′
	200′

No. 1 is seen along the road which passes across Walpack ridge near the forks above Le Barr's. It is an impure shaly limestone, and has been planed and grooved extensively by the ice. On a broad level shelf extending along the road many *striae* are seen pointing S. 70°–75° W. at an elevation of 200′ above the Delaware, or 500′ A. T. This course (S. 70° W.) shows that a portion of the great ice stream which filled the Delaware river valley moved in the general course of the river along the south-eastern line of the township. These *striae* are seen for 200 yards along the road, but have only been preserved where the surface of the rock has been covered with soil until a recent date.

The Stormville limestone is rather impure, containing much silicious material, on account of which it does not all slack well. It is of a bluish-gray color, semi-crystalline and quite fossiliferous, *Pentamerus* and *Spirifer* being very abundant. For analysis of specimens taken here see page 135.

The Decker's Ferry sandstone is here quite fossiliferous, and contains much lime, so much as to render the rock rotten after its removal on weathering. A *Chonetes* and a large species of *Avicula*, 3 inches across its valves, were seen in the sandstone. None were sufficiently well pre-

served to admit of specific identification, though the *Avicula* looks very much like A. *securiformis*, Hall, vol. III, N. Y. Palaeontology.

The Bossardville limestone is covered up at this locality by the First river terrace, and hence does not make its appearance, though No. 7 of Section 54 extends down to near where its top ought to appear.

Passing over to Marshall's creek from Le Barr's, the road leads over the outcrop of the *Oriskany sandstone* and *Cauda-galli grit*, coming down to the *Corniferous limestone* at Butter Milk Falls. Here Marshall's creek falls 35′ in a very steep slope over a ledge of *Corniferous limestone* thickly studded with large masses of *black flint.* The limestone comes athwart the stream at this locality and forms a natural dam for the use of Trach's mills situated there. The fact that Marshall's creek has not appreciably lowered this natural dam below the general level of the valley above this point, shows that Marshall's creek has not always been flowing through this valley to the Delaware, this part of its course, as stated elsewhere, being most probably of *Post-glacial* origin.

Just below the road crossing of Marshall's creek here, the stream makes another fall of 10′ over the top of the *Cauda-galli grit*, which is seen forming a great ledge along the road there.

Atrypa reticularis was seen in the base of the Corniferous limestone just above the falls, on the east bank of this creek.

The Oriskany sandstone is seen forming a cliff along the hill opposite Pipher's mill, one fourth mile below Buttermilk Falls, and under it 40′ of the *Stormville limy shales* occur down to the bed of the stream. On above the *Oriskany* come the bluish-gray cliffs of *Cauda-galli*, here caught in a *synclinal roll* along the crest of a sharp ridge, beyond which the dip changes to the north-west and the *Oriskany sandstone* comes up, and has been qurrried just north from the summit of Walpack ridge, on the land of Mr. P. F. Kurtz. The rock is very difficult to work owing to its pebbly character.

Brodhead creek after entering this township, and coming up to the northern slope of Walpack ridge, turns north-eastward, and flows along the strike of the strata for about 1½ miles. Then, veering south-eastward it cuts through this ridge, one mile and a half above Water Gap Station, the course of the stream being very different from that shown on the county Atlas. Just where it enters the ridge the dip is vertical to the north-west or even overturned beyond the vertical, and there the following section is exposed.

Brodhead Creek Section (55).

1. *Corniferous limestone,*			100′
2. *Cauda-galli grit,*			250′
3. *Oriskany sandstone,*	Pebbly sandstone,	10′	25′
	Flinty layers,	5′	
	Pebbly and flinty layers,	10′	
4. Concealed,			10′
5. *Stormville limy shales,* visible			60′
			445′

The Corniferous limestone is seen in the bed of Brodhead creek, where the stream makes a fall of 10′ in a series of cascades over the lower portion of the stratum, which is very hard and silicious, in addition to being filled with masses of flint. The limestone dips N. 20° W. 70° near its base, but rapidly declines from this, and further north along the creek is almost horizontal.

The Cauda-galli grit is here caught in an almost vertical position between the *Corniferous* and *Oriskany*, where its thickness was easily determined, and found to be about 250′. It is a bluish-gray, hard, slaty sandstone, with obscure bedding planes, but cleaving conspicuously to the south-east.

The Oriskany sandstone comes up on a slightly overturned dip, and juts out of the hill in a bold prominence like a dike. The rock is quite fossiliferous throughout, *Spirifer arenosus* being abundant, as well as other forms too badly preserved for identification. The uppermost 10′ is quite pebbly and massive, while the rest of the rock consists of interstratified layers of pebble rock and calcareous flinty beds.

The N. Y. S. and W. R. R. crosses Brodhead creek at this point, and the upper 10′ of *Oriskany* has been *quarried* to procure stone for building bridge abutments. It is very hard and difficult to work, but is the only stone attainable for such purposes in this region. The rock is quite calcareous at times, and its weathered surface then peels off in a thick coating of rotten, porous material.

The Stormville shales, under the *Oriskany*, are well exposed in the cutting along the D. L. and W. R. R., and are seen to be quite fossiliferous—containing much lime, as well as many layers of *chert*.

Where the D. L. and W. R. R. crosses Brodhead creek, one half mile below the locality of the last section, the west bank of the creek is composed of these *Stormville shales* for about 100′, when we come to the top of a bluff capped by the *Oriskany sandstone*, in a vertical ledge 45′ high. This fine exposure shows it composed of alternate layers of pebbly sandstone and calcareous flinty beds each ½′–1′ thick, except at its top, where the 10′ of hard *pebbly calcareous* sandstone is seen that occurs in the previous section. It was *quarried* on top of this bluff twenty-five years ago for constructing the piers of the D. L. and W. R. R. bridge across Brodhead, and is now being wrought for a similar purpose by the N. Y. S. and W. R. R. Granite could not be more difficult to dress into shape than the blocks from this stratum, and except for the fact that the joints run very straight and thus give two very nearly smooth faces to the stone, it would be almost impossible to work it except at great expense.

The cuttings along the N. Y. S. and W. R. R., after it crosses Brodhead, expose the rocks at many points, and show the curious manner in which the *Oriskany sandstone* is thrown into *plications* along the northern slope of Walpack ridge. This *fan-shaped folding* of the *Oriskany* is well seen about one half mile above the crossing of Brodhead. Here is a continuous rock cutting along the strike of the strata. The *Oriskany* is seen rising rapidly above track level, in a cliff 25′ high, below which are seen 30′ of the cherty impure limestone at the top of the *Stormville*

shales, then the *Oriskany* turns and comes down below track level again, the gentle arch thus made having a chord of 500′. The top of the sandstone is a mere mass of quartz pebbles and fragments of fossil shells, cemented into a matrix of carbonate of lime. When the cementing material dissolves out, the pebbles and *shells* are left in a loose crumbling heap, the latter being fragmentary. The sandstone passes under the R. R. track here, but 300′ further southwest, suddenly comes up, bent over toward the north-east beyond the perpendicular, with a few feet of *Cauda-galli* caught in the sinus of this sharp plication, strike S. 65° W.

Above this latter point the cherty, upper beds of the *Stormville limy shales* are seen for several feet and then the Drift covers up everything for about one half mile, under which the *Oriskany* comes down unnoticed; so that the next beds exposed in the R. R. cuttings as we ascend Brodhead belong to the *Cauda-galli*, a bluish-gray, very hard, sandy slate which on account of its cleavage to the southeast in thin laminæ gave the workmen grading the track much trouble, since a blast however deep would blow out only a small portion of the rock material, because the slate splits so easily along the cleavage planes.

On the north bank of Brodhead, below where that stream passes into this township, a great bed of *Drift* is seen filling the sides of the valley to a height of 100′, the material being sand, clay, small rock fragments and some 10′ in diameter; they are mostly angular. Among the large bowlders *Corniferous limestone* fragments seem to predominate in number and size, though very large ones of *Cauda-galli grit* and *Oneida conglomerate* occur.

The contact of the *Corniferous limestone* with the *Cauda-galli* is shown in the creek bed at this point just opposite the "fill" on the D. L. and W. R. R., the former being fillled as usual with masses of *black flint;* the dip of both rocks is S. 20° E. 17°. This is on the north side of the sharp *syncline* which crosses Brodhead just above the locality of section 53. The rocks continuing to rise rapidly to the north-west the whole of the Corniferous limestone is

soon seen forming an immense vertical *cliff* 250′ above the level of Brodhead.

The high ridge of *Cauda-galli grit* which extends southwestward through Middle Smithfield parallel with the Delaware river also continues on through Smithfield, covering a belt 1–1½ miles in breadth, across which local *folds* in many places catch long narrow strips of the *Corniferous limestone* in the synclinal trough thus formed. The northern outcrop of the *Cauda-galli*, where it passes under the Corniferous limestone, runs almost parallel with the Milford Pike crossing north of it only twice and never found more than ⅛ mile south of the same. It is everywhere scored and smoothed by *Glacial action*, its very hard silicious character admirably fitting it for preserving the *ice scratches*.

Marshall's creek cuts straight across a low place in the *Cauda-galli ridge* and flowing a little west of south, exposes the *Oriskany sandstone* for about two miles, having first cut down to it about one mile below Marshall's creek Post office. From this point it is constantly seen in a bold ledge of conglomerate along the road leading down the next bank of the creek for a long distance while just above it the *Cauda-galli grit* makes a very rough looking cliff, owing to its shelving off in huge plates along the cleavage planes. A fine example of these *cliffs* is seen near Mr. L. Bartron's on Marshall's creek where that stream first cuts through the *Oriskany conglomerate*.

Just above where the road crosses Marshall's creek, near Bartron's, that stream makes a *cascade* 6′ high over the upper cherty layers of the *Stormville limy shales*, and then continues to flow in a narrow valley of these rocks for about one and a half miles.

East from Marshall's creek, the surface slopes up faster than the *Oriskany sandstone*, so that it is soon buried under a thick covering of *Cauda galli* which rises at the summit of the ridge to an elevation of 850′ A. T., half-way between Marshall's creek and School No. 10. The *Cauda-galli* continues to cover up the *Oriskany* along this road until we come to the steep bluff overlooking the Shawnee valley, 100 yards south-east from School No. 10. There

the *Oriskany* crops out in a bold cliff 20′ high and 800′ A. T., from which point it can be seen in a long line of cliffs to the north-east until it passes below the bed of Shawnee, near the township line.

On the road which leaves the Milford pike at J. Marsh's, in the edge of Stroud township, the *Cauda-galli grit* is seen beginning just at the Smithfield line, and forming a smooth pavement along the road for 100 yards; dip N. 30° W. 8°. Its surface is scored with *glacial grooves* going S. 25° W.

The Cauda-galli continues to make the surface rock south-eastward along this road until we come to the hill south of Mr. B. Morgan's, where a long narrow *trough* of *Corniferous limestone* is caught in the crest of the ridge, and extends from this point south-westward to the Stroud township line.

In the road near P. Pipher's, the *Cauda-galli* is seen dipping S. 25° E. 7°, the *axis* having been crossed one half mile north. On its top many glacial *striae* go S. 40° W. M.

Just south from this last locality the south-east dip steepens to 10° then 15° and 20°, when the *Corniferous limestone* comes down and makes the surface rock.

All through this region, on the south side of the *Cauda-galli ridge*, immense *bowlders* of *Corniferous limestone* cover the surface, many being 20′ in diameter; they have evidently been brought by the *Glacial ice* from the crest and northern slope of the *Cauda-galli ridge* to the north.

Glacial striae are seen on the *Corniferous limestone* about ¾ mile south-east from B. Morgan's, going S. 40° W. the masses of chert which fill this stratum being planed off smooth with the rest of the rock and *striated* in very fine lines; elevation 600′ A. T.

On below this, along the road at 575′ A. T. *striae* are seen on the same rock going S. 30° W. while the *limestone* dips S. 20° E.; the flint nodules are shaved off smooth here as in the other instance noted above.

The *Cauda-galli* is seen well exposed along the road which leads from the Milford pike, near J. Terpenning's south-

eastward to J. Hoffman's. The *Corniferous limestone* extends for only a few rods southward from the pike, when the *Cauda-galli* comes up dipping 15° N. 25° W. The *dip* gradually slackens to 20° as we go south-east, then 8° and 5° when it finally at the summit (750′ A. T.) of the ridge, (which here coincides with an anticlinal axis) becomes *nil* and then *reverses* to the south-east. This is just north from J. Weller's, about ¾ mile south from the Milford pike. The south-east dip continues at about 4°–5° on several rods beyond J. Hoffman's where it is *reversed* to the north-west and the *Oriskany sandstone* is brought up at the Marshall's creek road, near D. Yetter's, one mile from the crest of the *axis*.

The *Corniferous limestone*, in addition to the limited patches already mentioned, forms a continuous belt of outcropping rock through this township, along either side of the Milford pike, the breadth of which varies between ¼ and ½ half mile, depending on the rapidity of dip and the nature of the topography.

There is every reason for believing that in *pre-glacial* times this belt was one to two miles wider, and that it then covered all the northern slope of the *Cauda-galli ridge*, and probably passed in an unbroken sheet over its crest and southern slope. The immense *blocks* of this rock (often 20′×20′×30′) which we find scattered all over the Cauda-galli area, and especially along the southern slope of the ridge, make it extremely probable that the ice pushing south-westward across it, with irresistible force, broke up and removed the *Corniferous limestone* from a very large area which this rock had covered in pre-glacial times. This could be accomplished the more readily, because of the numerous joints which always extend through this formation from its top to bottom.

This conclusion is in a measure supported by the isolated patches of the rock found still *in situ* over the surface of the *Cauda-galli*, where they were protected in synclinal troughs, or by the conformation of the surface. A good example of the latter is seen just south of the Milford pike at the western line of the township, where a ledge of *Cor-*

niferous limestone 50′ high is seen along the road leading south-eastward, while the top of the *Cauda-galli* is *striated* with glacial grooves on every side of the *Corniferous island.*

The northern outcrop of the *Corniferous* limestone dips down under the southern margin of the ancient *buried valley* which follows the strike of the *Marcellus shale* south-westward through this township. Pond creek flows on its upper surface from the eastern line of the township to Marshall's creek P. O., the northern outcrop being only 2–4 rods north from the Milford pike. In passing south-west from this point, however, the northern outcrop gets further and further away from the pike, until at the western line of the township it is more than ½ mile distant. The southern outcrop has also got north of the pike.

This *limestone* has been quarried at several localities, and attempts made to burn it for agricultural purposes, but in every case so little success was attained that not a single kiln has been in operation for many years. The reason is obvious; the rock is everywhere so filled with masses of *flint*, that when they were not separated from the limestone (and they never were) the resulting lime would seldom slack, and frequently form a fusible slog in the kiln itself. Messrs. Deitrich, Campbell, Marsh, Terpenning, and others have made attempts at separation.

Since the *Corniferous limestone* is constantly in sight along the entire length of the Milford pike through this township it would be needless detail to refer to the hundreds of localities where it may be seen and studied.

The dip to the N. N. W. varies between 10° and 20° being most commonly about 16° and the thickness cannot be far from 200 feet.

The *Marcellus shale* passes through this township under the ancient *buried valley*, to which reference has already been made, as extending from Marshall's creek south-westward to and beyond the western line of the same and therefore little or nothing is seen of these beds.

One half mile east from Marshall's creek P. O. the contact of the Marcellus with the *Corniferous limestone* just es-

capes being seen by the intervention of Pond creek, whose narrow channel (10′) alone separates them and conceals the line of junction. The *Marcellus* is there, however, a hard, bluish-gray, sandy slate, only 3′–4′ above the limestone. It doubtless continues of the same character down to the latter.

From the fact that this *old Marcellus valley* is a mile broad in some localities it is possible that a low *anticlinal* may pass through that formation near the center of the valley, since the dip of the *Corniferous limestone* (16°) if maintained would give too great a thickness for the *Marcellus* (1320′.)

Marshall's Falls are situated on the creek of the same name just below where the latter enters this township; it is a cataract descending 35′ almost vertically over the hard sandy strata near the base of the *Hamilton* proper. At the head of the falls (550′ A. T.) numerous *fossils* were observed, among which were *Spirifer granuliferus*, *Grammysia bisulcata*, *Athyris spiriferoides*, besides numerous *Crinoidal stems*. The stream has cut a narrow gorge at the base of the *Hamilton* only 5′–8′ wide through which it falls into a large amphitheater hollowed out of the soft *Marcellus beds* below; elevation at base of falls, 515′ A. T.

The Hamilton sandstone beds are occasionally seen making cliffs in the hills north from Sambo run, between that and Ruliff's run, but the exposures are few and poor.

The *Genesee* is entirely covered up by *Drift*, though it doubtless forms the valley of Ruliff's run across the northern apex of the township, since that stream has excavated a considerable valley along the *strike* of the rocks.

The *Chemung beds* make a narrow belt north from Ruliff's run, as determined by the characteristic *ridge* which always succeeds the *Genesee slate*, though the actual outcrop of the rocks was not observed, everything being buried from sight by the great thickness of Drift rubbish.

The Catskill rocks cross the extreme northern point of this township and probably do not cover more than 20 acres of its surface.

Glacial striae are very numerous on the surface of the

Medina sandstone, in the extreme southern portion of this township along the foot hills of the *Blue mountain*, and if anything may be judged from their direction the great *glacier* passed diagonally over its crest.

Along the road which leads from Water Gap station southwestward past L. Bartron's *glacial striae* are very numerous. One half mile north from Mr. L. Bartron's and about one mile and a quarter from the crest of the Kittatinny, the *striae* are seen going S. 20° W. (770′ A. T.) A short distance further north, at the sharp turn in the road, a very large area of reddish *Medina sandstone* is bare, and its entire surface is planed off smooth by the Ice the *striae* running S. 20°–30° W.; (elevation 700′–750′ A. T.) The slope of the smoothed rock surface is here 17° to the north-west which must be about the same as the dip.

Still further down the hill (north) other *striae* are seen on a polished rock surface going S. 20° W. while across these another series go S. 30°–35° W., the top of the planed rocks sloping 18° down to the north-west; (600′ A. T.)

A wide level area is seen a short distance north from the Water Gap hotel, at an elevation of 500′ A. T., and the Delaware doubtless once poured across this through the Water Gap when cutting its channel down to the present level.

Glacial striae are seen about 300 yards above Water Gap station, along the D. L. and W. R. R. on hard, gray *Medina sandstone;* direction S. 40° W.; elevation 320′ A. T. The rock is planed smooth comformably with the dip which is here 30° to the north-west.

Barometric Elevations in Smithfield.

(*Above Tide.*)

Delaware river, at Northampton county line,	293′
Delaware river just above the mouth of Brodhead creek, at crossing of N. Y. S. & W. R. R., (low water, 1881,)	394′
Marshall's creek, at crossing of N. Y. S. & W. R. R.,	309′
Brodhead creek, " " " "	329′
Level of ground at Water Gap house,	555′
Forks of road north of R. Weiss',	945′
" " near S. Gulick's,	335′
Level of Cherry creek there,	330′
Forks just north of S. Gulick's,	450′

Forks next west, ... 500′
" at A. Le Barr's, ... 340′
" near M. E. church, in Water Gap village, ... 390′
" at Cherry valley road, in Water Gap village, ... 340′
" east from E. Poole's, ... 510′
" near B. Morgan's, ... 670′
Lane west of A. Le Barr's, ... 680′
Forks of road near A. Le Barr's, ... 680′
Cross-roads at Wesley Water Cure, ... 385′
Forks of road one half mile east, ... 425′
" " 96 rods north of last, ... 500′
Lane 145 rods N. of last, ... 645′
Forks of road near Mrs. A. Zimmerman's, ... 330′
" " near Peter F. Kurtz's, ... 390′
Cross-road at Pipher's mill, ... 360′
" near Maple cottage, ... 390′
Marshall's creek, at top of Lower Butter-milk falls, ... 360′
Top of main Butter-milk falls, ... 410′
Forks of road near A. Smith's, ... 475′
" " 117 rods south-east of last, ... 510′
" " near D. Le Barr's, ... 360′
" " in Shawnee village, ... 360′
" " at Presbyterian parsonage, next above, ... 365′
" " near V. Weaver's school-house, ... 460′
" " 170 rods north of last, ... 900′
Summit of Mosier's knob, ... 1175′
Forks on Shawnee creek, near Geo. Strunk's, ... 395′
Shawnee creek, at road near J. M. Strunk's, ... 465′
Forks of road near J. Mosier's, ... 515′
Milford pike, opposite Oak Grove house, ... 475′
" " at Marshall's Falls P. O., ... 480′
" " at lane to D. Bush's, ... 485′
Marshall's creek, at Milford pike crossing, ... 465′
Milford pike, at Craigstown cross-roads, ... 490′
" " summit of ridge, next south-west, ... 605′
" " J. Terpenning's, ... 570′
" " forks 77 rods from last, ... 540′
" " " 21 " " . . . . . 545′
" " school-house near H. H. Campbell's, ... 500′
" " forks 100 rods from last, ... 525′
Forks of road near J. Hoffman's, ... 710′
" " " P. Row's, ... 580′
Forks north of J. Casebeer's, ... 535′
Marshall's creek, at road crossing near D. Yetter's, ... 450′
Forks of road at school-house, No. 10, ... 810
Level of Sambo creek, near J. Cristle's, ... 470′
" " " Geo. B. Brutzman's, ... 475′
Forks of road at lane to Weller, Fine & Co.'s house, ... 580′
" " 78 rods north from last, ... 665′
Cross-roads near Geo. Canfield's, ... 565′
Crossing head of Sambo creek, just south, ... 490′

Forks of road north from J. Posten's,	475′
Summit on the road between this last and Ruliff's run,	810′
Road crossing of Ruliff's run, near A. Hoffucker's,	750′
Forks next north,	790′
Forks of road at J. Ruster's,	800′
" " school-house, No. 11,	850′
Ruliff's run here,	820′

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14. Stroud Township.

This is a very large district lying directly west from Smithfield, and like it extending southward to the crest of the Kittatinny mountain at the Northampton county line.

The township is drained by Brodhead and Cherry creeks which carry the water direct to the Delaware, emptying into the latter within a few rods of each other in Smithfield township.

Brodhead creek enters the township from the extreme north, and flowing nearly due south for seven miles is joined at Stroudsburg, (the county seat of Monroe,) by McMichael's creek from the west, the latter having received the waters of Pocono creek (draining the intermediate area) one mile above its mouth.

Cherry creek flows along the southern slope of Walpack (Godfrey's) ridge, nearly parallel to McMichael's creek, often less than a mile distant, and drains the northern slope of the Kittatinny (Blue) mountain.

The geological structure is the same in this township as in Smithfield to the east, except that another anticlinal is added to the list in the shape of a low uplift which passes under the *Marcellus shale*, parallel to the other axes, and which seems to represent the vanishing swell of the great anticlinal which crosses the Lehigh river at Lehighton. It is a mere roll, which seems to die out entirely in Smithfield to the east.

The section of the rocks extends from about 2000′ above the base of the *Catskill series* in the northern portion of

the township down nearly to the base of the *Oneida conglomerate* along the crest of the Kittatinny mountain at the Northampton county line.

The *Oneida conglomerate* is seen along the northern slope of the Kittatinny when its outcrop is not concealed by the great heaps of *débris*, which have come down from the crest above. The dip of the rock for 300′–400′ below the summit of the mountain is quite rapid, (usually about 45°,) so that along that portion of the range the *débris* does not accumulate. The rock is the same hard, gray, coarse conglomerate as elsewhere.

The crest of this mountain range formed by the *Oneida Conglomerate* has an elevation of about 1500′ A. T., but in Tatorny and Bangor road gaps, it sinks to 1250′ and 1350′ A. T. respectively.

The Medina sandstone covers a belt about one mile and a quarter wide, beginning in a synclinal valley ½ mile north from the crest of the Kittatinny. This area of *Medina rocks* is materially broadened by the existence of the *Kemmerville anticlinal* which makes a long high (1000′ A. T.) anticlinal ridge, one mile north from the Kittatinny summit, from which it is separated by a low synclinal valley of No. V, buried to an unknown depth with Drift trash.

Mountain run heads in this valley just east of the township line, in the edge of Smithfield, starting in a swamp on an imperceptible divide from which a stream also goes eastward to Cherry creek, near the Water Gap. But Mountain run comes westward falling slowly down the syncline to a point one half mile beyond the center of the township, when it turns suddenly at a right angle and cuts squarely through the anticlinal ridge north of it, descending in a rapid torrent between cañon like walls of the *Medina sandstone* and finally joins Cherry creek midway in its course through this township.

It is quite possible that Mountain run has been cut through the anticlinal ridge since the beginning of the glacial epoch, because the cut itself looks much like a new one, since the drift deposits are absent along its entire course through the ridge, and then the existence of the old *buried valley* be-

tween it and the Kittatinny mountains, would tend to show that in pre-glacial times a stream flowed through it southwestward to its junction with Cherry valley in Hamilton township, (the one next west,) but that the valley having been choked up with drift material, the water from the eastern portion found a lower outlet across the *Medina sandstone ridge* to the north, thus taking a short cut to Cherry creek valley, instead of the long détour it had formally made by way of Hamilton township.

Many *bowlders* of both *Upper* and *Lower Helderberg limestone* lie scattered along this old valley, and far up the sides of the Kittatinny where they have been carried by the ice.

The Medina sandstone is frequently seen cropping out along the anticlinal ridge at the very summit of which the dip changes to the south-east (15°–20°.) On the northern side of this anticlinal, the dip is more rapid, since in the gorge of Mountain run just north of the axis, we see *red* and *gray Medina beds* dipping N. 20° W. 35°–40°.

The height of the Medina ridge at the eastern line of the township is about 1000′ A. T. but westward, it gradually falls away, the axis flattening out at the same time, until at the western line of this area it is only 700′ A. T. *Glacial striae* are seen on the summit of this ridge along the road near Marsh's school-house, going S. 40° W., (elevation 700′ A. T.) Also near Mr. P. Edinger's, at the eastern line, pointing S. 35° W. (at 950′ A. T.) Either of these courses would carry the ice diagonally across the Kittatinny mountain.

Many hugh bowlders of limestone (15′ in diameter) are seen scatttered over the surface where Mountain run makes its exit from Edinger's ridge. They are principally from the *Lower Helderberg*, and have been transported across the Cherry creek valley and dropped with other finer Drift material.

From the summit of Edinger's ridge the slope, at first, rapid, finally becomes gentle and passes gradually down into the broad valley of Cherry creek, which also flows over a deeply buried ancient channel. Cherry creek valley is excavated out of the *red shale*, and the *Poxono shales*, at the

base of *VI*, the present stream bed, being generally underlaid by the latter, though some of its northern meanders may possibly encroach upon the *Bossardville limestone.*

The red shale beds of No. V underlie most of the Cherry creek valley south from the stream and extend a short distance up the foot of the slope towards Edinger's ridge, covering a belt varying in breadth from ¼ to ½ mile. Their thickness is even more problematical than in Smithfield, where the nearest estimates possible place the thickness anywhere between 500′ and 1000′. Only one outcrop of these *red shale beds* was observed in the township, and that is along the road descending Mountain run, near Mr. S. Hohenschildt's grist-mill. There the soil has been removed over a small path and exposes a *deep, dull-red shale*, but the rate of north-westward dip could not be determined.

*Walpack ridge** with its characteristic knobs, continues on through this township, just north of the Cherry creek valley with which it is parallel. The southern slope is almost as steep as when it overlooks the Delaware river in Smithfield township, and is composed of the same rocks, the *Lower Helderberg beds*, forming its southern face and often extending to the crest, while the *Oriskany* comes up along the crest, and sometimes just over the same well down on the northern slope of the ridge, at the foot of which, and often extending far up the northern slope, comes the *Caudagalli beds.*

The quarry limestone (*Bossardville*) is not opened anywhere in this township, being constantly concealed under the deep covering of Drift and detritus along the northern bank of the Cherry creek valley. The farmers believe that it is absent in this township, having thinned out; but there is no adequate reason for this belief, since its horizon is nowhere exposed, and hence its seeming absence means nothing. Then it is about 100′ thick just east from this township at the Croasdale quarry in Smithfield; and of nearly equal extent just west from this area in Hamilton; from these facts the only reasonable hypothesis is that it extends

*Godfrey's ridge of the old reports.

through this township also, but its horizon being constantly covered up the limestone is nowhere visible.

It would be well worth while for the farmers living along the Cherry Creek valley, to make a systematic search for this valuable bed of limestone, by uncovering some of the steep slopes along the northern bank of Cherry creek, where it would almost certainly be found.

The Stormville limestone and its associated *conglomerate* are frequently seen cropping out along the road which passes down Cherry creek; but this limestone has now become too sandy and impure to burn with much success, except in thin streaks not easily found.

A pebbly, impure, sandy limestone is seen making a bold ledge 20′ high, just below the road at Mr. J. Caldwell's. It looks something like the *Decker's Ferry sandstone*; should it prove such, the *Bossardville limestone* could be found just under it; but should it be the *Stormville conglomerate*, the former stratum should be looked for further down in the valley near Cherry creek.

The *Stormville limestone* is seen at the western line of the township, near C. Dennis', along the Cherry creek road, dipping S. 25° E. 23°. A large area of limestone is exposed at this locality, the soil having been removed from several square rods of it. The rock is bluish-gray, hard, somewhat silicious, and the upper surface has a very wavy appearance like ripple marks, but probably due to weathering.

Godfrey's ridge being anticlinal, it frequently happens that the *Oriskany sandstone* passes in the air over its crest, but comes down on the southern face.

A fold of this kind is seen near Mr. J. Huffert's, where two great cliffs of *Oriskany sandstone* are seen extending along the south face of the ridge, one half way up and the other 100′ higher. From a distance it would be supposed that they were two separate beds outcropping one above the other, but it is the same rock, which skims along the surface having been removed by erosion between the two cliffs. The following structure is exhibited by the *Oriskany* at the lower cliff:

J. Huffert's Section of Oriskany Sandstone (56).

1.	*Very pebbly sandstone,*	10′ 0″	
2.	Pebbly beds, alternating with layers of chert each 1′–1½′ thick,	10′ 0″	
3.	Limy chert, with streaks of pebbles,	5′ 0″	
4.	Pebbly layer,	0′ 8″	
5.	Chert "	0′ 7″	
6.	Pebbly "	1′ 0″	
7.	Chert "	0′ 8″	
8.	Pebbly "	0′ 4″	
9.	Chert "	0′ 8″	
10.	Pebbly "	0′ 4″	41′ 11″
11.	Chert "	1′ 6″	
12.	Pebbly "	0′ 4″	
13.	Chert "	0′ 4″	
14.	Pebbly "	0′ 6″	
15.	Chert "	1′ 0″	
16.	Pebbly "	0′ 6″	
17.	Chert "	0′ 5″	
18.	Very pebbly, fossiliferous sandstone,	4′ 0″	
19.	Impure limestones, with layers of chert,	4′ 0″	
20.	Concealed to level of Cherry creek, (360′ A. T.,)	200′ 0″	

This exhibits nearly the entire thickness of the *Oriskany sandstone* proper, and shows in an admirable manner the detailed structure of the rock in this township, since the *pebbly* layers are gradually extending downward and becoming more numerous.

The top portion No. 1 is a nearly pure conglomerate, free from chert, and contains but few *fossils*. It is probably 5′–10′ thicker than the section shows, the upper portion having been lost by erosion. *The ice* has worn it away to some extent; for its upper surface, which dips rapidly south-east, is planed off smooth and striated S. 30° W. at (600′ A. T.)

On above this cliff the dip to the south-east is steeper than the slope of the hills in the same direction, so that the sandstone arches above the present surface to near the crest of the southern face of the ridge, when the dip having slacked, the surface catches the 2nd line of cliffs more than 100′ above the 1st. Then again passing into the air the stratum arches up over the summit of Godfrey's ridge exposing the *Stormville limy shales* along the crest of the same. They are of a bluish-gray color, and quite rich in lime. An attempt was once made to burn them for agricul-

tural purposes, but the experiment proved a failure as the rock is too silicious and impure to slack well.

The Stormville limy shales are exposed along the road which leads across Godfrey's ridge from T. W. Rhodes', a short distance below the locality of the last section, and there *glacial striae* are seen going S. 5° W. (540′ A. T.)

The Oriskany sandstone makes a great cliff along the summit of Godfrey's ridge overlooking Cherry creek valley at the extreme eastern line of the township from an elevation of 800′ above tide.

A short distance east from T. Stone's the *Oriskany sandstone* comes up on the north face of Godfrey's ridge, half way between its crest and the valley of McMichael's creek. It rises in a lofty cliff locally known as *Mt. Granite* from the hardness of the stone which is quarried there. The color is a grayish-brown, and the rock is filled with fossils, principally large *Spirifers*. From this locality was procured the stone used by Col. Norton in the construction of his residence and surroundings.

The Stormville shales, *cherty* and *limy*, are seen coming up under the *Oriskany*, and extending in a great arch clear across the crest of the ridge and half way down on the Cherry valley slope, the *Oriskany* having been eroded.

The Cauda-galli grit comes in just north from the crest of the Godfrey's ridge, and usually forms the greater portion of its northern slope, sometimes curving over on to the southern slope for short distances. It covers a comparatively small area in this township, being confined principally to the region between the crest of the ridge and McMichael's creek. This is owing to the rapid dip of the strata, and also to the fact that the Lehighton axis does not elevate the *Cauda-galli* above drainage. The rocks of this series are finely exposed along the roads which cross over from McMichael's creek valley to that of Cherry creek. It is still a hard, bluish-gray, sandy slate, cleaving sharply to the south-east, with the lines of bedding so irregular and obscure as to be almost indistinguishable. The top of the rock shades off imperceptibly into the *Corniferous limestone*

above, and contains much *chert* for 25′–30′ below the base of the latter. The contact of these two groups is finely exposed at the cut on the D. L. & W. R. R. one half mile below East Stroudsburg, where 50′ of the *Cauda-galli* is exposed in a narrow arch covered with *Corniferous limestone.* The base of the same is also seen along the road which leads from Stroudsburg to Water Gap Station over Godfrey's ridge, and to T. W. Rhodes' in the Cherry creek valley. Along the latter road *Glacial striae* are seen running S. 40° W.

About one half mile east from T. Stone's, along the grade of the projected Lehigh and Eastern R. R. the whole upper surface of the *Cauda-galli* on the northern slope of Godfrey's ridge seems to have been ground off smooth by the ice, conforming with the dip and the present topography. The *striae* go S. 30°–40° W.

The Corniferous limestone is exposed in this township along the northern foot slope of the ridge and along the crest of the East Stroudsburg axis.

McMichael's creek flows down a syncline of *Corniferous limestone* for about three miles after it enters this township, hence the rock has been mostly removed or covered up by alluvial deposits along this syncline.

The East Stroudsburg axis enters the eastern line of the township at the extreme south-eastern limit of that borough, and continuing S. 70° W. crosses to the north bank of McMichael's creek midway between its mouth and the western line of this area. It elevates the *Corniferous limestone* into a low sharp ridge all along its course.

The D. L. & W. R. R. passes through this ridge in a long deep cut just below East Stroudsburg, giving an almost complete exposure of the *Corniferous series*, which is here (at the entrance to the cut) pushed over beyond the perpendicular so as to dip south-eastward 65° on the north side of the axis. But as we approach the axis (near the middle of the cut) the strata gradually become perpendicular and then turn over to the north-west. Making due allowance for variable dip, the *Corniferous* exhibits a thickness of about 200′ at this locality, and there cannot be much more of it.

It is a dark bluish-gray rock quite fossiliferous in places, and filled with *black flint* nodules from bottom to top.

Passing through the northern slope of the anticline, and across the axis almost perpendicularly, the cut curves around and emerges almost parallel with the strike. The crest of the anticline is composed of *Cauda-galli grit* from which the arch of *Corniferous* has been eroded at this immediate locality; but the latter comes down again after passing south from the axis, dipping S. 20° E. 20°–25°. The flint nodules of the bottom portion have nearly all weathered out of the rocks on the south side of the axis, and the matrix is now honey-combed with holes from which the flint has disappeared. The cut is about 700′ long, and the axis passes across the middle of it, the Corniferous limestone being exposed for 300 feet on the northern side.

A short distance west from the D. L. & W. R. R. cut, Brodhead creek trenches through the same axis, and entering the *McMichael's creek syncline*, veers north-eastward, flowing along the *strike* out of this township into Smithfield. The *Corniferous limestone* is seen in great blackened *cliffs* along this creek south from the cut. Just beyond the creek, however, the south-east dip is suddenly reversed and the *Corniferous limestone* arches into the air over Walpack ridge, the *Cauda-galli* becoming the surface rock.

The *East Stroudsburg axis* passes through the center of the wide level bottom just south from Stroudsburg, where a low ridge of *Corniferous limestone* is seen just east from the Water Gap road making a steep *cliff* facing southward. Numerous *fossil shells* are seen in the top of the limestone at this locality.

The N. Y. S. & W. R. R, also cuts through the northern slope of this *anticline* along the west bank of Brodhead creek, a few hundred yards below the mouth of McMichael's creek. The rock is much weathered where cut by this road under several feet of Drift.

Just north from this, and opposite the iron bridge across McMichael's creek, the limestone is seen dipping down under the bluish-gray *Marcellus beds* N. 20° W. 25°–27°.

The Corniferous limestone is seen along the Water Gap

road (leading southward from McMichael's creek) near Mrs. Gordon's, making a narrow band of outcrop, the dip being almost vertical. This is most probably the westward extension of the sharp overturn which crosses Brodhead creek in Smithfield township, near the locality of section 53.

This limestone is also seen where the *East Stroudsburg axis* crosses the road between Col. Norton's and the bridge across McMichael's creek, just above (west). Here the contact with the *Marcellus bluish-gray beds* only escapes being seen by the intervention of 2′–3′ of concealed, both rocks being planed off smooth and *striated* S. 30° W. Just south from this a bold *cliff* of *Corniferous limestone* is seen extending along the bluff of McMichael's creek. The upper portion of the *limestone* is quite *fossiliferous.*

The arch of the *East Stroudsburg axis* is very finely exposed about one mile west from Col. Norton's, 2½ miles west from Stroudsburg, near J. W. Huston's. Here the *Corniferous limestone* arches over the ridge unbroken, going under the *Marcellus*, ⅕ mile north from McMichael's creek. It was once quarried and burned to a considerable extent at this locality. Its immense number of *flint nodules*, however, led to the abandonment of the quarry.

Glacial striae are seen on the *Corniferous limestone* along the McMichael's creek road just above Mr. Huston's, going S. 50° W. and the whole surface is planed off squarely through the flint nodules, conformably with the dip (here 20° S. 25° E.)

The Corniferous limestone is finely exposed, on the land of Mr. W. Chapman, where the *anticlinal* crosses Brodhead creek, one mile and a half above Stroudsburg. The south-east dipping rocks form there a natural dam 10′ high across Brodhead creek. By closing one break, only 10′ wide, splendid water power is furnished to the grist mill situated one fourth mile below. The *limestone* is quite *fossiliferous* and dips S. 20° E. 16°, in the vicinity of the dam.

A *bluff of Drift* 65′ high, rises almst perpendicularly from the bed of the creek on the west bank of Brodhead, attain-

ing an elevation of 475′ A. T. at the summit of the general level, the creek below the dam being 410′ A. T.

About 300 yards above the mill-dam, the *anticlinal* crosses the creek, and there we see a cliff of *Corniferous limestone*, in layers 1′–2′ thick, dipping slowly N. 25° W. It contains many *fossil corals*, *crinoids*, and *mollusks*, together with vast quantities of *flint nodules*. The rock has been quarried and burned to a considerable extent at this locality on the land of Mr. Chapman, but the *flint* is so abundant that the lime slacks very imperfectly, while much of it will not slack at all.

This *anticlinal* leaves the township eastward near Posten school-house, (No. 4,) crossing between it and the cemetery, just south. *The Corniferous limestone* is seen in a cliff 75′ high, just west from the cemetery, and 540′ A. T., at top. It was once burned here on the land of Mr. Vliet. The layers are almost horizontal, but just north from this, dip rapidly (20°) under the *Marcellus beds*.

The outcrop of the *Corniferous limestone* also occurs on the southeast slope of the *anticlinal* a few rods north from where the Milford pike crosses the D. L. & W. R. R. It forms a steep bluff just west from the R. R., and there were collected the specimens analyzed by Mr. McCreath, (page 118.)

A cut on the D. L. & W. R. R., just south from Sambo creek, also exhibits the outcrop of the *Corniferous*. In both localities it is nearly half composed of *black flint*.

West from Brodhead creek, the *anticlinal* fails to bring the *Corniferous limestone* above drainage, since it is everywhere buried by a broad outcrop of *Marcellus shale*, which arches over this low axis from the *Stroudsburg syncline* to the south.

The *Marcellus shales* have been widely eroded in the vicinity of Stroudsburg and East Stroudsburg, where broad and almost level plains covered with Drift, effectually conceal the bed rock, except in road cuttings, and the excavations of the streams.

Much of the Drift material in this vicinity has probably

been rehandled by the streams, Brodhead, Pocono, and McMichael's creeks which converge at this point.

The surface is usually covered to a depth of 5′–8′ with rounded *bowlders*, below which begins a bed of coarse brownish-gray sand and extends to a considerable depth, containing few if any bowlders.

Several well defined *Terrace levels* may be seen in the vicinity of Stroudsburg. The first (400′–405′ A. T.) includes the eastern portion of the borough; the second (430′–335′ A. T.) the western half of the same, and the level space around the East Stroudsburg Depot, (D. L. & W. R. R.) Then from the *second terrace* there is everywhere a sudden slope upwards to the *third terrace* at an elevation of 465′–475′ A. T., which takes in a wide expanse everywhere covered with Drift material, and extending by a gradual rise upward as we proceed northward from Stroudsburg, until a very wide level plain is found at about 490′–500′ A. T.

In the escarpment of this *fourth terrace* at the north line of the borough of Stroudsburg, great numbers of immense *bowlders* occur, the largest of which are *Corniferous limestone* and *Hamilton sandstone*, one of the former being seen which I at first mistook for the outcrop of a ledge of bed-rock. Small bowlders of *Oneida conglomerate* are frequently seen in the Drift in the neighborhood of Stroudsburg.

The lower portion of the *Marcellus shale* is finely exposed along McMichael's creek, just under the iron bridge leading out of Stroudsburg; here this stream has evidently veered away from its ancient channel, and removing the drift deposits has cut a deep narrow trough through the bluish-gray shales at the base of the *Marcellus*. The rocks dip N. 20° W. 27° and exhibit a cleavage structure to the south-east. The 50′ seen at this locality is mostly composed of very hard, bluish-gray slate, through which at interval of 3′–5′ are interstratified thin bands (3″–5″ thick) of a light-drab colored rock.

The *Corniferous limestone* comes up 100′ south from this locality, so that only 40′–45′ of rock intervene between the

base of the exposure and the top of the *limestone*. This same portion of the *Marcellus* is also well exposed in a cutting along the road one mile and a fourth west of Stroudsburg, just opposite the residence of Col. Norton, where the cleavage is very regular and distinct.

These gray Marcellus beds are also seen in a cutting along the D. L. & W. R. R. just below the station, at East Stroudsburg, where they appear nearly horizontal.

Although the *anticlinal* does not bring up the *Corniferous limestone* except along the immediate valley of Brodhead creek, yet it has a considerable influence on the topography by widening the belt over which the *Marcellus rocks* are spread to nearly one mile and a half.

Just north from the road running nearly east and west along the north line of Stroudsburg borough, a bluff of *dark-bluish slate* makes a cliff-like outcrop. It belongs to the *Marcellus series*, and has been quarried to some extent for rip-rap for the roads; it is quite fossiliferous.

One mile north of Stroudsburg, another road runs east and west across a north and south ridge of *Marcellus* rocks lying between Brodhead and Big Meadow creek, and along that road near Mr. S. Smiley's the *upper* or *black Marcellus* is seen cropping out in the shape of very *black slate*.

The Marcellus bluish-gray beds are well exposed in the bed of Brodhead creek at Wyckoff's mills one mile and a half above Stroudsburg; here the creek has veered out of its ancient course and cutting through the drift deposits has excavated a long deep channel in the *shales* wearing out large "pot holes," and leaving many queer shaped rock forms along the stream. The walls of the dam are formed of *Marcellus rock* in its natural position, which dip N. 30° W. 10° in some places, and is nearly horizontal in others. It is exposed along Brodhead for about 300 yards and exhibits cleavage to the south-east.

The gray Marcellus is seen outcropping along the road, just south from H. R. Rausbury's, where it is planed off smooth, and *glacial striae* go S. 45° W. on its surface, at 570′ A. T.

The Hamilton sandstone makes an outcrop across this township, nearly one mile in width, its top layers going under Brodhead creek, about one and one fourth mile below Spragueville, and extending S. 65°–70° W., leave the western line of this area a short distance north from where Pocono creek enters the same. Its hardest beds make a well marked ridge, rising 750′–800′ A. T.

The fossil coral bed is seen near its top along the road between Spragueville and Stroudsburg, one fourth mile south from the Brodhead creek crossing, the rock being perforated in every direction with the holes left from the removal of *corals* and other *calcareous remains*, by solution.

Fossil shells are very abundant, *Spirifer*, *Tropidoleptus*, and *Avicula*, being very numerous, while *crinoidal fragments* also abound.

Glacial striae go S. 45° W. at this locality, and the whole surface is planed away smooth, conformably with the dip.

A kettle moraine is seen at the western line of the township, near B. Walter's, where the road passes along on a narrow ridge of Drift, sloping down almost perpendicular eastward to Pocono creek, 100′ below, and westward leading into the "Kettle hole," 50′ deep and several rods long.

A small "kettle hole" is also seen along the Milford pike just north from East Stroudsburg.

The Hamilton sandstone rocks are seen in the bed of Pocono creek, just below the dam which leads the water to the Tanite Co.'s works, the stream descending over them in *cascades* and falling 20′ in 300 yards. The rock is bluish-gray, quite sandy, and dips N. 25° W. 8°–10°.

Just opposite the Tanite Co.'s works, a bluff of *Hamilton rocks*, 65′ high, rises almost vertically from the bed of Pocono.

The Genesee slate outcrop crosses Brodhead creek at the road crossing, one and one fourth mile below Spragueville, where it is seen as a bluish-black sandy slate, dipping quite rapidly to the north-east; from this point its outcrop extends south-westward, making a decided valley between the *Hamilton sandstone ridge* and the *Chemung ridge* next

north, down which Hoffman's run flows north-eastward to Brodhead creek. These rocks are also exposed along the road between J. P. Hoffman's and J. Moore's, where they are quite dark and sandy.

The Chemung rocks make a steep, high ridge directly north from the *Genesee slate valley*, and extend parallel with it about S. 70° W. across the township. These beds are well exposed along the road, just below Sprague ville, where they dip N. 25° W. 25°–30°.

Along the county road, about one half mile below Sprague ville, the *Chemung rocks* are seen in cliffs of gray, fine-grained sandstone, quite *fossiliferous*.

A coarse, yellowish-gray sandstone occurs about 200′ below the top of the Chemung, near Sprague ville; it is only partially exposed, and its thickness is not known.

Further west the base of the *Chemung* is seen at the sharp bend of the road, just north from J. P. Hoffman's. The shaly rocks at the top of this series make a valley depression similar to that of the *Genesee slate* and Prince's run flows north-eastward down their strike for a considerable distance in the western part of the township.

The Catskill beds cover the extreme northern portion of this area, forming a well marked ridge northward from the *Chemung belt*, and extending to a much higher elevation than that of the latter.

The Starrucca gray beds are seen crossing Brodhead creek in the vicinity of Sprague ville, this town being situated about on their middle portion, they dip 25°–30° N. 15° W. and make long cliff outcrops.

A short distance east from Sprague ville the Starrucca *gray rocks* have been quarried for flagging and there we see large perfectly smooth surfaces 20′ or more, dipping N. 25° W. 21°.

A sharp ridge of Catskill rocks (Starrucca) crosses the road just above Sprague ville, and the D. L. & W. R. R. makes a cut through the same beds.

The New Milford red shale makes a conspicuous band of deep red sandy shale across the northern end of this township, entering it near the north-eastern corner, across

Brodhead creek ⅛ mile above Sprague ville and leaving the township near R. Barry's.

The D. L. & W. R. R. cuts through this *red shale* above Sprague ville just north from where it crosses Brodhead creek and there we see a ridge of the *red rock* dipping N. 25° W. 25°.

A broad band of the same *red rock* is seen crossing the road which ascends Brodhead creek just south from Lee's run where it dips rapidly north-west. Lee's run flows in this *red shale* from the point where it enters the eastern line of the township, until it empties into Brodhead creek.

At the junction of Brodhead creek with the West Branch a reddish sandstone is seen dipping N. 25° W. 10°–11° and planed off smooth by Ice action, the *striae* going S. 30° W. From this point on up the Brodhead creek road to the Price township line, the rocks are frequently seen at the roadside *striated* with Ice scratches S. 30°–35° W.

The Catskill rocks are quite well exposed in cuts along the D. L. & W. R. R. from Sprague ville on north to where it leaves the township. The rocks are generally gray after crossing the *New Milford red shale* and the general dip is to the north-west, but occasional *rolls* cross the measures, when for very short distances the *dip is reversed* to the south-east.

Barometric Elevations in Stroud.

(*Above Tide.*)

Stroudsburg at corner of Elizabeth and Franklin streets,	435′
" at lowest point on Walnut street	400′
Mouth of McMichael's creek,	385′
Bridge connecting Stroudsburg with East Stroudsburg,	405′
Milford pike at crossing of D. L. & W. R. R.,	460′
" at forks near J. Marsh's,	475′
" " D. Callahan's,	465′
Sambo creek at crossing near cemetery,	450′
Forks near school-house No. 4,	460′
" G. Bush's,	465′
By-road west from M. Bush's,	495′
Level of Sambo creek at road crossing near William Henry's,	445′
Forks of road near Charles King's,	460′
" in Sprague ville,	525′
" next east, (64 rods,)	580′
" north from Joseph Lee's,	540′

Junction of Brodhead with West Branch, ... 550′
Forks of road there, ... 560′
Brodhead creek at crossing near William Smiley's, ... 500′
Forks at Wolf school-house, ... 515′
Hoffman's run at road crossing, ... 515′
Dusenberry's run, ... 500′
Next forks south, ... 475′
Forks 139 rods east from last, ... 455′
Brodhead creek below dam at Wyckoff's mill, ... 435′
Forks of road just south from W. Chapman's, ... 475′
Brodhead creek at top of Shug's mill dam, ... 425
Forks of road near C. Henry's, ... 470′
" near G. G. Ramsey's, ... 435′
" 68 rods south of last, ... 465′
" next west, ... 505′
" " near M. Dreher's, ... 470′
Big Meadow creek at road crossing near J. White's, ... 465′
Forks next west from E. Flagler's, ... 500′
Forks at Stonington school-house, ... 525′
Forks near L. Drake's, ... 500′
Big Meadow creek just east at road crossing, ... 475′
Summit of ridge on road east from last, ... 590′
Forks of road 298 rods east from L. Drake's, ... 480′
" at school-house, 92 rods north of last, ... 490′
" 117 rods north of last, ... 490′
" near G. Stone's, ... 590′
Dusenberry's run at crossing near P. Lee's, ... 600′
Forks just south from M. Brish's, ... 670′
Hoffman's run at crossing near T. Roland's, ... 570′
By-road near J. Eckert's, ... 690′
Forks of road next west, ... 750′
" near W. W. Chipperfield's, ... 780′
Hoffman's run near J. P. Hoffman's, ... 745′
Sharp bend of road north from J. P. Hoffman's, ... 760′
Wigwam run at road crossing south from M. Brown's, ... 810′
" " near W. Winn's, ... 935′
By-road near A. Metzgar's, ... 920′
Forks south from J. Martz's, ... 700′
Forks near H. Neyhart's, ... 680′
Wigwam run here, ... 675′
Forks near L. Merion's, ... 700′
Forks 53 rods south-east from last, ... 710′
Forks 123 " " . . . . . 690′
Level of Pocono creek at road crossing above Tanite Co.'s works, ... 535′
Cross roads near S. Frazier's, ... 480′
Forks near A. J. Bush's, ... 480′
Level of Pocono creek at road crossing near G. Phillip's, ... 465′
Snyder's Corners, ... 495′
Dry run at road crossing near its mouth, ... 485′
Forks next north from Mrs. M. E. Detrick's, ... 695′
Forks near C. Gearing's, ... 725′
Tributary of Dry run at road crossing near H. Frantz's, ... 695′

Forks next north-west, ... 715'
Dry run just west from last, ... 685'
" at road crossing near W. B. Ruff's, ... 730'
Wigwam run at road crossing next south of I. Merrin's, ... 650'
Pocono creek just south from last, ... 575'
Forks of road next south, ... 595'
Lane at B. Walter's, ... 605'
Forks of road next south . . . . . 685'
Lane at H. Beesecker's, ... 645'
Cross-roads next south, near Shaffer's cemetery, ... 570'
Forks of road near R. Houston's, ... 570'
By-road to H. R. Ransbury's, ... 570'
" just east, 6 rods, ... 580'
Forks at J. W. Houston's, ... 520'
Forks near Jas. H. Kern's, ... 500'
McMichael's creek just south, ... 440'
Forks near Mt. Paul school-house, ... 500'
Cross-roads next west from last, ... 530'
Forks near S. Ree's, ... 430'
" 164 rods south from McMichael's creek, at Stroudsburg, ... 475'
" near J. Decker's, ... 640'
" east from A. LeBarr's, ... 390'
" near T. W. Rhodes', ... 400'
" " Mrs. E. Decker's, ... 670'
" " J. Huffert's, ... 400'
" " J. Caldwell's, ... 395'
Cherry creek just south from last, ... 360'
Forks near Mrs. J. Keller's, ... 380'
" " P. Keller's, ... 400'
Level of Cherry creek just opposite, ... 375'
Walpack ridge near Highland cottage, ... 730'
Forks of road near S. Hohenschildt's mill, ... 405'
Mountain run at road crossing ⅛ mile above last, ... 550'
" " " near C. Dreher's, ... 725'
Forks of road near C. Dreher's, ... 735'
Summit of Kittatinny Mt. on Bangor road, ... 1350'
Forks of road near P. Edinger's, ... 920'
" " 137 rods east, ... 970'
" " near J. W. Drake's, ... 905'
Level of Mountain run next south, ... 880'
Summit of Kittatinny Mt. Tatarny's gap, ... 1250'

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15. Hamilton township.

This township lies directly west from Stroud and also adjoins Northampton county along its southern line. Its shape

is almost rhombic except that the southern line is broken by the irregularities of the Blue Mountain crest.

The rain falling on this area is carried off north-eastward into the Delaware river, reaching the latter stream just north from the Water Gap, through Brodhead and Cherry creeks.

Cherry creek takes its rise at the western line of the township, in an old drift filled valley, where the surface slopes away in either direction so insensibly, that it is impossible to determine the exact locality of the divide. A portion of the water falling on this old valley comes eastward by way of Cherry creek to the Delaware; while another portion goes westward by way of Aquanchicola creek to the Lehigh river in Carbon county. This valley is excavated from the soft rocks at the junction of VI and V, and is the south-westward extension of the Delaware river valley above the mouth of Brodhead, in Monroe county.

McMichael's creek drains the rest of Hamilton township, north from Godfrey's ridge, except the extreme north-eastern corner, through which Pocono creek makes an ox-bow bend.

The main branch of McMichael's creek takes its rise in another ancient drift-buried valley, just west from the Hamilton township line, and along the northern slope of Walpack ridge.

Lake Poponoming, a beautiful sheet of water, of semi-lunar form, occupying a deep "kettle hole" in the *Terminal moraine* pours a constant stream of water into this branch of McMichael's creek. The Lake is 35′ deep, and great hills of drift surround it on every side. A very narrow steep bluff of drift separates its southern shore from McMichael's creek, which, in passing it, cuts down through the drift deposits several feet below its level, (620′ A. T.)

McMichael's creek flows eastward in an ancient Drift-buried valley underlaid by *Marcellus shale rock*, being the westward extension of the old valley which enters Monroe county near the mouth of the Bushkill, and runs south-westward through Middle Smithfield, Smithfield and Stroud townships, entering Hamilton just east from where McMichael's creek turns southward near Wm. Felkner's.

The section of rocks exposed in this area extends from the *base of the Chemung* (which comes into the hills at the extreme northern portion) down nearly to the base of IV along the summit of the mountain at the extreme southern line.

The geology of the township is peculiarly interesting from the fact that the *Upper Helderberg group* (*Corniferous limestone* and *Cauda-galli grit*) thins away and disappears entirely near its western boundary, coincident with an extensive *thickening up* of the *Oriskany sandstone* (VII).

The rock structure remains about the same as that in the corresponding portions of Stroud, except that the a new *anticlinal* makes its appearance south of the *Kemmererville anticlinal.*

This *Offset anticlinal* comes through the Blue mountain from Mount Bethel township in Northampton county. On that side of the mountain it makes the cove behind Offset mountain, down which Offset creek flows eastward. On the Monroe county side of the mountain it makes the long nose which descends westward straight towards Saylorsburg; and it might properly be called the *Saylorsburg anticlinal.* Offset mountain is merely the high east end of the synclinal south of the Offset anticlinal.

The *Kemmererville axis* is flattened out to a considerable extent.

The East Stroudsburg axis enters the township just below Kunkleville, its structure being well seen along McMichael's creek, where that stream cuts across it into the syncline to the south. It seems to flatten out south-westward toward the western line of the township.

No roads pass across the *Kittatinny mountain* in this township and hence the outcrop of the *Oneida conglomerate* is seen only along the summit of these mountains, although its northern slope is thickly covered with *Oneida débris* from the upper portion of the range.

Offset Mountain makes a much more conspicuous figure in the topography when viewed from the Northampton county (southern) side of the mountain, than from the Monroe county (northern) side.

The Medina sandstone beds come to the surface mostly along the lower half of the northern Kittatinny slope, and hence are nearly always covered up under great heaps of débris from the Oneida outcrops.

At Kemmererville, where a small stream cuts across the axis of that name, to unite with Cherry creek, some reddish sandstone beds are exposed which doubtless belong to the top of the *Medina*.

The red shale beds of No. V are only slightly exposed in this township, since they underlie the Cherry valley region, and the foot slopes of the Kittatinny mountain, localities which are nearly always covered with Drift. They are exposed, however, just north from Kemmererville, where the Drift deposits have been stripped off along the road. There, opposite Mr. J. Heiner's, a very deep *red shale* is seen whose top is planed off smooth, and is scored with straight *Ice grooves* many of which are 2″ broad and 1″ deep, going S. 40° W., (at 450′ A. T.)

These *red beds* are also seen along the road leading south from Saylorsburg just north from where it crosses the old buried valley at the head of Cherry creek.

The Lower Helderberg rocks, No. VI, are quite well exposed along the southern slope of Saylorsburg ridge.

A nearly complete section of these beds was obtained in the vicinity of Stormville, where the following section was observed:

Stormville Section, (57.)

1. *Oriskany sandstone*, visible	25′
2. Concealed, (*Stormville shales*,) about	150′
3. *Stormville conglomerate*,	45′
4. " limestone,	50′
5. " water lime, ("Pethstone" of Cook, in New Jersey,)	8′
6. Rough, brecciated, impure limestone,	6′
7. Concealed,	10′
8. *Decker's Ferry sandstone*, pebbly, visible,	20′
9. Concealed,	10′
10. *Bossardville limestone*,	50′
11. Concealed,	50′
12. *Poxono buff, limy shale*, visible,	100′
13. Concealed to top of *Clinton red beds*,	75′ ?
	599′

The Oriskany sandstone, No. 1, occurs in a field, near the top of the ridge, a short distance north-west of Stormville, where it juts out in a bold ridge dipping nearly vertically N. 25° W. The upper portion only is visible, and it is composed very largely of white quartz pebbles, cemented into a matrix of coarse, gray sand.

The *Cauda-galli grit* is seen coming in immediately above No. 1, and forming a line of cliffs in a bluff along the top of the ridge; cleaving steeply to the south-east.

The cherty, limy *Stormville shales* cover a broad band of outcrop along the hill directly south from the *Oriskany sandstone*, and are partially exposed in several places, though owing to a rapid flattening of the dip, or even reversal, their thickness could not be certainly determined.

The *Stormville conglomerate* makes a bold bluff overlooking Cherry creek valley, and about 150′ above the same. It is composed of alternate layers of impure, sandy, pebbly limestone and pebbly sandstone, the latter predominating near its top. The layers of limestone are crowded with *Pentameratus*, *P. pseudo-galeatus*, *Spirifer macropleurus*, and many other characteristic *Lower Helderberg* fossils. The physical character of this *Stormville conglomerate* is exhibited by the following more detailed section of this stratum taken at Stormville:

Stormville Section, (*58.*)

1. Alternating layers (1′–1½′ thick) of sandy limestone and limy sandstone all filled with small quartz pebbles,	10′
2. Very hard white sandstone filled with small pebbles,	2′ 6″
3. Sandy limestone, with some pebbles,	10′
4. Bluish-gray limestone, very fossiliferous, impure and sandy, with few pebbles,	10′
5. Concealed,	2′ 6″
6. Sandy, pebbly limestone,	10′
	45′

By reference to the sections in Middle Smithfield, and Smithfield townships, of the preceding pages, it will be seen that the *pebbly layers* have been gradually invading the *limestone layers* downward from the base of the *Stormville shales*; since at Decker's ferry, where these beds first appear

in Pennsylvania, the *pebbly beds* are about 5′ thick, there being no quartz pebbles in the massive limestone which there underlies the few feet of conglomerate. These facts are of especial interest in connection with the sudden and great thickening up of the *Oriskany sandstone* southwestward from the center of this township.

The Stormville limestone, No. 4, has been designated from this locality, and I have used the name in the township east from this to include all the limestone layers between the *Stormville water lime*, No. 5, and the base of the *pebbly layers* next above; so that in Smithfield and Middle Smithfield townships this term includes a portion of the *Stormville conglomerate* of this section. The 50′ of rocks in it at this locality consist of bluish-gray impure layers, many of which are quite fossiliferous. Near its middle occurs a stratum about 15′ thick which is banded along the bedding planes with alternate laminae of gray and buffish-white colors. Some of the layers in this 50′ are pure enough to burn for lime and they have been quarried for that purpose on the land of Mr. Hartman just east from Stormville, near the Stroud township line.

The Stormville water lime makes its appearance in the section again at this locality, having been found continuously between this point and the eastern line of the county wherever its horizon is uncovered. As stated elsewhere there can be little doubt that it represents the "Peth rock" of Prof. Cook at the Nearpass quarry locality in New Jersey, 45 miles north-east from Stormville. The rock is quite impure, being of a buffish color, and where its lime has been removed by solution the residuum is a soft ochery substance. For its analysis see page 135.

Immediately under the last stratum there comes a bed of impure brecciated limestone, filled with chips of shale, limestone, and other material, the most of which has been rounded by attrition in water during the accumulation of the bed.

The *Decker's Ferry sandstone*, No. 8, is quite hard and full of very small quartz pebbles in its upper half, the lower part passing down into a greenish shale. The sandstone portion is fossiliferous, of a grayish-white color, and like

all the rest of the section above it, up to the base of No. 2 (Stormville shales) dips N. 25° W. 60°–75°.

The Bossardville limestone is here (opposite J. Snover's, where all the members of the section above it were measured) concealed under the drift which fills the Cherry creek valley, but a short distance (½ mile) westward it makes a bluff along the northern boundary of the valley, and has there been quarried and burned extensively on the land of Mr. C. Metzger. It is a dark-bluish rock of which 50′ are exposed, dipping N. 25° W. 75°. The base of the rock shows the impure layers finely banded with thin laminæ in which the *columnar structure* occurs near the Water Gap.

The Poxono buff shales are quite well exposed for nearly 100′ along the road which crosses Cherry valley past the M. E. church, one mile above (west) Stormville. The material is a light-yellow limy shale, in which some beds occur near the base of the exposure which might be termed *limestone.* No fossils of any kind were observed in these rocks.

The same beds are exposed along Featherman's creek, just below the cross-roads, at A. H. Featherman's, 100 rods west from the last locality. The stream descends over them in *cascades*, and the bottom of the *buff*, *limy shales* is reached near the mill dam, 50 rods south from the Stroudsburg road, where reddish variegated beds begin to come up. Several layers of buffish, impure *limestone* occur interstratified with the *shales* at this locality, and all dip to the north-west at a high angle.

The Bossardville limestone comes down into the steep bluff north from the road, and just east from A. H. Featherman's, on whose land it has been extensively quarried and burned for agricultural purposes. It occurs in two bluffs, and exhibits an outcrop 50′–60′ thick, the whole dipping rapidly north-westward. The rock is much twisted and contorted, exhibiting considerable calcite in veins and cavities.

Just west from Featherman's creek Godfrey's Ridge is suddenly turned southward to what was the center of Cherry creek valley farther east, while the *Bossardville limestone* curves over its crest and descends to the level of Cherry creek, near C. Featherman's. The limestone covers an

extensive area in the vicinity of Bossardville, being there burned to a greater extent than anywhere else in the county.

Mr. Geo. Heller has the most extensive quarry in the limestone at Bossardville and the rock shows great cliffs 40′–50′ high just above the road where the rock has been excavated back into the hill. The output of his kiln is about 100,000 bushels of lime annually, which brings from 6 to 8 cents per bushel at the kiln. It makes an excellent fertilizer and is hauled many miles for agricultural purposes. It is equally suitable for making mortar, and all building purposes not requiring lime of pure whiteness. The limestone is mostly of a dark-bluish color, with thinly bedded layers much contorted; apparently non-fossliferous, dipping N. 25° W. 30°–35°.

It is also extensively quarried and burned at this locality by Messrs. Williams, Bossard, Butz and others.

The columnar limestone occurs at the base of the *Bossardville limestone* in this vicinity and was once burned for *hydraulic cement* of which it is said to have made a very good quality.

Just south from Bossardville, Godfrey's ridge slopes rapidly up to an elevation of 900′ A. T. over which the limestones of VI curve as surface rocks and then dip down to the south-east until the *Bossardville limestone* comes to the valley of Cherry creek at Mr. C. Featherman's, 430′ A. T., where it has been quarried in a bluff 35′ high, just north from the creek. The rock is dark blue, with slaty fracture, and filled with streaks and veins of calcite; dip 10°–15° to the north-west.

Westward from Bossardville, this *Bossardville* limestone is seen no more within the township, being everywhere concealed under an enormous heap of débris from the *Oriskany sandstone*, or else absent entirely, the latter hypothesis being the one generally held by the farmers of the region. This belief rests entirely on negative evidence for its support, since there is not a single locality where the limestone could be seen between Bossardville and Saylorsburg, even if hundreds of feet of the rock were present.

Drift stuff and other débris conceal effectually all the stratified rocks of this horizon.

The increased amount of local débris which covers both the north and the south slopes of Godfrey's ridge southwest from Bossardville is primarily due to the great thickening up of the *Oriskany sandstone*, which takes place in that region. Just how the thickening is brought about cannot be seen directly, but the probability seems strong that it originated by the gradual invasions of the *Stormville shales* and underlying *calcareous conglomerate* by sandy material; so that the entire interval from the base of the *Cauda-galli* to the base of the *Stormville conglomerate* becomes sandstone and sandy shale.

That this was the *modus operandi* of the thickening is also affirmed by the fact that a great thickness of buffish-white sandy shale makes its appearance under the top ledge of the *Oriskany*, all along Godfrey's ridge west from Bossardville.

The Oriskany sandstone first makes its appearance on the south side of Godfrey's ridge, just west from the road which crosses the Cherry valley between C. B. Shaffer's and J. Ruth's. East of this, the *limestones of VI* are the surface rock in the vicinity of Bossardville on both the north and the south slopes of the ridge as well as the summit, the *Oriskany sandstone* having been entirely removed by erosion.

Glass sand has for a long time been obtained from the *Oriskany* on the summit of Godfrey's ridge, about two thirds of a mile west from the road referred to above. The locality where it has been most quarried is on the land of Mr. Samuel Shafer's, (825′ A. T.) the East Stroudsburg Bottle Glass factory having obtained its sand there for many years. The rock is a grayish-white, rather coarse-grained sandstone with many small flat pebbles which have a darker appearance than the enclosing matrix. The rock is hauled in wagons seven miles to the furnace. It contains too much iron for window glass.

The Oriskany is seen making a great cliff along the summit of the ridge, overlooking Cherry creek valley opposite

Mr. J. Mansfield's. The rock is mostly broken and crushed, while large heaps of bowlders cover the surface to an unknown depth on both sides of the ridge.

The Stormville shales are seen making much buffish-white débris along the cuts in the road which crosses this ridge northward from Mr. G. Barger's.

The Oriskany sandstone is also quarried along this road for *glass sand*, just south from the crest of the ridge, at an elevation of 750′ A. T. The rock is much decomposed, so that down under the superficial covering of bowlders the sand is so loose that it can be cut out with a spade. It is hauled to East Stroudsburg and used for making bottles at the new factory recently erected there, (1881.)

Good sand for bottle-making purposes can be obtained anywhere along this ridge, between this locality and the western line of the township. No measurement of the Oriskany in this region is possible, owing to lack of exposures, but it can hardly be less than 150′ thick, and possibly 200.′

The Cauda-galli grit, as has already been stated, thins away to a feather-edge on the *old Oriskany sandstone beach*, which begins to come in near the center of the township. The exact place where it disappears is mere conjecture, since its outcrop is entirely concealed in the western portion of the township, but its disappearance is presumed to be coincident with that of the *Corniferous limestone*, which, there is good reason for believing, thins to nothing, about one mile from the western line. The disappearance of the *Cauda galli*, at the same time, is inferred from the fact that a short distance westward, (two or three miles,) in the adjoining township, the *Cauda-galli grit* is absent.

This rock enters the eastern portion of the township along the crest and northern face of Walpack ridge, having a narrow outcrop, owing to the rapid north-west dip, which soon carries it down under the *Corniferous limestone.*

The East Stroudsburg axis brings up the *Cauda-galli grit* just north from the McMichael's creek syncline, along which it forms a high ridge extending from the eastern line of the township south-westward parallel to Godfrey's ridge,

until it gradually dies away, when the *Upper Helderberg rocks* thin out, west from the center of this area. McMichael's creek cuts through this ridge at the sharp turn in the road, 100 rods below Kunkleville. There the *Cauda galli* is seen as a dull gray, sandy slate, cleaving in thick plates to the south-east, and dipping both north-west and south-east under an arch of *Corniferous limestone.*

The outcrop of the *Cauda-galli* is also seen along the road leading southward from Kellersville, where it crosses the *East Stroudsburg axis* between Mr. W. Benzoni's and G. Erdman's, the summit of the ridge in the gap through which the road passes being capped by *Cauda-galli grit,* at 650′ A. T., though eastward it rises 100′–200′ higher, while westward it gradually sinks toward the valley of the lake branch of McMichael's creek, near which it seems most probable that both it and the *Corniferous* disappear, since neither are again seen west from that stream.

The Corniferous limestone is finely exposed at the eastern line of the township, for several rods along McMichael's creek, in the vicinity of Kunkleville, where it dips N. 25° W. 15°–20° for over 600′, which would indicate a thickness of at least 150′, and possibly 200′. The rock is very flinty, and but little of it is pure enough to slack on burning. It passes below the bed of McMichael's creek, just above the bridge at Kunkleville.

West from this it forms a line of ledges running about S. 60°–65° W. and extending a long distance without interruption. It is seen along the road at the forks next west from W. Bittenbende's, where it has been quarried and burned to a small extent, though it slacked very badly, owing to the innumerable black flint nodules with which it is filled.

About one mile west from McMichael's creek, the *Corniferous limestone* forms a bluff 100′ high, at the forks of the road just south from Mrs. W. Heller's, where, on the north side of the East Stroundsburg axis, it dips N. 25° W. 25°–30°.

It is also seen where the road crosses a small stream, about one half mile south from Kellerville, extending along

the road southward for several rods past Mr. W. Benzoni's, near whose house it is planed off smooth squarely through the *flints* by Glacial action, and striated S. 35° W. over a considerable area. The rock is quite sandy and seems to possess only a small quantity of lime. It also appears much thinner than usual and dips N. 25° W. 25°.

On passing still further south from this last locality, the Corniferous limestone arches in the air over a ridge of *Cauda-galli grit* but comes down to the surface again at Mr. G. Erdman's, where it dips S. 25° E. 16°.

Continuing further south on this same road we cross the *McMichael's creek syncline* and come to the reversed dip of the rocks which rise south-east to the summit of Godfrey's ridge. Near the point where this reversal takes place at A. Meizell's, a broad outcrop of the *Corniferous limestone* is seen along the road. It is so sandy that but for the *flints* contained it would not be recognized as having any relationship to a *limestone*. This is the most western point at which the *Corniferous limestone* has been seen in Monroe county and it probably thins away entirely within one or two miles from this point.

The Hamilton Group covers all the rest of the township north from the Corniferous limestone outcrop, or about half of its area.

The soft buffish-gray and blackish *Marcellus beds* occur along the valley of McMichael's creek, the greater portion of which has been excavated out of these rocks. They are mostly covered up and concealed, however, by a great sheet of *Drift* which is piled up in hummocks, scattered in ridges, and fitted with "Kettle holes." These latter are most abundant in the vicinity of Mr. P. Mosteller's, one half mile, north from Kunkleville. Here several *Kettle holes* occur 30′–50′ deep, while in the same vicinity *Drift mounds* and ridges rise from 50′–100′ above the general level. A large conical Drift mound is seen just south from Sciota, nearly 75′ high.

Where the stream cuts through the Drift deposits, the *Marcellus* is occasionally seen. Near Mr. G. Snyder's, McMichael's creek cuts a narrow gorge through a ridge of

Marcellus, and just above it makes a vertical *fall* of 15′ over the dark blue slates of this series.

About one mile south from this last locality a low bluff of *Marcellus shales* is seen in a field near Mr. Yinger's, which has been quarried to some.extent for "slate gravel" to be used in repairing the roads. The bluish-black slate contains many fossils at this locality, but they are mostly fragmentary and indeterminable.

A bed of bog iron ore occurs along McMichael's creek about one half mile west from the village of Sciota. It has been leached out of the *Marcellus beds* which are frequently iron bearing. The deposit is not now visible, having been covered up with débris, though many years ago it was dug out and hauled to Weissport, in Carbon county, for use in the manufacture of mineral paint.

One of these local accumulations of iron ore is also seen along the north bank of Little McMichael's creek, about one mile above Sciota. It was cut by an excavation for the road, and is seen to consist of a yellowish clay ore in small nodules and finer material, under which lies this blackish *Marcellus shale.*

These deposits would yield a valuable iron ore of medium richness if they could be found sufficiently extensive, which is hardly probable.

Just east from Kunkleville, the *Marcellus* is seen nearly in contact with the *Corniferous limestone*, there being only 20′ of concealed material between the two outcrops. The lowest portion of the Marcellus seen there is a dark gray, hard, sandy shale.

The Hamilton sandstone makes a considerable ridge along the northern portion of this township, but it is much less elevated than further east.

Pocono creek cuts through a ledge of *Hamilton calcareous sandstone*, at Custard's Mills, in the north-eastern corner of the township, where it makes a *fall* of 20′ in a short distance. Many large *pot-holes* have been worn into the dark-blue sandstone layers at this locality.

The Hamilton sandstone beds are well exposed along

Little McMichael's creek, where it enters the township, and immediately southward, where the stream cuts through the *Hamilton ridge.* It flows in a narrow gorge, hemmed in by almost vertical slopes of gray, sandy rocks, 200′–300′ high. Immense *bowlders* of the rock are scattered over the surface and strewn along the stream.

The Genesee slate is seen along the road which runs east and west, one fourth mile north from Custard's Mills. It makes a black streak in the road, and its narrow belt of outcrop runs near the northern line of the township, sometimes being in Hamilton, and again just over the line in Jackson, except near the western line of the township, where it passes some distance (one half mile) north from the Hamilton township line.

The Chemung beds cap the summit of a ridge, near the eastern line of the township, along its extreme northern border, for a short distance, (one to two miles,) but west from this their southern outcrop passes northward into Jackson township.

It is also possible that the basal members of the *Chemung series* come into the summits of the hills in the central portion of the *Stroudsburg syncline*, at the extreme western line of the township.

Barometric Elevations in Hamilton.

(*Above Tide.*)

Cross-roads near J. Snover's, (below Stormville,)	420′
Forks at Stormville P. O.,	430′
Forks at Rev. G. L. Shafer's,	515′
Level of Cherry creek, just south,	395′
Forks next south,	405′
" in Kemmererville,	450′
" C. Fetherman's,	440′
Cherry creek there,	430′
Forks 150 rods north,	610′
Cross-roads at J. H. Fetherman's,	525′
Forks of road opposite hotel in Bossardville,	670′
Summit of Walpack ridge, just south,	900′
Forks near C. B. Shafer's,	650′
" " C. Houser's,	610′
Cross-roads just south from E. Shafer's,	700′
Cherry creek, near G. Barrier's,	525′
" " at road crossing below A. Shoemaker's,	560′
" " " " near J. Katz's,	600′

Highest point in old buried valley at head of Cherry creek, ... 625′
Forks of road in Saylorsburg, at hotel, ... 745′
Lake Poponoming, ... 620′
Lake creek at western line of Hamilton township, ... 625′
" " at road crossing one half mile east from last, ... 585′
Forks next north, ... 670′
" " " from M. Kintz's, ... 670′
" 292 rods north-east from last, ... 600′
" P. W. Shafer's, ... 550′
Lake creek at road crossing next east, ... 540′
Forks east from G. Umphred's, ... 740
" 93 rods east from last, ... 730′
" just north from E. Shafer's, ... 595′
" near J. Houser's school-house, ... 590′
" " M. Fetherman's, ... 560′
Cross-roads at J. Erdman's, ... 570′
Forks at school-house near J. Bossard's, ... 600′
" near G. Heller's, ... 660′
" " G. Erdman's, ... 575′
Summit of ridge in road just north, ... 650′
Forks near W. Haney's, ... 560′
" " C. Yinger's, ... 555′
Creek level there, ... 525′
Cross-roads, 151 rods northwest from last, ... 545′
Forks near A. Bowman's, ... 765′
" " J. Umphred's, ... 725′
Cross-roads near J. Shoemaker's, ... 625′
" 100 rods east from the last, ... 620′
" near G. Snyder's, ... 540′
Forks near Dr. Levering's, ... 575′
" " J. Marsh's, ... 575′
Little McMichael's creek, at Sciota, ... 540′
Forks of road in Sciota, ... 565′
Level of Little McMichael's creek, near L. Houser's, ... 580′
Forks of road near G Bittenbender's, ... 600′
Cross-roads, 209 rods east of last, ... 600′
Forks at I. Kirkuff's, in Kellerville, ... 500′
Level of McMichael's creek there, ... 490′
Forks near W. Benzoni's, ... 510′
Level of little stream just north, ... 500′
Forks near S. Katz's, ... 700′
" " A. Staple's, ... 570′
" " J. Cressmon's, ... 500′
Cross-roads near A. Snyder's, ... 485′
Forks next west, (131 rods,) . . . . . 490′
Level of McMichael's creek, near S. Lesh's, ... 480′
" " " " J. Fetherman's, ... 475′
Forks next north, ... 545′
" near G. Houck's, ... 620
" " P. Mosteller's, ... 515′
Cross-roads near G. F. Heller's, ... 545′

McMichael's creek, near M. Shoemaker's, ... 465′
McMichael's creek, at Kunkleville, ... 455′
Cross-roads there, ... 470′
Pocono creek, at Custard's mill-dam, ... 735′
Forks of road next west, at Luth. church, ... 800′
" " 97 rods north from last, ... 785′

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16. Ross township.

This township lies next west from Hamilton and borders Northampton county on the south.

The drainage is nearly all westward into the Lehigh river though Aquanchicola creek and its tributaries. This stream rises in an old *buried valley* lying between the Kittatinny mountain and the *Oriskany* ridge, at the eastern line of the township, from the highest point (625′ A. T.) of which, where the divide is almost imperceptible, Cherry creek starts eastward and Aquanchicola westward.

Frantz's creek flows west along the north side of the ridge. This stream also heads in an old drift-filled valley where the divide between it and the water flowing eastward to the Delaware through McMichael's creek, is almost imperceptible, there being an extensive *swamp* nearly on the crest of the divide out of which Frantz's creek issues westward; while to the north and separated from it by only a low ridge of Drift the waters of Lake creek go eastward; the summit of the divide being 635′ A. T. or only 10′ higher than the summit of the Aquanchicola buried valley, one mile south.

This township is the westward limit of the great glacier which moved south-westward down the valley north from Walpack ridge, for west from the center of this area there is no Drift nor any evidence of glacial action, while to the east are great heaps of true *Terminal moraine* more than 100′ high. These Drift heaps, mounds, and ridges are most numerous along the eastern line of the township, and about one mile west from the same; beyond this, westward, the

Drift heaps become less frequent, and finally disappear altogether before the western line of this area is reached.

The structure of the rocks is simpler than in Hamilton township, because of the disappearance of the *East Stroudsburg axis* which flattens out between the *Stroudsburg* and *McMichael's creek synclines* where they come together near the eastern line of the township.

The rocks exposed extend from the *Catskill* down to the *Oneida conglomerate* which here as eastward caps the summit and upper slope of the Kittatinny (Blue) mountain. *The Catskill* is caught in the deep fold of the *Stroudsburg syncline* along the northern portion of the township.

Wind Gap is a name given to a great cut through the Kittatiny mountains at the eastern line of this area. The crest of the Kittatinny at the Wind Gap is about 1450′ A. T., but the summit in the gap is only 978′ A. T. From crest to crest across the gap is not far from ¾ mile, while at the base of the same the sides have converged until they are separated by only one eighth mile. The floor of the gap is covered with rubble and rock débris. An excavation 12′ in a R. R. cut shows many of the small bowlders rounded as if from attrition in water.

The origin of this gap will most probably always be left to conjecture, but I can see no plausible explanation for it except that it has been cut down by a stream of water which flowed through it in the remote past, descending from the Pocono escarpment at the north across the wide, eroded area which extends northward from the gap to far beyond the township line. This, however, is mere conjecture, since the stream which produced the erosion of the gap, has so long ago ceased to flow, that subsequent erosion has practically made an entirely new topography. It is possible that the flooded rivers from the melting and retreating glaciers which filled the valley north and south from Walpack ridge, may have cut down the plateau of soft rocks across which the ancient stream flowed through the Wind Gap, thus leaving only the remnants of its ancient course.

No *Drift* materials of any kind are to be seen in the gap,

so that its erosion can hardly be connected with the glacial epoch.

The Oneida conglomerate is seen cropping out in immense *cliffs* on either side of the Wind Gap, from which large *bowlders* and great heaps of débris have rolled down the slopes into the gap.

The red shale rocks of No. V are seen in several localities along Aquanchicola creek, whose valley is excavated out of these. They are quite soft and of a deep dark color.

The only portion of the *Lower Helderberg series* exposed in this area, is the *Bossardville limestone* which has been extensively quarried along the south side of the ridge just west from the village of Saylorsburg. Messrs. Lessig, Altimus, Mackes, and others have quarries in it. The rock is very much contorted, being so twisted about as to render the determination of the dip at any locality almost impossible. Sometimes it appears to dip south-eastward, and again to descend almost vertically to the north-west. It also frequently presents a rude cleavage structure to the south-east. The rock is dark-blue and bluish-gray, almost totally non-fossiliferous, and when cleaving presents a very slaty aspect. Though not pure, it burns into an excellent lime for agricultural purposes. [These disturbances of dip are produced by the *Offset anticlinal.*]

Iron Ore—On the land of Samuel Lessig, quite a large deposit of *Brown Hematite Iron Ore* has lately been developed under the superintendency of Mr. Nelson Le Barre, of Portland, who seeing *ore* scattered over the surface, leased the land from Mr. Lessig, and went to work systematically to search for the main body of the same. Almost the first trial hole sunk resulted in striking a body of *flat ore* which was proven for 48′ in depth, and several feet in width. This *ore* comes in layers 1½″–3″ thick, which descends almost vertically except that the layers are frequently curved and bent from side to side.

The geological position of the *ore* is just above the *Decker's Ferry sandstone*, which forms a ledge of hard, grayish-white conglomerate immediately south from the exploita-

tion shaft. This fact has been of much service to Mr. Le Barre in a further seach for the *ore*.

Some specimens for analysis were taken from this shaft, for the composition of which see page 138.

A second shaft sunk a few rods south-west from the last and probably 100′ north from the *Decker's Ferry sandstone* ledge gave the following section, (59):

1. Sandy ochre,	10′
2. *Iron ore*, somewhat sandy,	12′
3. Ochre,	5′
4. Iron ore "Bomb-shell,"	3′
5. Ochre,	1′ 6″
6. "*Bomb-shell*" *ore*,	4′
7. Sandstone,	?
	35′ 6″

The ore from this shaft which was 38′ in depth at the time of visiting the same, is more silicious than that in the other shaft.

The Ochre is of a yellowish-brown color and some of it is quite pure. For analysis of the *ore* and *ochre* from this shaft, see page 139.

The "*Bomb-Shell*" *ore* is so called from its being found in spherical nodules containing a central hollow partially filled with loose, clayey materials, or a reddish oxide of iron.

The origin of these ore deposits is a question of considerable geological interest. The portion of the ore, as already stated, is just above the *Decker's Ferry sandstone*, while on above it lies a great mass of *Oriskany sandstone* completely decomposed, its débris forming a bed of white sand and silicious clay of unknown thickness. The ridge at this point, where the *Oriskany sandstone* is decomposed, is only about 800′ A. T.,* but only one mile west it rises in a lofty rock-capped ridge to 1200′ A. T. and is covered with immense blocks of brown iron-stained sandstone, in which much iron is seen. It appears quite probable that on the Lessig and Mackes farms the iron from the decomposed *Oriskany sandstone* has been transferred to the limestone

*Called Dodendorf mountain.

layers of the *Stormville beds* which had previously been deprived of their lime by solution leaving only the insoluble portions to act as a receptacle for the iron.

The beds of ochre seem to have originated by the removal of lime from the beds containing considerable iron, thus leaving it in a loose, porous condition, or the iron of the *ochre* may have been transferred to it from other sources.

The Oriskany sandstone attains a great development in Walpack ridge just west from Mr. Samuel Lessig's on whose land it rises in a great peak to 1200′ A. T., and from this point continues on south-westward along the summit of the ridge at about the same height for several miles, covering its crest and both the north and south slopes of the ridge with its débris to a great depth. Although the blocks of Oriskany scattered everywhere over this ridge have a very massive aspect, yet we seldom find the rock cropping out on the surface, and when it does the stratum appears to be all broken up and crushed. Many casts of fossils are seen in the *Oriskany sandstone* blocks which often have a dark brown or almost black appearance from the oxidation of its included iron.

The considerable mountain thus formed by the *Oriskany sandstone* is locally known as Dodendorf Mountain in this township.

Nothing whatever is seen of either the *Cauda-galli grit* or *Corniferous limestone* in outcropping ledges, or even in scattered blocks so that the conclusion about the thinning away of these groups in the western portion of Hamilton seems fully borne out.

The Marcellus dark shales are seen exposed along the road on Frantz's creek, just below the cross-roads at D. Andrew's, and a short distance below there opposite G. Kleintob's a high bank of Marcellus is exposed at a cutting along the road; it dips N. 25° W. 35°, and cleaves at a steep angle to the south-east.

The Marcellus beds are quite bituminous at a locality on the land of Bonser Bros. (Simon and William) and there many hundred dollars have been expended in a fruitless search for anthracite *coal*, several entries having been driven

into the base of Dodendorf Mountain, on its northern side, just south from Frantz's creek. The bituminous matter of the Marcellus has here been partially metamorphosed by the crushing and folding to which it has been subjected so that it now resembles very impure anthracite. About 20′ of this black *Marcellus shale* are exposed in one of the old drifts, where it is seen with streaks of very impure coaly material scattered through it in thin layers. The rock is fossiliferous but the organisms are so distorted as to be indeterminable.

Iron ore in small quantity is found resting on the *Marcellus* immediately under the surface débris, at the mouth of the entries. It is a yellowish-brown hematite, and has doubtless accumulated like the *bog ores*, though this is on a considerable slope.

One of the entries was driven into the hill about two hundred feet, and the point where it ends cannot be far from the horizon of the Oriskany sandstone, since the dip is here very steep to the north-west.

The *débris* from the *Oriskany sandstone* covers the entire northern face of the ridge, and extends down into the valley of Frantz's creek, thus extending out over the *Marcellus beds* for several hundred feet. As the glacial ice never covered this portion of the township the *Oriskany sandstone* bowlders have here got out so far over the *Marcellus outcrop* by simply rolling down the steep slope of Walpack ridge from the point where that stratum outcrops along the summit.

The rapid dip northward from the ridge soon carries all of No. VIII below drainage level and brings down the *Catskill beds*, about one mile north from Frantz's creek at the western line of the township, since the *Wire ridge syncline* rapidly deepens toward the south-west.

The red beds of the *Catskill* are seen along the road near David Heffelfinger's, just south from Mixsell creek, and from this point they extend eastward with a constant northward trend, until the syncline becoming too shallow they pass into the air near the northern line of the township, leaving the *Chemung beds* to occupy the end of the syn-

cline eastward to the Hamilton line. This syncline of hard rocks (Catskill and Chemung) along the northern line of the township, with soft beds (*Hamilton*) both north and south, has been left by erosion in a long high upland known as Wire Ridge, its summit rising from 1000′–1100′ A. T., seen from across the Hamilton valley to the north it looks very much like a genuine uplift, but it owes its height simply to the protective power of the *Catskill* and *Chemung beds*.

Near the head of Lake creek, just above Mr. A. Flyte's, the *Hamilton sandstone beds* are exposed along the road, where they have been quarried for use in repairing roads. The rock is slightly fossiliferous.

Barometric Elevations in Ross.

(*Above Tide.*)

Summit in Wind Gap, (Report N,)	978′
Summit of Kittatinny on either side of the gap,	1450′
Forks of road next north from Wind Gap,	850′
Level of stream at crossing near P. Arnold's,	815′
Forks near Jonah Smith's,	745′
Forks next west, (154 rods,)	700′
Level of Aquanchicola creek, near R. Van Buskirk's,	595′
Forks there,	610′
Cross-roads near Samuel Lessig's,	650′
Summit of Walpack ridge on the road between Samuel Lessig's and David Andrews',	875′
Level of Old valley where Aquanchicola creek starts west, near township line, (eastern,)	625′
Summit of Dodendorf mountain, (west from Lessig's,)	1200′
Forks of road west from J. Smith's,	650′
Level of Frantz's creek there,	640′
Cross-roads near D. Andrews',	655′
Forks at G. Kleintob's,	635′
Forks at school-house one mile west,	635′
Frantz's creek opposite G. Bouser's,	585′
Forks near J. Andrews',	785′
" Charles Buskirk's,	880′
Level of creek near David Heffelfinger's,	775′
Cross-roads near John Mixsell's,	825′
" east from D. Rhodes',	900′
Level of stream next west,	835′
Forks of road near W. Smith's,	900′
Forks near John Mission's,	950′
Cross-roads near P. Getz's,	1025′
Summit of Wire ridge just north of last,	1075′
Forks near H. Kindt's,	1100′

Cross-roads near G. Flyte's,	1075′
Lake creek at road crossing below M. Frantz's,	910′
" " " near A. Flyte's,	820′
Forks of road near J. Shook's,	750′
Level of Lake creek there,	745′
Forks of road near I. Rashy's,	760′
Lake creek near L. Stallet's,	700′
Cross-roads near A. Kresge's,	715′
Forks at P. R. Trausue's,	705′
Forks near T. Marsh's,	640′

17. Eldred Township.

This lies directly west from Ross, and occupies the extreme south-western corner of Monroe, having Northampton county on the south and Carbon on its western border.

The rainfall is all drained westward to the Lehigh river through Aquanchicola creek, and its principal tributary, Frantz's creek. The latter drains all the northern half of the township, and flows south-westward, along the northern slope of the No. VII ridge, rudely parallel to Aquanchicola, which meanders along the southern side of the same ridge through the valley of soft rock (No. V) at the foot of the Kittatinny mountain. Westward from the center of the township, Aquanchicola and Frantz's creeks gradually approach each other until at the Carbon county line they are only 200 rods apart. Frantz's creek cuts through No. VII ridge at what is known as Little Gap, and the two streams having united, the Aquanchicola keeps on to the Lehigh river at the Lehigh Water Gap.

The extreme north-western portion of the township drains northward to Big Creek, which flows westward to the Lehigh river near Weissport.

The glacial ice seems never to have extended over any portion of this area, except possibly along the old valley which extends northward from Frantz's creek through Wire ridge to Big Creek; since no *striae* were observed on the

outcropping rocks at the hundreds of localities where they are bare in the township; and there is no drift except along the valley referred to.

The summit of this divide is a broad, level valley near the northern line of the township, (only 730′ A. T.,) while both east and west of it Wire ridge (through which the gap is cut) rises 350′–400′ higher. Some *drift bowlders* are found along this old valley as far south as Frantz's creek; but as no *glacial scratches* were observed it is possible that they were transported by the water which (fed from the melting ice in the Big creek valley) excavated this gap.

It is possible that this accession of water to the valley of Frantz's creek from the overflow of the Big creek valley to the north was the determining agency in enabling the waters of Frantz's creek to make a breach through No. VII ridge and join the Aquanchicola at Little Gap. This seems all the more probable because Frantz's creek constantly approaches the latter after the ancient valley debouches into it three quarters of a mile below Kunkletown.

There is a marked change in the topography in passing from the region of *glaciation* in the eastern portion of Ross township (the one last described) westward into the *driftless* area; for instead of broad valleys through which the streams wander over beds of drift, with scarcely appreciable fall, we now get narrow gorge-like valleys, with the streams descending over rocky bottoms often in cascades, and always with a rapid descent.

The rocks of this township are the same as those in Ross; and about the only change in the *structure* is a constant westward deepening of the *Wire ridge syncline*, which brings the *Catskill beds* into the hills only one mile north from Frantz's creek, in the western portion of this area, instead of at the very northern line of the township, as in eastern Ross.

The Oneida Conglomerate forms the summit of the Kittatinny mountain, in this township, as it does everywhere between the Delaware and Lehigh Water Gaps. The crest rises to 1500′–1600′ A. T. On the road which crosses the

Kittatinny, south from Kunkletown, the summit has an elevation of 1540′ A. T., while the crests east and west rise to 1575′ A. T. The actual outcrop of the Oneida is buried deeply under its own débris, except near the summit of the mountain, where the dip becomes so steep, 45°–50°, that the slopes will not retain the fragments. Where visible, it is a very coarse, hard, gray conglomerate.

The *Medina sandstone* is entirely concealed under the thick covering of *Oneida débris*, which veils the long northern slope of the Kittatinny, so that nothing can be seen of it in this township.

The Clinton red beds exist along the Aquanchicola valley, as is known by occasional exposures of *red shale*; but nothing is known of their thickness, since these rocks are only uncovered for a few feet at each locality. They are exposed along the north bluff of Aquanchicola creek, just below the cross-roads at R. Smith's, and also near Nelson's tannery, one mile below.

The Lower Helderberg rocks, whose outcrop still runs along the southern face of No. VII ridge, are constantly concealed by the débris of the *Oriskany sandstone*, from the slope above; except just south from Kunkletown, where they come out to the surface and have been extensively quarried for many years on the land of Messrs. Rauch, Smith, Engler, and others. The portion quarried is the *Bossardville limestone*, and about 30′ of it are visible. The rock is much contorted, and has been partially metamorphosed, through the intense lateral pressure to which it has been subjected, thus giving it a cleavage structure and a very slaty aspect in the less pure portions of the bed. The color is gray and bluish-black; no fossils were observed in it. No observations could be taken on the dip, since the bedding planes have been apparently destroyed, but from the fact that the *red shale* beds of No. V come up a short distance to the south, the *dip* must be very rapid to the north-west. The quarries south from Kunkletown have an elevation of 775′–800′ A. T. The *Columnar limestone* is seen in the bottom of Mecka's quarry, but it exhibits only

the cleavage structure here, and looks very much like the slates of some metamorphic regions.

The Bossardville limestone is last opened in this township and county about one mile west from Nelson's tannery, and within about one mile of the western line of the county. There, on the land of John Smith, the following structure is seen at his quarry, (60):

1. Soft, ochery shales, and sandy limestone,	15′
2. Bossardville limestone,	40′
	55′

There is considerable lime in No. 1, and where it has been removed by solution, the residuum is a soft, ochery material, of a dirty-brown color.

No. 2 has been quarried into the hill for several yards, where it dips N. 25° W. 40°. It is of a bluish-black color, on fresh fracture, except in the extreme upper portions, where it is gray.

The portion of No. VI between the *Bossardville limestone* and the base of the *Oriskany sandstone* is concealed everywhere within this township except the few feet exposed at the John Smith quarry. It is altogether probable, however, that no limestone pure enough to be of any economic use exists in this interval within Eldred township.

Westward from the John Smith quarry nothing is seen of the *Bossardville limestone* or any portion of No. VI, until we get several (5–6) miles into Carbon county, it having "run out" in the opinion of the farmers. The probabilities are that it is present, however, throughout all this intermediate district, but is constantly concealed by débris from the *Oriskany sandstone*. It is not seen from Lessig's quarry near the eastern line of Ross until we come westward to the vicinity of Kunkletown, in Eldred, a distance of over five miles, and yet it could doubtless be uncovered at most any locality at the right place along the southern slope of No. VII ridge. Search for it should not begin further than half way down the southern slope of the ridge. To the farmers who live along this region, where the limestone is apparently absent, it would be time well spent if a systematic search should be made for the *Bossardville lime-*

stone, as it could probably be found by stripping off the surface débris over a few rods at most.

The *Oriskany sandstone* continues its great development into this township from Ross, forming the crest and southern slope of the ridge which it keeps at a height of 1000′–1200′ A. T. until we come to the region of Kunkletown, where the ridge falls away, and there is a wide gap through it only 800′ A. T. The crest of the ridge at this locality is found to be underlaid with a pure, almost white, silicious clay which extends to a great depth. It has evidently resulted from the decomposition of the *Oriskany sandstone*, its iron having been removed and deposited elsewhere in a manner similar to that near Saylorburg. This was doubtless the course of the breakdown in the ridge at this locality.

Several years ago this silicious clay was mined and manufactured into what was sold as "soap." The material was passed through several vats filled with water until all the coarse sand grains had been deposited, and nothing remained in suspension but the impalpable silicious powder which then accumulated by deposition, and from which was manufactured the so-called "soap." A specimen of this silicious powder analyzed by McCreath is given on page 127.

The Oriskany sandstone forms a great bluff or cliff along the summit of the ridge near the western line of this township, but the bed seems to be everywhere shattered and broken as though from earthquake action, though it may have resulted from the strong folding and erosion to which these rocks have been subjected. *Oriskany blocks* which are everywhere scattered over the surface of both slopes of the Walpack ridge, are filled with quartz pebbles, and often contain numerous casts of fossil shells, principally large *Spirifers*.

The top of the *Oriskany* is not seen within the township, that horizon being constantly concealed, so that there is some uncertainty in regard to the character of the rocks immediately above the sandstone beds.

The Marcellus shale along Frantz's creek is often very bituminous. This is the case opposite Kunkletown and it

has there been extensively drifted upon in search of *coal*. Three tunnels were driven into the hill several hundred feet, and one of these must have penetrated nearly to the top of the *Oriskany sandstone*, since the last material brought out looks very much like the *Carbonate of Iron*, which often rests upon the latter rock. The outcrop of the *Marcellus* at Kunkletown is quite black, and has scattered through it thin streaks, a very impure kind of *anthracite*, which will burn with a slight blaze when placed on a hot fire, leaving a great bulk of slaty ash. The presence of these carbonaceous laminae led to the search for coal, on which the sum of $5,000 has already been expended. It is needless to state that *no coal* fit for burning can ever be found at this horizon, since it comes at least 10,000′ below the lowest anthracite beds along the Lehigh river, fifteen miles away.

A bed of bog iron ore occurs on the top of the *Marcellus*, opposite Kunkletown, which was once manufactured into a very fine quality of *metallic paint*, by Mr. Metzgar. The deposit is only 2′–3′ thick, and seems to be quite local, since there is none on the opposite side of the ravine only two rods distant. The ore is rich enough to warrant mining and shipping could it be found in sufficient quantity.

Where the road crosses Mixsell creek, near its mouth, that stream makes a vertical *fall* of 60′ over hard, gray, sandy slates, which may possibly belong to the *Hamilton sandstone beds*. Frantz's creek flows in a deep narrow gorge at this locality, and Mixsell creek coming up to its bluff passes over the 60′ fall directly into it. The rocks cleave at an angle of 80° to the south-east.

The *Hamilton sandstone beds* form a belt of outcrop about one half mile broad directly north from Frantz's creek, and are seen making rounded hills covered with the peculiar fragments into which its rocks break when exposed to atmospheric action.

Along Prince's run, these beds are finely exposed in an almost constant succession of cascades from Frantz's creek north for one half mile or more, the dip being N. 25° W. 40°–45°, and the beds cleaving rudely at right angles to this into plates 1″–4″ thick. *The Genesee beds* may be recog-

nized in the dark sandy slate exposed for a short distance along Prince's run just before the *Chemung* appears.

The Chemung beds come down to the level of Prince's run on a dip of 35° N. 25° W., about three fourths of a mile north from Frantz's creek, and are seen as olive, sandy shales and sandstone, along the road, well exposed at a cutting for a building near Mr. Altmyer's.

The top of the *Chemung* comes down to drainage level about 100 yards below Point Nelson, and at about one mile from the top of the *Oriskany sandstone* in No. VII ridge, which, with an average dip of 35°, would give a thickness of 3000′ for No. VIII in the vicinity of Kunkletown, probably distributed among the different members of the group about as follows: *Marcellus*, 800′; *Hamilton*, 900′; *Genesee*, 200′; *Chemung*, 1100′. It is quite possible that the Chemung is somewhat overestimated at 1100′ since its lowest beds are concealed, and elsewhere it appears to make quite a narrow belt of outcrop, but it cannot be more than 100′–200′ out of the way on either side.

The Catskill rocks make a broad belt in the deep *Wire ridge syncline*, the central line of which passes across the northern portion of the township, thus making the *Catskill belt* about one and one half mile broad, and extending quite to the northern line of this area.

A thick band of *red rock* comes a few hundred feet above the base of the Catskill, and this is succeeded by gray beds which, in aspect, look much like Chemung, but being entirely unfossiliferous, they cannot belong there, but represent the *Delaware flags* of Pike county.

Barometric Elevations in Eldred.

(*Above Tide.*)

Kittatinny Mt. summit, on road south from Kunkletown,	1540′
Aquanchicola creek, near R. Smith's,	500′
Forks of road near P. Shafer's,	690′
" " above Nelson's tannery,	500′
Aquanchicola creek there,	485′
" " at junction with Frantz's creek, in Carbon county,	420′
Forks of road at Little Gap hotel, (near last,)	430′
Level of little brook, at road crossing near K. Meckes',	475′
" " " " " P. Jones',	485′

Forks of road at Lower Kunkletown hotel,	495′
Level of Frantz's creek there,	485′
Forks at Upper Kunkletown hotel,	545′
" near E. Kleintop's,	585′
Mixsell creek, at road crossing just above its mouth,	595′
Frantz's creek, at mouth of Mixsell creek,	530′
Prince's run, at road crossing north from E. Kleintop's,	540′
Forks there,	545′
Gower's run, near Point Nelson hotel,	600′
Cross-roads near R. Christman's,	615′
" at R. Barger's,	885′
" at A. Daniel's,	605′
Forks near W. Smale's,	670′
Level of ancient valley here,	665′
Forks near J. Smale's,	710′
Summit of old valley just north,	730′
Smale's run, near E. Frantz's,	820′
Forks of road, near E. Brutzman's,	920′
" " next south-east,	900′
" " next south,	845′
Prince's run there,	835′
Forks of road just north from P. Barger's,	690′
Prince's run there,	680′
Forks of road near P. Gower's,	670′
Gower's run, near D. Gower's,	780
Forks of road near J. Newhart's,	800′

18. Polk township.

This lies directly north from Eldred, and is bordered both west and north by Carbon county. It is drained westward to the Lehigh river by Big creek, which flows south-westward along the crest of the Lehighton axis, receiving several tributaries from the north, which descend the southern slope of the Pocono mountains.

The surface of this area, unlike that of Eldred to the south, has been extensively glaciated; for everywhere almost, except along the summit and base of Wire ridge at the extreme south line of the township, there occurs a deep covering of *Drift*, and where this is absent huge *bowlders* transported from the Pocono mountains give evidence of the activity of the ice.

An old *buried valley* leads south from the valley of Big creek past the Washington Hotel, making a gap through Wire ridge about 400′ deep, and connecting southward with the one described in Eldred township. Its summit is near the southern line of Polk, and at an elevation of 730′ A. T., from which the surface descends both north and south, falling only 100′ to Big creek in Polk, but about 250′ to Frantz's creek in Eldred.

The structure of the rocks is quite simple, the only axis passing across them being the *Lehighton* which runs almost parallel with the southern boundary of the township and about one mile north from it, bringing up the *Hamilton beds* along its crest. Then the dip changes to the north-west, quite rapid at first but gradually declining toward the north, until it is only 4°–5°.

The rocks of this area extend from the upper portion of the *Catskill* down into the *Marcellus shale*, the beds of this group being brought up under the wide drift-filled valley of Big creek.

Wire ridge extends along the southern border of the township and is capped in its higher portions 1000′–1100′ A. T. by the hard rocks of the Catskill.

The Chemung beds make the northern face of Wire ridge, dipping S. 20° E. 30°–35°, and are exposed along the road at the extreme south-east corner of the township. The portion seen is of an olive color and is composed of flaggy sandstone with much shale.

The Genesee slate and *Hamilton sandstone beds* are brought up to daylight by the strong south-east dip about ½ mile north from the southern line of the township, and are frequently seen cropping out along the road which passes westward, just south from Big creek.

At the eastern line of the township, near E. F. Kresge's, a great bed of *corals*, *shells*, and other organic remains is seen along the road. The *corals* are especially numerous and seem to perforate the rock in every direction. This most probably represents the *coral horizon* at the top of the *Hamilton* proper since the *Genesee slate* occurs just south.

Drift seems to be entirely absent from the south side of Big creek until we come west to the gap through Wire ridge, where plenty of it appears. Many large *bowlders* of the *Cherry Ridge conglomerate* lying stranded in this old valley near the south line of the township. It is very probable that a lobe from the northern *ice sheet* descended through this gap much further south than the *general body of the ice*, which did not in this township pass south from Big creek. The erosion of this ancient valley was possibly accomplished by means of this glacial prong and the water flowing from it.

Near the Carbon county line on Big creek, the uppermost portion of the *Marcellus* was once extensively quarried and manufactured into *school slates*, of which it is said to have made a superior quality though it was not durable enough for *roofing slate*. The cleavage planes at this locality dip S. 70° E. 50° but the dip of the bedding planes could not be determined.

This black slate horizon is seen exposed at two or three localities between the Carbon county line and Kresgeville, but it does not appear pure enough for *slates* at any of them.

Just north from where the road crosses Little creek, a stratum of *Hamilton rock* is seen which is crowded with *fossil corals* and *shells*. It cleaves to the south-east but dips rapidly north-west. This is the same stratum that occurs near E. F. Kresge's at the south-eastern extremity of the township.

The valley of Big creek is in many places a mile and a half wide, at almost a uniform level, except the immediate channel of the stream. Much of it is covered with Drift so that the underlying rock cannot be seen; but, from what is exposed along both the north and south slopes of the same, it is known that the bed rock consists of *Hamilton proper*, the Marcellus beds appearing along the crest of the axis which lies a short distance north from the present channel of Big creek.

The Chemung beds come down, on Little creek, about ¾ mile north from Kresgeville, dipping N. 25° W. 50°.

They are mostly olive and bluish-gray sandstones, some of are quite massive. These rocks make a narrow belt south from the middle of the township, its northern boundary crossing Pohopoko creek near J. Merwine's.

The Catskill beds come in on Little creek about one fourth mile below Mr. S. Heckman's, dipping N. 25° W. 40°.

The New Milford red shale soon passes under, and just beyond Mr. Heckman's the gray *Delaware flags* come down and cover the surface with their dèbris. North from this a great bed of *red shale* comes down and makes a wide belt of outcrop, just south from School House No. 2. This would represent the *Montrose red shale.*

The basal portion of the Catskill crosses Pohopoko creek just south from the cross roads at J. Merwine's; and from there north to the Carbon county line, there is a constant succession of the *red shales* and greenish-gray sandstone of that group.

The Montrose red shale makes a wide belt of outcrop in the vicinity of C. Everitt's, at the head of Pohopoko creek.

The north-west dip continuing, the *Cherry ridge conglomerate group* comes into the section at the northern line of this township, where it makes the southern escarpment of Pocono mountain.

The Cherry Ridge conglomerate is seen along the road which leads up into Pocono from New Mechanicsville Hotel, making a great bluff and cliff at 1500′ A. T. It is very full of pebbles and has a reddish cast, being quite massive. It comes in at the sharp turn in the road ¾ mile north from the Hotel. The entire southern slope of Pocono is covered deeply with rock dèbris that has been broken off the cliffs above, by the action of the elements.

Barometric Elevations in Polk.

(*Above Tide.*)

Cross-roads east from R. Heiney's,	750′
Forks next south,	820′
" near E. F. Kresge's,	685′
Level of Big creek, just north,	655′
Cross-roads at Gilbert's P. O.,	660′
Forks near G. W. Bauch's,	660′

Pokopoko creek, at road crossing near M. Heiney's, ... 640′
Forks next west, ... 655′
Cross-roads at school-house near H. Lobach's, ... 665′
Forks 146 rods south from last, ... 655′
Pokopoko creek, at crossing near N. Gregory's, ... 640′
Cross-roads at G. Angelmyer's, ... 715′
Forks near N. Searfoss', ... 690′
" of road at Washington hotel, ... 715′
Cross-roads near J. Boyer's, ... 930′
Forks of road near D. Shelley's, ... 645′
Pohopoko creek, at road crossing just north, ... 620′
American hotel, in Kresgeville, ... 660′
Forks near J. Hawk's, ... 630′
Pohopoko creek here, ... 610′
" " at old slate quarry, ... 600′
Cross-roads west from J. Muffley's, ... 750′
" south from P. J. Haney's, near stream, ... 950′
Forks 121 rods south from last, ... 985′
Cross-roads west from R. Steiner's, ... 900′
Level of Little creek, at crossing below W. Zacharias', ... 775′
Cross-roads near G. Hawk's, ... 840′
Forks south from S. Hawk's, ... 770′
Little creek, at Gregory's saw-mill, ... 675′
Forks 60 rods south, ... 675′
Cross-roads east (49 rods) from Kresgeville, ... 650′
Forks near M. Fisher's, ... 685′
" just west from J. Berger's, ... 740′
Cross-roads near J. Merwine's, ... 840′
Forks 446 rods west from last, ... 760′
Middle creek, a crossing here, ... 750′
Forks 200 rods south, ... 720′
" near J. Schwartz's, ... 830′
" " R. Hawk's, ... 880′
" 71 rods north of last, ... 950′
" near E. Obcherchner's, ... 960′
Cross-roads near S. Hawk's, ... 1060′
Forks near G. Selger's, ... 920′
Middle creek, at crossing near L. Switzgable's, ... 890′
Forks near G. Warner's, ... 975′
" 314 rods north-west, ... 1165′
New Mechanicsville hotel, ... 1140′
Crossing of stream just north of last, ... 1135′
Pocono mountain, at Carbon county line, 380 rods north of last, ... 1600′
Cross-roads in Carbon, ½ mile north of last, ... 1700′
Forks of road near P. Smith's, ... 940′
Level of Pohopoko creek there, ... 930′
Forks just north, ... 970′
Cross-roads next south from P. Smith's, ... 950′

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19. Chestnut Hill township.

This township lies directly east from Polk having Ross to the south and Tunkhannock on its northern border.

The rainfall over its eastern half passes eastward of the Delaware river through McMichael's creek, which rises near its north-eastern corner, and flows southward to within one mile of the southern line, when entering a valley of Hamilton rocks, it turns eastward down the same. The western half of this area is drained by Pohopokó creek, a stream, which, rising on the southern slope of the Pocono mountains, flows southward into the same old Hamilton valley, and then turns westward to the Lehigh river.

The surface of the township has been extensively glaciated, since everywhere over it, except along the summit of Wire ridge at its extreme south line, are found great heaps of drift. In the vicinity of Brodheadsville, many "Kettle Holes" occur 30′–40′ in depth, and some of quite large size, *Lake Minneola*, itself is probably nothing but a large "Kettle Hole" filled with water from the surrounding drainage basin, since it has neither inlet nor outlet that is visible, being fed by springs which rise from beneath its surface. It doubtless has a subterranean outlet through the coarse drift deposits to McMichael's creek which flows by it, ¼ mile eastward.

An ancient drift-buried valley extends east and west across the southern portion of this area, and connects at the west with the wide valley along Pohopoko creek in Polk township. Its greatest elevation is about 700′ A. T. near Brodheadsville, from which it gradually slopes away both eastward and westward.

The rock structure is the same in this township as in Polk directly west, there being a high ridge (Wire Mt.) of hard rocks (*Chemung*) along its extreme southern line; and the Pocono mountain along its northern boundary; while the

Lehighton axis brings up the Hamilton beds (soft rocks) in an intermediate valley.

The Hamilton beds come up with a strong south-east dip along the northern base of Wire ridge, and are exposed in cuttings at the roadside in the vicinity of Mechanicsville.

How much of the *Hamilton group* is brought up along the crest of the *Lehighton axis* cannot be determined, since all of the *Hamilton beds* are covered up with drift in the wide valley which they make, except on the extreme sides of the same.

North from the *Lehighton axis*, the *Chemung beds* come down on their north-west dip in the vicinity of Effort P. O. just south from which *Chemung flaggy sandstone* fossiliferous, occurs at the roadside.

The same narrow belt of steeply dipping (north-west) rocks cross McMichael's creek in the vicinity of Mr. S. Gearhart's.

The Catskill beds cover all the northern half of the township with alternate outcrops of *red* and *gray* strata. The base of this series comes down to drainage level on Pohopoko creek just north from the village of Effort; and the same outcrop crosses McMichael's creek near Brang's sawmill.

Some nodules of *Iron ore* have been found on the land of Mr. Merwine, near Merwinesburg, scattered over the surface of *red Catskill rocks*; and this has led some people to believe that valuable beds of *iron ore* exist in that vicinity; but the nodules found are entirely too silicious to be of any value even if they existed in considerable quantity, which is very improbable.

The southern escarpment of Pocono mountain makes the northern portion of this township, and its long steep slope is deeply covered with talus and débris from the great cliff of *Cherry Ridge conglomerate* which outcrops in bold cliffs along the brow of the mountain.

On the road leading north from Merwinesburg, the mountain (Pocono) rises to a height of 1800′ A. T. near the northern line of the township; while on the road leading north from McMichael's P. O. it rises to 1850′ A. T.

Barometric Elevations in Chestnut Hill.

(*Above Tide.*)

Forks of road near D. Hutmaker's,	830′
Cross-roads in Mechanicsville,	685′
" near T. Altimus',	690′
Small stream at road crossing, near Mrs. Newell's,	650′
Forks near S. Weiss',	675′
" " J. Siglin's,	680′
" " E. Altimus',	695′
" 115 rods west from last,	700′
Lake Minneola,	680′
Forks of road at north end of Lake Minneola,	730′
" " in Brodheadsville, (at J. Arnold's,)	695′
" " at school-house west from Brodheadsville,	725′
" " near P. Kresge's,	710′
" " " Wm. Searfoss',	715′
Summit of Wire ridge, just south,	1075′
Forks of road, near J. Smale's, (south-west corner township,)	920′
" next south-east,	900′
Cross-roads at Gilbert's P. O.,	660′
Pohopoko creek, just north,	655′
Forks near P. J. Shafer's,	660′
" next north,	670′
" at eastern line of township, near P. Setzer's,	840′
" west from S. Setzer's,	800′
" 100 rods west from last,	825′
" 123 rods " "	800′
" 110 " " "	800′
" 35 " " "	865′
Cross-roads near A. Hardy's,	750′
Level of McMichael's creek, at S. Gearhart's,	710′
Forks near L. Everitt's,	765′
Pokopoko creek, at crossing below Effort,	710′
Forks near P. Dorsheimer's,	720′
" " G. Warner's,	760′
" " J. Elliott's,	760′
Pohopoko creek there,	750′
Forks near J. Everitt's,	780′
Pokopoko creek, at crossing next north,	785′
" " " near C. W. Loux's,	800′
" " " " J. Siglin's saw-mill,	875′
Forks at J. Merwine's, in Merwinesburg,	940′
" next north,	995′
North line of township, on Wind Gap pike,	1800′
Cross-roads at McMichael's P. O.,	1010′
McMichael's creek there,	1000′
Crossing at P. Kresge's,	1050′
" next north,	1015′
Forks ½ mile south of northern line of township, on road leading north from McMichael's P. O.,	1510′

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20. Jackson Township.

This township lies next east from Chestnut Hill, having Hamilton on the south and Pocono on the east.

The rainfall all reaches the Delaware river going eastward through McMichael's and Pocono creeks to Brodhead's creek at Stroudsburg.

The rocks of this area dip to the north-west, except over a small area near its south-west corner through which the *Lehighton axis* passes a short distance north from its extreme south-western point.

The section exposed within the township, extends from near the top of the *Catskill* down into the *Hamilton sandstone beds.*

The Hamilton rocks make a triangular belt across the southern portion, beginning as a mere lining near the eastern margin and gradually widening westward until they cover a little less than one mile along the western border, extending northward along Little McMichael's creek to Rinkerville where the *Genesee black slate* occurs.

The Genesee slate is also seen making a black band along the southern margin of the township between A. Newhart's and L. Shook's.

The Chemung rocks make a high ridge in the eastern portion just north from the southern line, gradually getting further and further north, toward the west.

The New Milford red shale is seen along the road which runs eastward from Jackson Corner's, past P. McCluskey's. It is quite sandy and dips N. 25° W. 28° under a greenish-gray sandstone which makes a cliff 20′ high above the road near Mr. McCluskey's.

The Montrose red beds are seen in the western portion of the township near Mr. W. Mosier's, making a great red band across the field.

There is a wide and nearly *level plain* extending east and

west along the base of Pocono mountain, in the northern portion of this area. It varies in altitude from 1100′–1200′ A. T., and is covered to a great depth with *Drift* trash, Mr. W. H. Reinhart having sunk a well 41 feet without reaching bed rock. The plain is from one to one mile and a half wide and from its northern side the escarpment of Pocono mountain rises percipitously nearly 1000′ higher.

The Cherry ridge conglomerates jut out in bold cliffs far up towards the summit of Pocono; and the débris from these and other massive rocks of the Catskill cover the southern face of the mountain with a thick layer of talus.

Pocono mountain rises to about 325′ above the level of the Cherry ridge conglomerates or 2225′ A. T., thus overtopping by about 100′ any other elevation in Pike or Monroe counties.

Barometric Elevations in Jackson.

(*Above Tide.*)

Forks near G. Swink's,	745′
" " L. Shook's,	765′
Creek there,	750′
Forks near A. Newhart's,	910′
" 420 rods west from last,	915′
Cross-roads near A. J. Detrick's,	805′
Forks near L. M. Hobbs',	750′
Level of Little McMichael's creek, just south,	700′
Forks north from B. Snyder's,	800′
" 109 rods west from last,	860′
" near A. A. Singer's,	840′
" west from J. Hofmer's,	825′
" north from J. B. Heller's,	880′
" near J. Fetherman's,	865′
Little McMichael's creek, near M. Miller's,	905′
Forks near D. Pease's,	950′
" " J. M. Kinsley's,	1100′
" " W. H. Reinhart's,	980′
Little McMichael's creek there,	975′
Forks near C. Miller's,	925′
Stream crossing here,	920′
Cross-roads near P. Felkner's,	965′
Forks 466 rods east,	935′
Stream at P. McCluskey's,	900′
Cross-roads near S. Able's,	845′
Forks near S. Heller's,	910′
Stream just south,	900′
Forks near J. Dailey's,	985′
" " J. Parsinger's,	1050′

Level of stream just east,	1035′
" " near J. Smith's,	1055′
Forks near Mrs. R. Parsinger's,	1065′
By-road near T. Frantz's,	1105′
Little McMichael's creek, near A. Parsinger's,	1085′
Forks near J. Frailey's,	1100′
" " R. Marvin's,	1100′
Stream at school-house, next west,	1110′
Forks near P. Frailey's,	1145′
Stream next west,	1135′
By-road to J. Green's,	1175′
Forks next west,	1190′
" 9 rods west from last,	1160′
Stream just north,	1150′
Cross-roads near W. H. Reinhart's,	1160′
Forks just north from S. Reinhart's,	1040′

21. Pocono Township.

This township lies next east from Jackson, and north from Stroud. It is drained principally by Pocono creek which carries its rainfall to the Delaware by way of Brodhead creek. The West Branch of Brodhead flows southward near its eastern line, and drains a small area in that region eastward to the main branch of Brodhead.

Erosion has cut a large basin out of the Pocono range, thus giving its southern escarpment a great curve to the north. This has been accomplished principally by the waters of Pocono and Brodhead creeks.

The southern escarpment of Pocono mountain which extends through the townships west from this, in nearly a straight line along their northern borders suddenly ends at the western margin of this area in a lofty bluff rising 1000′ almost vertically above the level of Pocono creek. Turning here at right angles, the Pocono escarpment curves back northward parallel with Pocono creek which it almost overhangs, so precipitous are its slopes.

The rocks of this area belong entirely to the Catskill except at the south-west corner where the *Chemung* makes a

narrow belt of outcrop and the top of the *Hamilton* barely touches the extreme south-west corner, in the vicinity of Bartonsville.

Chemung sandstone is seen outcropping in the road just south from Addison Long's and dipping N. 25° W. 23°. In the field just west, the same bed makes a long cliff outcrop.

The following section was obtained in descending from the summit of the Pocono Knob.

Pocono Knob Section, (61.)

1. Conglomerate, reddish,	*Cherry Ridge,*	30′
2. Concealed,		20′
3. Conglomerate, reddish, (base 1800′ A. T.,)		25′
4. *Red sandy shales,*		250′
5. Pebbly sandstone, massive,	*Honesdale?*	15′
6. Sandstone, flaggy and massive, reddish,		60′
7. Concealed with appearance of reddish sandstone,		70′
8. Massive, grayish-white pebbly sandstone,		20′
9. *Red rock,*	*Montrose,*	30′
10. Sandstone, grayish-green,		10′
11. *Red shale,*		600′
12. Grayish-green sandstone,		20′
13. *Red shale,* visible,		150′
		1295′

The upper portion of this section was measured vertically in the steep escarpment of Pocono, but the lower portion was determined from the dip and measured horizontal distance the dip N. 25° W., being 7°–10°.

In examining this section, and carefully comparing it with the Wayne and Susquehanna Section of IX (see Report G⁵) it seems highly probable that the following identifications may be safely made, viz: that Nos. 1–4 represent the *Cherry ridge group* including the *conglomerate sandstone, limestone, shales, &c.*

That Nos. 5–8 represent the *Honesdale sandstone group.* Nos. 9–13 a part of the *Montrose red shale.*

But while there is a general harmony of this kind, it will be seen at a glance that a great change has taken place in the thickness of the different groups, the *Cherry ridge* be-

ing here 325′ or twice its thickness in Wayne county; the *Honesdale sandstone* 165′ or only a little larger than its thickness at Honesdale.

The Montrose red shale (810′ visible) has nearly quintupled its thickness at Montrose (170′).

The Cherry ridge conglomerate No. 1, and the stratum No. 3 which represents the *Cherry ridge sand and limestone* of Wayne county are almost duplicates of each other in every lithological character; both are very full of quartz pebbles, pieces of shale, sandstone, and *fish remains;* the color of the rock has a decided reddish cast, the quartz pebbles being both white and reddish tinted. The pebbles of No. 1 are quite large, some being more than 1½″ in diameter and on the whole they are more numerous than in No. 3, which is very pebbly at the bottom and top; central portion being merely a coarse sandstone.

The bottom portion of No. 3 contains many *fish fragments* and breaks into irregular cubical blocks around its outcrop just like the *Cherry ridge limestone* of Wayne county, though there is very little lime in any portion of the rock at this locality. At the most southern locality in Wayne, however, this rock was seen changing to a *conglomerate*, so that the absence of its *limy character* here is no evidence whatever against the identity in question.

A large area of No. 1 is bare; but no glacial scratches are seen on its surface; for the ice sheet did not cover this summit of Pocono, the deep valley to the east having received the glacial current.

Immense *blocks* from both these *Conglomerate beds* lie strewn over the sides and along the lower slopes of Pocono mountain, while the beds themselves stand out in great bold *cliff,s* visible from a great distance. These massive rocks have protected this high point from erosion, and also the Pocono escarpment from this point to the western line of the county.

The Cherry Ridge red shale, No. 4, weathers away very rapidly. Along the eastern face of Pocono its outcrop presents an almost vertical wall. At one locality its upper

portion is a reddish green sandstone, but on the other side of the point is seen changed to a red sandy shale.

The Honesdale sandstone group Nos. 5–8, has a very massive grayish white pebbly sandstone 15′ thick at top, containing many white quartz pebbles.

The central portion of this group Nos. 6 and 7, are reddish, shaly sandstones very much like the *red rock* separating the Upper and *Lower Honesdale sandstones* in Wayne county.

The basal member of the group, No. 8, is a massive, grayish-white sandstone, containing quartz pebbles. It is grayish brown on fresh fracture, but weathers whitish by bleaching of its contained iron.

The Montrose red shale, Nos. 9–13, makes a great red band around the base of the steeper portions of the mountain. It is not a homogeneous red shale, but has intercalated at several horizons thin beds of greenish gray sandstone some of which like No. 12 are 20′ thick; usually, however, they are not more than 5′–10′ thick.

The New Milford red shale is seen crossing Pocono creek and the road along the same, about two miles above Bartonville, just north from Mr. Jacob Learn's. There it makes quite a broad belt of *red* across the road, and seems to be quite sandy.

A similar stratum is seen crossing the road which goes east from Pocono creek, between P. Metzgar's and J. Clarke's, half way to the latter point.

Red shales crop out along the creek road about ½ mile above Tannersville, and they probably come at the *Montrose horizon.*

The Pocono valley is very wide in the vicinity of Tannersville and below, the surface being covered deeply with drift deposits.

South from Tannersville there are localities where the rocks appear to *dip to the south-east* indicating the presence of an axis, but closer examination reveals the fact that in every case they are mere *rolls*, in which the dip is reversed to the north-west within a few yards, or three to four rods at most.

Red rocks are quite often seen along the eastern portion of the township, alternating with greenish gray current-bedded sandstone, and dipping 7°–12° toward the north-west.

Barometric Elevations in Pocono.

(*Above Tide.*)

Forks of road in Bartonville,	785′
" next north from A. Albertson's,	835′
Run at crossing just north from last,	800′
Forks near John Aliger's,	900′
" Jacob Learn's,	850′
Pocono creek near D. Learn's,	810′
Forks of road 241 rods west,	880′
Cross-roads in Tannersville,	845′
Level of stream just west,	835′
Pocono creek at crossing next west,	835′
By-road to J. Edinger's,	885
Forks of road near E. Warner's,	900′
" " A. Dailey's,	985′
" " J. Angelmoyer's,	985′
" 163 rods east from last,	915′
Pocono creek above dam at Kistler's tannery,	920′
Cross-roads at Kistler's tannery,	925′
Forks of road next south,	890′
Pocono creek at road crossing near P. Warner's,	880′
Forks of road near J. Clark's,	985′
Run at road crossing just north,	925′
Pocono creek at crossing near A. Miller's,	970′
Forks of road at G. S. Knife's,	1000′
Pocono creek here,	990′
By-road to J. Barry's,	1165
Forks next east,	1200′
Forks near F. Shiffer's,	1225′
Butz's creek near Thos. Sebring's,	1115′
Forks near William Freeland's,	1125′
Cross-roads near Wilson Le Barr's,	1100′
By-road near D. Wolfinger's,	1105′
Forks near J. Smith's,	1135′
" H. Woodling's,	1085′
" D. Bowman's school-house,	1175′
Forks at Stanhope P. O.,	1150′
West Brodhead there,	1140′
Forks north from H. W. Miller's,	1235′

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22. Paradise township.

This township lies next east from Pocono, running to a long narrow point southward between it and Price.

The West Branch of Brodhead and its tributaries drain the area southward into the main branch of that stream just beyond the southern point of the township. All the streams rise on the southern slope of the Pocono range and they have thus eroded its escarpment northward so that from the high Knob at the western line of Pocono township this mountain range takes a wide sweep in an irregular curve northward clear beyond this township.

The rocks belong entirely in the Catskill series and extend from the horizon of the *Honesdale sandstone group* down to within about 1000′ of the *Chemung.*

No axes cross the measures in this township, though small *rolls*, where the dip changes for only a few feet, may frequently be seen. One of these being especially marked where the road crosses West Brodhead creek, ½ mile below Henryville. Just under the bridge at this locality the strata pitch sharply to the south-east, and at first I was led to believe that an axis of considerable size existed there, but further examination showed the dip reversed to the north-west about 3 rods below the bridge, and also just above the same so that the S. E. dip, under the bridge, is a mere roll like those so frequently seen in the cuts along the D. L. & W. R. R. through this area.

The Delaware flagstone group (New Milford) is well exposed along West Brodhead, in the southern point between Price and Pocono townships, and has there been extensively *quarried* for flagging by Messrs. Doyle, Norton and others. The rock is greenish-gray, and splits into very smooth flags of most any size.

Anticlinal roll.—At one of these quarries the dip is S. 25° E. 10°, but only a few rods south massive beds of rock

occur which dip north-west at the rate of 17°, and also just north from it they dip in the same direction 13°. These massive beds crop out along Brodhead creek in great *cliffs* and their débris is scattered all over the surface, in both small and large *bowlders*.

A short distance south from Henryville, a bed of *red shale* is seen in a cut dipping N. 25° W. 15°, and in it occur vast numbers of fronds of *Archæopteris Jacksoni*. The rapid dip brings down 65′ of the stratum before the surface deposits conceal its horizon which is in the lower portion of the *Montrose red shale*.

Near the western boundary of this area the D. L. & W. R. R. passes through a small tunnel cut through a sharp projecting point. At the north end of the tunnel the following section was seen:

Tunnel Section, (north end,) (62.)

1. Gray, flaggy sandstone,	25′
2. *Red shale*,	10′
3. Gray massive sandstone to track level,	40′
	75′

The beds dip 8°–10° N. 25° W., and at the south end of the tunnel the following is exposed:

Tunnel Section (south end,) (63.)

1. *Red shales*,	20′
2. Greenish-gray sandstone,	30′
3. *Red shale*,	25′
4. Gray sandstone to track level, (1575′ A. T.,)	20′
	95′

About ¼ mile further up the track, a bed of greenish-gray sandstone 25′ thick occurs in a cut above 20′ of red shale, all dipping N. 25° W. 12°.

A heavy bed of conglomerate is seen at extreme western line of the township just where the D. L. & W. R. R. passes into Coolbaugh. It is 40′ thick and succeeded above by gray flaggy sandstone and then an appearance of red shale, many blocks of *calcareous breccia* are scattered over the ground at this horizon (1675′ A. T.) and the stratum of conglomerate very probably belongs *in the Cherry Ridge group*.

Red rocks are seen along the creek just above Paradise Valley P. O. where they dip N. 25° W. 10°, and most probably belong to the *Montrose horizon.*

The same beds are seen along the road leading south from Paradise Valley, and they frequently form a smooth pavement for the road bed for long distances, being somewhat sandy.

A well dug on the land of W. B. Metzgar passed through 10′ of surface débris, and then through red shale for 25′. The red material at this locality contains considerable iron, though not enough to make it possible to use as ore. It comes in the *Montrose series*, which cover a wide belt with *red rock* between Henryville and Paradise Valley.

A bed of red shale occur near the summit of the hill where the road passes across from Timber Hill creek to West Brodhead. Greenish-gray, current-bedded sandstones are seen above and below it, all dipping N. 25° W. 12°.

Glacial striae occurs on the summit of a high ridge, one mile and a quarter south from Fork's Station, at an elevation of 1500′ A. T. going nearly due south. The rock which has preserved them is a *red shale*, and its surface is planed off quite smooth.

Barometric Elevations in Paradise.

(*Above Tide.*)

West Brodhead, at mouth of little run, ¼ mile north from the southern point of the township,	600′
West Brodhead, at crossing opposite D. Clahan's,	650′
" " " near J. Henry's,	675′
" " " " C. Henry's,	715′
Forks of road at school-house next west,	885′
Summit between this and Paradise creek,	940′
Junction of Paradise creek with West Brodhead,	800′
Forks of road near Mrs. H. Bush's,	810′
" " " J. Hardenstine's,	900′
Cross-roads near Mr. Grover's,	960′
Level of Timber Hill creek, just south,	950′
Forks near G. Heller's,	1050′
" " A. Storms',	1010′
" south-east from J. Storms',	910′
West Brodhead creek, at crossing next south,	900′
Cross-roads in Paradise Valley P. O.,	965′
Paradise creek, just south,	955′

By-road near C. W. Row's, ... 970′
Paradise creek, at crossing near Mrs. J. E. Boavern's, ... 1000′
" " " above H. Ornt's, ... 1065′
Forks of road south from F. Keller's, ... 1075′
Paradise creek, at crossing just west of last, ... 1075′
Forks next west, ... 1100′
Cross-roads near G. Knoll's, ... 1150′
Timber Hill creek, at road crossing at western line of the township, . . 1450′

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23. Price Township.

This township is along, narrow irregular area, immediately south-east from Paradise, while it rests on Middle Smithfield at the east except along the north, where the eastern portion adjoins Pike county.

The rain fall is carried off almost entirely by Brodhead creek which flows south along the western margin of the township, receiving several small tributaries from the east.

Big Bushkill flows across its extreme north-eastern point and drains a small area in that region.

The surface is quite wild and rough, being covered in many places deeply by *Drift*.

The rocks belong entirely to the *Catskill series*, since the highest beds of the *Chemung* go under drainage level about one half mile south from its extreme southern portion.

The lowest bed of rock exposed in the township is the *New Milford red shale* which is seen making a red band across the road near W. C. Kramer's at the south-eastern corner, near the Stroud township line, where the dip is N. 25° W. 20°, elevation 875′ A. T.

Along Brodhead creek the *Catskill sandstones* make frequent cliff outcrops. One of these sandstone beds is seen crossing the road near Mr. G. Haase's where it forms a high jutting point along the hillside; the road passes through it between two joints 8′ apart and running north-west and south-east, the dip being N. 27° W. 15°.

flagstone quarry has been operated to some extent

just above this on the land of Mr. Haase, where very nice smooth flags are obtained, several feet square and two to four inches thick. The rock is grayish-green and somewhat micaceous.

Where the road crosses Clear run near its mouth, the rocks dip N. 26° W. 11°, and the surface is planed and grooved by Glacial action, the *striae* pointing S. 35° W.

Jack's Falls on Brodhead occur about three fourths of a mile below the mouth of Stony run. It is a succession of cascades 3′–4′ high through hard gray *Catskill sandstone* over which the stream descends 30′ in about 300 yards, the top of the Falls having an elevation of 715′ A. T.

Much *flagstone* has been quarried from the greenish-gray beds of the Catskill between Jack's Falls and the mouth of Stony run, the largest of these quarries being just below the mouth of the latter stream.

Targa Falls is a short distance above the mouth of Stony run, and there Brodhead descends 10′ vertically in two cascades, the top of the first being 755′ A. T. The rock over which the stream falls is a very hard, greenish-gray sandstone.

A high cliff of *Catskill sandstone* is seen, a short distance east from the cross-roads at J. Price's, and it has been quarried for flagstone at an elevation of 950′ A. T.

Glacial striae occur in a ledge of grayish-gray sandstone which crosses the Brodhead creek road near the northern line of the township; the *striae* go S. 30° W. while the bed rock dips N. 28° W. 10°.

The region between Brodhead and Big Bushkill is a very wild, rocky plateau, 1100′–1200′ A. T., and covered with *Drift*, there being not more than a dozen cleared farms in all the township east from the immediate valley of Brodhead creek.

Barometric Elevations in Price.

These may be relied on almost to the foot, since I had the transit levels of the N. Y. S. & W. R. R. to check from at many points.

(*Above Tide.*)

Brodhead creek near G. Haase's,	615′
Long run, at road crossing near its mouth,	605′

Clear run, at road crossing near H. Lesoine's,	650′
Pine Mt. run " " " school No. 1,	670′
Forks of road there,	685′
Laurel run, at road crossing near its mouth,	680
Top of Jack's Falls,	715′
Level of Stony run, at road crossing near its mouth,	755′
Brodhead creek, at mouth of Stony run,	745′
Top of Targo Falls,	755′
Brodhead creek, opposite Wm. Bates',	775′
" " at road crossing near J. Price's,	820′
Cross-roads just east,	835′
Forks of road at Louis Lesoine's,	1075′
" " next south from last,	1000′
Long run, at road crossing east from C. Pennell's,	1000′
Forks just south from last,	1115′
By-road, ⅛ mile north from last,	1125′
Brodhead creek, at southern line of township,	565′
Stony run, ½ mile below, where it enters Price township,	1061′

24. Barrett township.

This township lies north from Price and Paradise, and is bordered on the east and north by Pike county, thus occupying the north-east corner of Monroe.

It is drained principally by Brodhead creek which takes its rise on the southern slope of the Pocono mountain escarpment in several small streams that unite along the center of the township to form the main southward flowing stream.

A small area at the eastern margin drains into Bushkill creek.

The rocks belong entirely to the *Catskill* extending to near the summit of that series on the crest of Pocono mountain. This range enters the township from Pike county near the middle of its northern line and passing westward curves gradually southward along the western line, its elevation varying from 1900′–2000′ A. T.

Considerable quantities of *flagstone* are quarried from the *Catskill beds* along Brodhead creek between Spruce Cabin run and the southern line of the township, these beds being owned and operated by Fred'k Deubler, who ships the flags

to market over the D. L. & W. R. R. from Oakland Station, two and one half miles distant.

Much red shale is seen near the mouth of Mill creek, and it most probably belongs in the *Montrose* horizon.

A flagstone quarry is operated quite extensively on the land of Mr. J. H. Price, about ¾ mile east from Oakland Station. The rock is grayish-green, and dips N. 25° W. 13°; elevation 1150′ A. T. From it excellent flagging are obtained and shipped to Scranton and northward for pavement and other purposes.

In the vicinity of Mountain Home, there is a wide level area stretching across toward Brodhead creek at an elevation of 1150′–1200′ A. T. It is covered deeply by drift deposits, and its origin is doubtless connected with that of the latter.

In descending the road eastward to Brodhead creek above Canadensis much red shale is seen between 1185′ and 1000′ A. T., and just below the bridge across Brodhead, opposite A. J. Decker's, a massive sandstone occurs along the bed of the stream.

At the very northern line of the township along the road that leads northward from Canadensis up Brodhead creek into Pike county the following section was made, Fig. 64:

Monroe-Pike Line Section.

1. White, pebbly sandstone, (top 1900′ A. T.,)		20′
2. Gray, pebbly sandstone,		70′
3. Red shale and concealed,	*Cherry ridge red shale,*	50′
4. Gray pebbly sandstone,		30′
5. Red shale, visible,		150′
		320′

At first glance No. 1 looks much like the *conglomerate of No. XII*, but a stroke of the hammer reveals a decided difference in lithological composition, since the interior of the rock is a brownish-gray, its whiteness, the result of bleaching or atmospheric change the rock itself being also much softer than we usually find the rocks of XII. There can be little doubt that this, with the great pebble rocks below, represent the *Cherry Ridge conglomerate* of Wayne coun-

ty, while Nos. 3–5 would then represent the *Cherry Ridge red shale.*

Nos. 1 and 2 make great *cliffs* around the summit of Pocono mountain for many miles along its southern face, and their hard unyielding nature has doubtless been the source of its preservation from erosion.

Along the road which passes up the Buck Hill Branch of Brodhead, a high *cliff* of conglomerate occurs about one half mile above Jno. Ace's, its base coming at 1700′ A. T. It contains large quartz pebbles some of them being 2″ in diameter. The rock makes a great *cliff* around the south side of the stream and is 40′–50′ thick. Below the horizon of the conglomerate much red shale is seen.

About one mile north from this point, along the road which passes into Coolbaugh township, we come to the outcrop of a great *cliff* of gray pebbly sandstone at 1970′ A. T. below which much red shale occurs for 150′. This pebbly bed is doubtless one of the *Cherry ridge conglomerate* and the *red shale* below would be the *Cherry ridge red shale.*

Leves Branch of Brodhead rises near the north-western corner of the township and flowing north of east passes into Pike county, just north from the southern crest of the Pocono escarpment. It keeps eastward a short distance north from the township until near the central line of the same when veering suddenly southward, it cuts through the *Pocono escarpment* and descends rapidly towards Brodhead, making two large *falls.*

The Upper Leves Falls near the county line has an elevation at top (according to the levels of the N. Y. S. & W. R. R. kindly furnished me by Mr. Schermerhorn C. E.) of 1681′ A. T.; at base 1579′ A. T. or a total descent of 102′ in 150 yards, making several cascades.

The Lower Leves Falls is about two miles below the upper one, the top of which has an elevation of 1435′ A. T.; base 1317′ or a total fall of 118′ of which 90′ is almost vertical, the rest of it being in two or three cascades.

The descent is over massive *Catskill sandstone* at both localities.

Much *Drift* is scattered over this township, covering the highest summits 2050′ A. T. as well as the lowest valley and containing immense *bowlders* from the *Catskill sandstones* and occasionally a large black mass of the *Cherry ridge limestone.*

The engineers of the N. T. S. & W. R. R., Messrs. Coons and Shermerhorn, gave me many elevations obtained in running trial lines through this township. These are marked thus (*) in the following:

Barometric Elevations in Barrett.

(*Above Tide.*)

Forks of road on Brodhead creek, near southern line of the township,	850′
Lucky run at crossing next above,	825′
" ½ mile above its mouth,	877′ *
Little run at road crossing next above S. H. Peter's,	855′
Same run next above Z. Zabrishic's,	916′ *
Forks opposite the mouth of Mill creek,	875′
Brodhead creek just here,	865′
Forks one mile west,	1080′
By-road next south,	1080′
Level of Mill creek near Mt. Home,	1150′
Forks near L. Andrews',	1225′
Forks 105 rods north,	1230′
Brodhead creek near A. J. Decker's, above Canadensis,	990′
Forks at A. J. Decker's,	997′
Forks at Canadensis P. O.,	995′
Forks near John Deubler's, (at Moravian Church.,)	1015′
Level of Brodhead here,	1005′
Forks near Simon N. Stright's,	1130′
Brodhead creek near school No. 3,	1175′
Forks near E. Price's,	1185,
" G. W. Ink's,	1250′
Brodhead creek here,	1230′
Crossing of stream next north,	1310′
Summit of Pocono at northern line of Barrett township,	1900′
Leves branch just north in the edge of Pike county,	1800′
Buck Hill creek near George Price's,	1250′
" at crossing near John Ace's,	1575′
Road at F. Bush's,	1900′
Sharp turn westward one half mile north,	2000′
Summit of mountain (Pocono) above,	2075′
Goose pond,	1477′ *
Leves branch creek at road crossing near C. J. Price's,	1517′ *
Stony run opposite Joseph Brown's,	1313′ *
" at Elizabeth Feltham's pond,	1291′ *
" opposite school-house No. 5,	1211′ *
Spruce Cabin run ½ mile above its mouth,	963′ *

25. Coolbaugh Township.

This township lies next west from Barrett, being bordered on the north by Pike and Wayne counties, while the Lehigh river at the west separates it from Lackawanna (formerly a part of Luzerne). It is situated on the Pocono plateau and forms the culminating point of Monroe county, hence the rainfall is carried off in quite different directions. From the extreme north-eastern portion, the drainage is northward into Wallenpaupack creek whose waters reach the Delaware through the Lackawaxen river. The extreme eastern portion drains eastward into Brodhead creek, while all the rest of the township sends its waters westward to the Lehigh river, principally through Tobyhanna creek, a stream which flows southward through the central portion of this area, and passing into Tobyhanna township reaches the Lehigh river at the northern line of Carbon county.

Although all of this township is such an elevated region, much of it is very swampy and there are large tracts covered with bogs and marshes.

Extensive drift heaps are scattered everywhere over the surface, and bowlders of enormous size are seen commingled with fine materials, *sand, small bowlders, clay, &c.*

Sand Cut, a station on D. L. & W. R. R. just north from this township in the southern edge of Wayne county was so named from the character of the *Drift* in a cutting along the R. R. at that locality. The entire area has been glaciated, and the movement seems to have been nearly due south, for on the summit, a short distance south from Dowling's Hotel the *striae* go S. 5° W. at an elevation of 2150′ A. T., this being the most elevated point at which glacial scratches have been observed in this District.

The rocks of the township belong to the upper portion of the *Catskill*; the very highest ones belong to the basal member of the *Pocono series*, No. X. These beds being all

very massive, the surface is so covered with their débris that even when not swampy its cultivation is impossible, hence all the central and western portions are in a wilderness condition.

The rocks dip north-westward still, but at a much diminished rate, (only 2°–5°.)

The Mt. Pleasant conglomerate is seen making a great whitish, pebbly cliff around the summit of the Pocono plateau, about two miles and a half north from Tobyhanna. The base of the stratum comes at 2000′ A. T., and it extends up to 2050′; pebbly throughout, some of the quartz fragments having a reddish tinge. The surface is covered with large *bowlders* all around the outcrop of the conglomerate, which dips north-westward 2°–3°.

About one mile north from Tobyhanna a cut on the D. L. & W. R. R. exhibits 35′ of greenish-gray sandstone, dipping north-west 8°–10°, at an elevation of 1960′ A. T.

Along the Lehigh river, in this township, *cliffs* of grayish-white conglomerate are often seen, whose place in the series is rather uncertain, but they cannot be far from the *Mt. Pleasant conglomerate horizon.* Just beyond Cliffton, in Lackawanna county, on the north bank of the Lehigh, at the western line of the township, there are seen immense white *cliffs* capping a knob 200′–300′ above the river; they very probably belong in the *Mt. Pleasant* horizon, if the cliff seen along the valley of the Lehigh belong to the *Cherry Ridge group.*

The Mt. Pleasant conglomerate is seen along the Easton and Belmont turnpike, at an elevation of 2100′ A. T., about half way between C. S. Baylie's and the first branch of Tobyhanna creek. It is grayish-white and full of quartz pebbles.

Just east from the forks of the road, at D. McCartney's, the highest point measured in the township rises to an elevation of 2160′ A. T.

At Dowling's hotel, one half mile south from D. McCarty's, a well dug to a depth of 35′ passed through Drift for 25′, and then into a very hard red sandy shale for 10′. The

red shale contains considerable iron—enough to make it quite heavy, probably 15–20 per cent.

About 200 rods south from Dowling's hotel, the turnpike crosses the crest of Pocono at an elevation of 2150′ A. T., and the bed of *red shale* comes to the surface, which was struck in the well. It dips N. 25° W. 6°, and its upper surface is planed off smooth by Glacial action, the broad striated furrows on which point S. 4°–5° W.

Barometric Elevations in Coolbaugh.

(*Above Tide.*)

Lehigh river, near Cliffton,	*1586′
Lehigh river, at crossing of Plank road next above Cliffton,	1590′
" " " next above,	1660′
" " " " "	1680′
Intersection of Drinker turnpike and Plank road,	1830′
Easton and Belmont turnpike, at C. S. Baylie's,	2050′
" " " " at forks near D. McCarty's,	2120′
" " " " at Dowling's hotel,	2100′
Forks at cemetery, 226 rods south of last,	2100′
" near G. Vliet's,	2000′
" " D. Vliets',	1960′
Road at W. Ney's,	1900′
Forks at Mt. Pleasant hotel,,	1825′

26. Tobyhanna township.

This large area lies directly south from Coolbaugh, being separated from Lackawanna county by the Lehigh river, and from Carbon county by Tobyhanna creek.

The township is drained into the Lehigh river, chiefly by Tobyhanna creek and its principal tributary, the Tunkhanna.

The surface is very elevated (1500′–1900′ A. T.) but does not compare with Coolbaugh in this respect. It is covered with *drift deposits* to such a great depth that the underlying rocks are very seldom exposed, so that one may travel for hours along some of the roads over nothing but vast

* Preliminary Survey for N. Y. S. & W. R. R.—(Coons.)

heaps of sand and bowlders, through apparently interminable forests, the only settlements of any importance being along the Wilkes-Barre and Easton pike at the south-western border.

The rocks belong to the upper portion of the *Catskill series*, though at the extreme western line the *Pocono beds* cannot be far away, and possibly the basal members of that series may constitute the underlying rock in the vicinity of the Lehigh river.

Hungry Hill lies just south from Tunkhanna creek, in the eastern portion of the township, and is a low ridge of drift running nearly north and south and only 20′–30′ above the general level of the other drift-covered areas. It has the general appearance of what has been described as a *kame*; but I regard it as due to erosion. Coarse sand, rounded bowlders and other drift débris are seen where the road cuts across it.

A short distance east from Hungry Hill Mr. Houser dug a well which passed through 20′ of drift, and then entered *red shale*; elevation of mouth of well 1850′ A. T. It possibly represents the *Mt. Pleasant red beds.*

A short distance west of Hungry Hill Mr. Bouser found the following succession, in a well which he dug:

Bouser Well Section. (*65.*)

1. Sand, coarse,	6′
2. Clay,	2′
3. Reddish clay, mixed with bowlders,	29′
4. Bluish-gray sandstone,	2′
	39′

The elevation of surface at the well is 1845′, and the *Drift* is seen to be 37′ thick.

Along the south side of the creek, at Tompkinsville, a great bed of rounded *bowlders* occurs at 1730′ A. T.

From this point on out the old Sullivan road to Jno. Stiger's and thence south to the Wilkes-Barre pike not a single rock is to be seen *in situ* though the distance is nearly 10 miles, everything being buried by *Drift.*

Where the Wilkes-Barre pike crosses Tobyhanna creek, near Soxville some greenish-gray beds of the Catskill are

uncovered in the banks of that stream; they dip gently to the north-west.

Barometric Elevations in Tobyhanna.

(*Above Tide.*)

Cross roads at Pocono P. O.,	1840′
" 510 rods south-west of last,	1890′
By-road next west,	1880′
Summit of Hungry hill,	1875′
Forks of road near J. Hay's,	1785′
Tunkhanna creek at road crossing near Tompkinsville,	1715′
Forks of road near L. Stoufer's,	1705′
" at Houser's Hotel and P. O.,	1750′
Tobyhanna creek at road crossing near J. Christman's,	1650′
Branch run at road crossing near A. Peters',	1680′
Deep run " " John Stiger's,	1735′
Forks of road next west,	1750′
Dorey's run near A. Eschenback's,	1680′
Summit of Beach ridge,	1735′
Red run at road crossing near C. Snyder's,	1675′
Wilkes-Barre pike near P. Sox's school-house,	1690′
" " at Tobyhanna Hotel,	1670′
Tobyhanna creek at pike, (Wilkes-Barre,)	1580′
Level of stream at pike near W. Adams',	1640′
Old Sullivan road at crossing of south branch of Trout creek,	1675′ *
Tobyhanna creek 1000′ below its junction with Tunkhanna,	1626′ *

27. Tunkhannock township.

This lies along the Carbon county line directly south from Tobyhanna, extending southward to the southern escarpment of Pocono Mountain.

Tunkhannock creek rises in the north-east corner, and flowing south-westward through its center drains nearly all of the township westward by way of Tobyhanna creek into the Lehigh river. This creek (Tunkhannock) is a very sluggish stream, and near the center of the township it spreads out into a sheet of water known as Long Lake, only

*From preliminary survey of the N. Y. S. & W. R. by J. J. Coons, C. E.

a few rods wide, and 5′–10′ deep, but about three miles in length, and bordered by Cranberry marshes.

Drift spreads everywhere over this region and as found in the wells is seldom less than 20′ thick, and often 40′.

Between Long Lake and Tunkhannock Hotel, the surface is covered with sand and not a single rock is to be seen in place.

The rocks of the township belong in the top of the Catskill series, the lowest ones being the *Cherry Ridge group* which crops out along the southern face of Pocono mountain in long lines of *cliffs*, from which great heaps of débris have descended covering much of the Pocono slope with massive fragments.

The elevation of Pocono at the southern line varies between 1900′–2000′ A. T.

Pimple Hill and Pohopoco mountain are elevated regions in the south-western corner of the township which rise 1900′–2000′ A. T., and are capped by massive Catskill conglomerate.

Barometric elevations in Tunkhannock.

(*Above Tide.*)

Wilkes-Barre and Easton pike at little stream near J. Stetzer's,	1720′
Forks near A. Wrick's School-House,	1840′
Tunkhannock creek near E. Eckhart's,	1770′
Road at Tunkhannock Hotel,	1840′
Tunkhannock creek at outlet of Long Lake,	1835′
Forks just east,	1860′
By-road at J. E. Altimus',	1875′
Forks near G. L. Altimus',	1890
Fork near Cold Spring Hotel,	1846 *
Upper (southern) end of Long Lake,	1835′*
Tunkhannock creek at crossing just south from Geo. Merwine's,	1841′*
Summit of Pocono Mt. one mile south of last,	1901′*
By-road near southern line of township south of last,	1835′

*From preliminary survey of N. Y. S. & W. R. R. (J. J. Coons.)

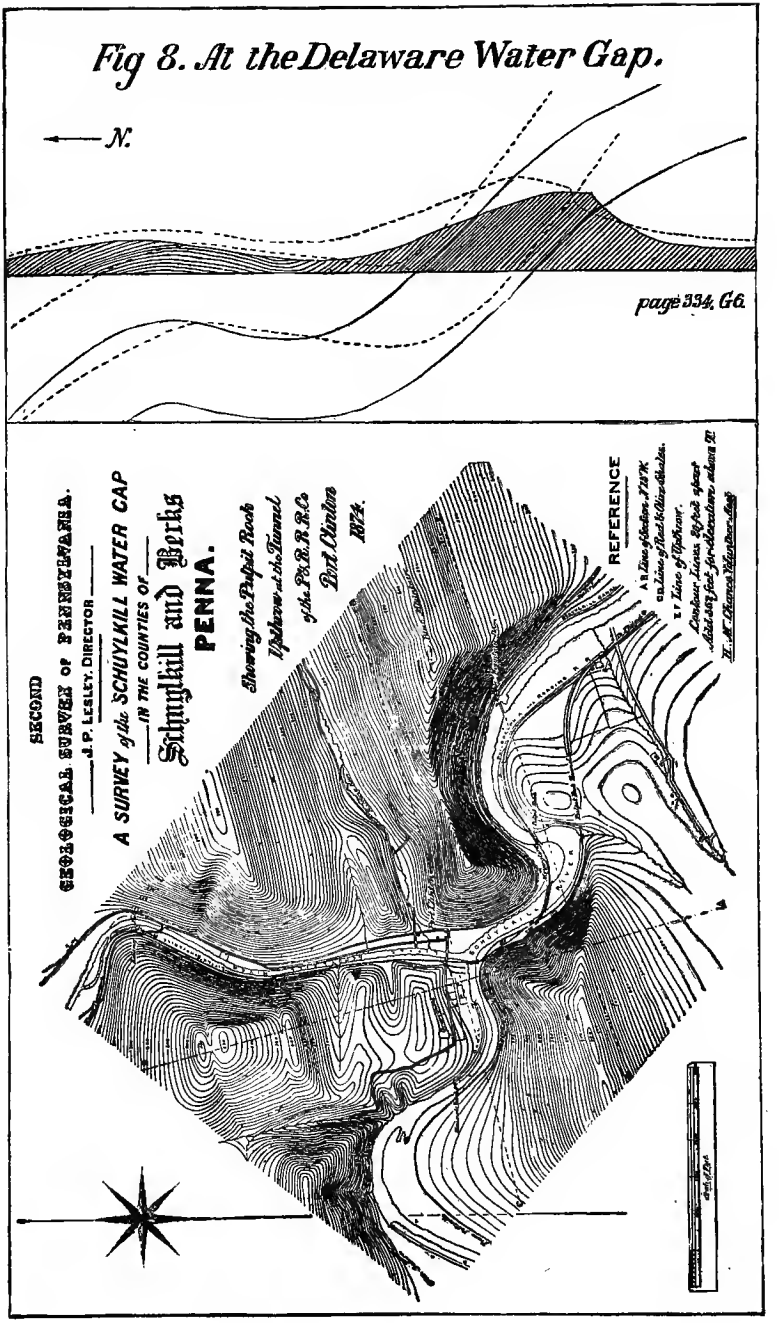
Fig 8. At the Delaware Water Gap.
N.
page 334, G6.
SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.
J. P. LESLEY, DIRECTOR
A SURVEY of the SCHUYLKILL WATER GAP
IN THE COUNTIES OF
Schuylkill and Berks
PENNA.
Showing the Pulpit Rock
Upheaval of the Tunnel
of the P. & R. R. R. Co
Port Clinton
1874.
REFERENCE

SPECIAL SURVEY

OF THE

DELAWARE WATER GAP,

IN 1874-5.

By H. Martyn Chance.

I. Topography and Structure.

The map accompanying this report shows the topography of about twelve square miles of country immediately surrounding the Delaware Water Gap, delineated by water-level contour-lines drawn twenty feet vertically apart. It is published on a scale of 1,600 feet to one inch or about 4¼ inches to one mile.

The arrows indicate the direction of dip; the figures, its strength.

From the Walpeck bend to the gap the Delaware river flows in a S. W. course along the northern foot of the second ridge of the mountain, but at the latter point it makes a sharp bend to the left, cuts through the mountain, and flows southeast towards Easton.

Above the gap the river flows in a valley of Clinton red shale (No. V,) bounded on the northwest by the hills of Lower Helderberg limestones and Oriskany sandstone (Nos. VI and VII,) and on the southeast by the Blue mountain. This valley is a prolongation to the northeast of Cherry valley.

In the upper part of the gap the river is very broad and shallow, and full of sand bars, in some places reaching a width of two thousand feet; but in the lower portion of the cut, where the river has eroded its way through the hard massive conglomerates of No. IV, the channel is very deep

and narrow, in some places barely reaching a width of 350 feet, and it is said to be from thirty to fifty feet deep.

Below the gap the river flows through the rolling slate and limestone (No. III and II) country of the Kittatinny valley.

The course of the crest line of the mountain at the gap is about S. 65° W.

Cherry Valley Anticlinal.

An anticlinal flexure exists in the north side of the mountain east of the gap, forming the bold second ridge seen north of the main crest.

Its axis sinks approaching the gap, and it can be detected on the west side of the gap only as far as the old bed of Caldeno creek. I was unable to discover any south dips west of this creek.

The Water Gap House stands almost directly upon the axis of this flexure, and the fact that it is rapidly dying out to the west is evident from the direction of the dip in that vicinity.

At Lenape Lake it can be observed without the aid of an instrumental examination. Here all the rocks are seen dipping towards the center of the lake, except those on its northern border, which dip parallel to that side.

Fig 8, p. 334,* drawn to show the difference in the curvatures on the east and west sides of the gap, develops the fact that this axis carries the formations much higher above water level upon the east than upon the west side, thus showing that its crest line is rapidly sinking to the west.

The diagram enables us to calculate approximately the strength of this inclination, which may be considered to be about 12°. It also shows that the formations are thrown further northwest on the Pennsylvania side than on the New Jersey side, showing that this axis runs more nearly east and west than the axial line of the main mountain.

* In this diagram the dotted lines represent the curves and profile of the New Jersey side, the full lines, the same data on the Pennsylvania side of the river. The line showing the structural curves include the formations from the top of the slates of No. III to the top of Sandrock No. 3.

Between this sub-axis and the mountain, the rocks are flattened, crushed, and faulted. The bold spur known as Blockhead mountain, furnishes a fine exposure of this faulting in the cliffs overlooking the river.

West of Caldeno creek this flattening of the rocks probably merges into a gentle anticlinal axis taking the place of the dying flexure. This conclusion is strengthened by an examination of the hill separating Poplar and Cherry valleys, but as there are no exposures showing any south dip, it is possible that a monoclinal dip prevails over this area, and that the hill is formed by some of the harder bands of the red formation (No. V.) For a long distance to the west this hill presents no marked change in its topographical features, and we can consequently assume a correspondingly regular structure.

Fault at the Gap.

By reference to the map it will be seen that the crest of the mountain on the New Jersey side of the river is not in line with the crest on the Pennsylvania side, but lies about 700 feet further north.

It will also be observed that the New Jersey mountain is about 100 feet higher than the Pennsylvania mountain, the highest point found upon the Pennsylvania side being 1187 feet above river level, while the highest point reached upon the New Jersey side was 1291 feet above the same datum level, viz: the water in the river.

This back throw of the mountain is occasioned by the difference of the dip upon the two sides of the river, which will be seen more clearly by reference to the diagram on page 334 in which the full lines represent the data upon the Pennsylvania side of the river; the dotted lines, the same upon the New Jersey side.

The lower line represents the base of Sandrock No. 1, the upper line the top of Sandrock No. 3. At river level we find that the outcrop of Sandrock No. 1 upon the Pennsylvania side is almost exactly in the line of strike with the outcrop upon the New Jersey side of the river.

From a series of careful observations taken at river level

on opposite sides of the gap, I have found a local variation in the strike of 5° 50′.

Upon the New Jersey side, the strike is N. 64° 20′ E. Upon the Pennsylvania side N. 70° 10′ E.

These facts seem to point rather to a *warping of the formations* than to a fault, as the origin of the difference of dip.

This conclusion is strengthened by the data furnished by the Cherry Hill anticlinal. From an examination and careful comparison of the exposures north of the main ridge, I am inclined to think that the back-throw produced by the warping has been nearly all absorbed by the small faults in the rocks of Blockhead mountain, and that the break through the anticlinal is *very slight.* If we trace a line northward from the *center* of the main gap, and perpendicular to the average direction of the mountain crest, we find along its course: 1st. a mark in the topography of the southern side of Blockhead mountain. 2d. a small ravine on its northern side; and 3d. the gap in Fox Hill. It will be observed that the marks of the break are very slight in Blockhead, and are much greater (as we naturally should expect) in Fox Hill. If the break had been as large in the anticlinal as in Fox Hill the river would probably have cut its channel in the axis of the break. For these reasons the conclusion has been reached that the break through the anticlinal is small, and the axis has therefore been drawn upon the map as an unbroken line.

Godfrey's Ridge.

This ridge is known by many different names, thus: "Trausue's Knob" is its eastern prolongation, and Fox Hill, Cherry Hill, Chestnut Ridge, and Stony Ridge are western portions of the same ridge. Only a very small part of it was surveyed at the Delaware, (see map of Delaware gap,) in fact no more than was necessary to get the contours of the gap and make a geological cross-section. Much of the topography is sketched in and the work is altogether much less accurate than the remainder of the map, which was surveyed, plotted, and contoured with great care.

It will be seen at a glance that there is a break in the crest line. The hill on the east side of the creek is thrown northward about seven or eight hundred feet. This is a prolongation of the same break or warping that affects the Kittatinny mountain in a similar manner.

The average strike of the rocks on the *western* side of the gap of Brodhead's creek is N. 47½° E., upon the *eastern* side it is N. 72½° E.

Upon the *western* side of the Brodhead creek gap, the hill contains a gentle synclinal and anticlinal roll, (see section,) while upon the eastern side the flexures are sharp; the *northern* dip of the synclinal being 90° or vertical, and the other sides correspondingly steep. As we go westward this synclinal makes into the center of the hill, producing two outcrops of the *Oriskany sandstone*, and consequently a double crested ridge, with arable land between the crests. The exposures are not good enough to enable us to accurately detail the structure upon the eastern side of the gap.

The character of the curvatures and irregularities of the structure in this locality can be seen in the limestone quarries. In the quarry nearest the Delaware water gap the limestone dips 30° and 60° N. 48° W. In this quarry about 30 feet of limestone is seen overlaid by 20 feet of lime shale. At the other quarry the limestone dips 20°–50° S. 45°–50° E. In this quarry there is about 60 feet of limestone overlaid by 20 feet of limestone and 15 feet of pea conglomerate. (See section of Godfrey's ridge, Plate 1.)

Upon the eastern side of the gap, the lime shale *below* the limestone is seen dipping 45°–60° N. 17½° W. (the limestone is not exposed) and the conglomerate above the limestone 90°, or vertically. This conglomerate here outcrops from 10 to 25 feet above the surface, forming a *perfectly straight vertical wall* 51 feet thick.

One set of cleavage joints is horizontal and another set nearly vertical, dividing the sandrock into rectangular blocks, and giving the wall an artificial aspect. It runs about ¼ of a mile, and has a course N. 72° 30° E.

This outcrop is almost entirely hidden by timber, but can

be recognized from a distance by a row of hemlocks which grow upon either side of it, and can be found by going about three hundred feet up a path which starts from the N. E. corner of the bridge across Brodhead's creek, and then turning into the woods to the right. The sight will well repay anyone the trouble.

II. Detailed description of the formations.

The formations seen in the Fox Hill gap and the Delaware water gap from the north southward, and from the top downward are as follows:

Base of No. VIII.	Corniferous limestone, (exposed at gap,)		20′–40′
No. VII, 195′	Oriskany sandstone, ...		±30′
	Oriskany shales, 150′ Conglomerate, . 15′	Oriskanyshales,	165′
No. VI, 825′+	Lime shale, Limestone, Lime shale,	Lower Helderberg,	15′–25′ 60′ ?
	No exposures. Red shale? Onondago? Water lime?		740′
No. V, 1685′+	Red shale, (Clinton upper,)		155′
	Sandstone C. (greenish gray,)	Ore S. S. and Clinton variagated shales, 450′	80′
	Variagated shales, .		90′
	Sandstone B. (greenish gray,)		70′
	Variagated shales, . .		130′
	Sandstone A, ...		80′
	Red shale and sandstone, (Clinton lower,)		740′
	Olive and light gray shales and S. S., (Clinton,)		340′
No. IV, 1565′	Sandrock No. 3. Medina upper sandstone, ...		200′
	Medina upper olive shales, . .		530′
	Sandrock No. 2. Medina white conglomerate, ...		200′
	Medina lower shales and sandstones,		110′
	Sandrock No. 1 *a*. Oneida gray S. S.,		75′
	Oneida shales and sandstones, ...		240′
	Sandrock No. 1. Oneida conglomerate,		210′
No. III, 3900′+	Hudson river slate, (measured,) . . .		2600′
	Hudson river and Utica (?) slates, . .		+1300′

Oriskany Sandstone.

This is not well seen at any one place, but from the exposures along the northern slope of the hill, and in the cliffs between the gap and Stroudsburg, it seems to be a mass of pebbly sandstones, chert, and calcareous cherty sandstones.

The lower portion is almost entirely composed of nodular chert, the middle portion of a tolerably pure, pebbly sandstone, and the upper portion largely of chert. Upon the edge of the above-mentioned cliffs there is situated a quarry, from which very good flags are obtained. The sandstone at this point exhibits impressions of the *Orthis Hipparionyx*. The thickness cannot be accurately determined, but is most probably over 30 feet.

Over this lies the Caudi-Galli grit and Corniferous Limestone.

Oriskany Shale.

This member consists almost entirely of lime shale, with an occasional cherty or sandy layer. Upon the eastern side of the gap it is very much crushed, but upon the western side it presents good exposures. Its outcrop can be seen nearly all the way from the limestone quarries to the crest of the ridge. It can also be seen in the cliffs about two miles west of the gap. Thickness, 150′.

Oriskany Shales Conglomerate.

This is a rather hard, calcareous, nut conglomerate of white quartz pebbles. Both underneath it and above it there is a layer, a few inches thick, of nodular chert. It is this sandrock that forms the wall upon the eastern side of the gap.

It probably corresponds to the 10-foot sandrock of the Oriskany shales at the Lehigh. Thickness, 15′.

Lime shale, (Lower Helderberg.)

Some portions are lime shale, but others are so calcareous as to warrant the calling it a shaly limestone, but

the *lime shale predominates.* It seems (either from erosion or crushing) to vary in thickness, ranging from 15′ to 25′.

It lies immediately upon the limestone, and underlies the conglomerate sandrock. At the exposure in the quarries, it has a thickness of 20′.

Lower Helderberg Limestone.

This lime is of a dark blue color and contains much calcite. In these seams of calcite there sometimes occurs the pink variety of fluor-spar. Minute pyrite cubes are sometimes seen scattered through the limestone.

This lime is now burnt almost exclusively for agricultural purposes, though it is occasionally used as a building lime. It was formerly used as a flux by the Scranton Coal and Iron Company.

Underneath this limestone is seen a considerable thickness of lime shale, which most probably belongs to the Lower Helderberg group of shaly limestones. This limestone, as seen in the most northern of the two quarries, has a thickness of 60 feet.

This concludes the description of the formations seen in the gap. From the limestone quarries southward to Cherry creek, a distance of 2,000 feet, there are no exposures, the valley being filled with alluvium and glacial drift.

It is probable, however, that this space is underlaid by the water-lime shale, Onondaga shale, and Clinton red shale, as these formations are seen to the northeast, in New York, and to the southwest, at the Lehigh gap, (see below.) If the structure of this valley is regular, the hidden thickness of these formations is between 700 and 800 feet.

Red Shale, (Clinton Upper.)

This is the true soft red shale of the Clinton group. In its lower beds are a few thin layers of olive shale. It can be seen along Cherry creek, near the railroad bridge. Its exposed thickness is 155′.

Sandstone C.

This is a hard, compact, greenish-gray, coarse-grained sandstone, with intercalated greenish shales, and steel-colored, fine-grained sandstones.

Some of the beds of sandstone are very massive, reaching eight or ten feet in thickness.

This rock is seen in the third railroad cutting above the depot. Thickness, 80′.

[NOTE.—The sandstones C, B, A (in part or in whole) probably correspond to the ore sandstone of the sections at the Lehigh and Schuylkill. With their included shale, they form the ground upon which the village of Dutotsville (water gap) is built, Table Rock, the hills upon the southern side of Cherry valley, and the southern bank of the Delaware river, for several miles east of the gap. Thickness of group, 450′.]

Clinton Variegated Shales, b.

A mass composed of olive, greenish, and red shales.

These shales yield readily to erosion and are in no place very well exposed. Thickness, 90′.

Sandstone B.

This is very similar to sandstone A, but contains more inter-bedded shale and fewer greenish layers. The shales are usually olive, grading upward or downward into red shales.

This sandstone can be seen in the second railroad cutting above the depot. It forms a ridge running westward from the river. Thickness, 70′.

Clinton Variegated Shales, a.

This is a group of red, olive, and brownish shales, generally exhibiting a well-marked cleavage, which is always to the S. E. It can be seen on the county road between the Kittatinny House and the town. Thickness, 130′.

Sandstone A.

This is a hard greenish-gray, coarse-grained sandstone, with some beds of red and olive shale, and some thin beds of fine-grained gray sandstone and sandy shale. The beds of the harder sandstones are from one to four feet thick.

This rock is seen in the first railroad cutting above the Depot, and produces a marked ridge by which its outcrop can be traced for a considerable distance. It forms the cliffs west of the Kittatinny house. Thickness, 80′.

Clinton Lower Red Shales.

A mass of indurated red shale and shaly sandstone. Near the center of this mass are some beds of shaly red sandstone much harder than the remaining portions. These hard beds form Prospect Rock and the cliffs at the western end of Blockhead mountain; also the steep hillside north of the Pitching Place.

These sandstones are full of concretions of iron, which are mistaken by many for fossil casts. The upper beds are variegated shales, red, olive, and brownish; but the red greatly predominates.

This outcropping mass occupies all the ground from the Kittatinny house to about 300 feet below Prospect Rock. Thickness, 740′.

Clinton Lower Olive Shales.

This mass consists of light gray sandstones and sandy shales, exhibiting the Medina fucoid *Arthrophycus Harlani.*

There is a well-marked boundary line between this mass and the one above it, the formations changing abruptly from gray to red. It can be seen on the county road through the gap, 325 paces (975 feet) below Rebecca's Bath. Thickness, 340′.

Between this and the formation next described, there is no well-marked boundary line, the change in character being very gradual.

Sandrock No. 3. Medina Upper Sandstone.

This is a mass of hard, coarse, and fine-grained, steel-colored to brownish sandstones, with some beds of slaty shale. Many of these beds are ferruginous, and some are filled with specks of ferric oxide.

This rock is seen in a short railroad cutting near the watch-house in the gap. It may also be seen near the Pitching Place upon the New Jersey side, just below the Slate Manufactory.

Its outcrop crosses the path to the summit near Hunter's Spring, forming the rocky steeps and loose stone débris above the spring.

It rises above water level on the New Jersey side of the river, in the axis of the Cherry Hollow anticlinal, and can be seen along the shore opposite the mouth of Cherry creek. (See section of river, New Jersey side.) Thickness, 200′.

Medina Upper Olive Shales.

This is a group of shaly sandstones, conglomeritic sandstones, and conglomerates. The conglomeritic sandstones predominate, but are soft and yield easily to erosion. The beds are all parted by argillaceous layers, which in some cases may be called beds of shale. A large part of the mass is composed of soft shaly sandstones.

In going up the path to the summit, from a short distance beyond Hunter's Spring to within about 700 feet from the crest, we pass over the outcrop of these beds. Thickness, 530′.

Sandrock No. 2. Medina White Conglomerate.

A hard, compact, pea conglomerate with beds of hard, coarse and fine-grained, gray to steel colored sandstone. Between some of the beds there are thin partings of black fissilé slate, though most of the partings are argillaceous deposits of a lighter color, and are oftener shale than slate.

The lower beds are coarse and of a white color; the up-

per beds, fine grained and darker, varying from gray to steel color.

It forms the crest on *both* sides of the river, and also a steep ascent north of the crest. On the Pennsylvania side of the river its outcrop is passed over just before reaching the crest. Upon the N. Jersey side of the gap, this rock forms a bold line of cliffs nearly as prominent as the main escarpment; and upon the Pennsylvania side a rock nose around which the railroad makes a sharp curve. Thickness, 200.′

Medina Lower Olive Shales.

This division is composed of soft grayish sandstones, with some beds of shale. It seems to have very nearly the same character as the mass lying between sandrocks Nos. 1 and 1 *a*, but being nearly everywhere covered by surface earth or débris of loose stone, its exact character cannot be told.

Its outcrop belongs just above that of sandrock No. 1 *a*, and extends northward to within a few feet of the center of the crest. Thickness, 110.′

Sandrock No. 1 a. Oneida Gray Sandstone.

This rock consists mainly of hard, compact, white sandstones with some beds of conglomerate. The beds of white sandstone exhibit hollow casts from ferric oxide concretions which are easily mistaken for those of fossil remains.

The softer beds of this rock contain thin layers of ferric oxide interlaminated with quartz.

This rock generally forms a marked bench just south of the crest of the mountain. Its outcrop can be seen a few feet south of Miners' and Sappers' View. It is also seen in the gap forming a thin rib running up parallel to the main escarpment. Thickness, 75 feet.

Oneida Lower Shales.

Lying upon the Oneida conglomerate is a mass of gray sandstones, possibly including some shaley bands. This

mass is much softer than the beds between which it lies and is covered by the débris from them, rendering an accurate description impossible, as the character of the mass can only be judged by the manner in which it has yielded to erosion and by the débris formed from it. Thickness, 240 feet.

Sandrock No. 1. Oneida Conglomerate.

This is a hard massive white conglomerate, with some beds of gray sandstone in the upper part of the mass. The conglomerate layers are composed of quartz pebbles from the size of a walnut down to fine sand.

Some of the lower beds of the conglomerate contain minute pyrite cubes, which, in some localities, are of large size and auriferous. (Geology of New Jersey, by Prof. G. H. Cook, page 147.) "The bottom beds of this conglomerate yielded $11 worth of gold to the ton, to our assays."

Some of the beds contain slate nodules, but whether these are slate *pebbles* or portions of the slaty partings which are found between the beds, is difficult to determine. Some few of these slate partings are five or six inches thick, but their average thickness is not over an inch.

The sandstone layers of this rock are dark gray, hard and compact, predominating in the upper portion. They form a bold line of cliffs sometimes 200 feet high on the southern flank of the mountain. Thickness, 210 feet.

Hudson River Slates.

On the hillside west of the house of Dan Bush are three openings which have been made for quarrying purposes, but the bad quality of the slate has caused them to be abandoned

At the second of these openings the slates are silicious and ferruginous, and at this point I have seen some traces of organic remains.

At the first of these openings the slates are silicious, and dip 15° N. 20° W.

Throughout the formation the slates have the characteristic dark blue color of ordinary roofing slate.

Its thickness from the escarpment of the mountain (its upper limit) down as far as the section in this work extends, is 2600 feet. [See local descriptions in Report of Progress D. 3, on Northampton and Lehigh counties.]

SPECIAL SURVEY

OF THE

LEHIGH WATER GAP,

IN 1875.

By H. Martyn Chance.

I. Topography and Structure.

In the immediate vicinity of the Lehigh gap, the flexures are gentle, and the resulting topography shows no extraordinary features.

The crest of the mountain presents a regular rounded contour, and the cliffs formed by the outcrop of the hard beds of sandstone and conglomerate, occurring near the base of No. IV, are much less prominent than those at the Delaware gap.

In the center of the gap the exposures reveal the presence of a gentle anticlinal roll, which, sharpening to the east, forms a hook in the mountain crest about one mile east of the gap. Westward, this flexure probably dies out in the valley of the Lehigh river and Lizard creek.

The terrace upon the north side of the mountain is a more prominent feature here than at the Delaware or Schuylkill gaps. It is formed by the outcrop of the Ore sandstone (?.) West of the gap, this sandstone outcrops high upon the mountain side, and forms a ridge resembling the ore ridge of the Juniata country, in Middle Pennsylvania.

South of the mountain, the topography consists of a monotonous succession of slate hills. The structure, however, consists of a most complicated series of overturned anticlinals, synclinals, and faults.

A flat water basin, fifteen hundred to two thousand feet wide, lies north of the mountain, presenting no exposures

of the underlying rock. This valley separates the mountain from a sharp, rugged ridge (Stony Ridge) formed by the outcrop of the Oriskany sandstone;—north of this ridge lies the hilly country formed by the Hamilton and Chemung measures.

From Weissport southward to Hazardville, the Lehigh river flows south by east in an approximately straight line. At the latter point it encounters the mountain, and turning abruptly eastward, flows for about two miles along the foot of the mountain. At the head of the gap, it turns sharply to the south, and flows through the gap and through the slate country, as far as Slatington, in a remarkably straight course.

The Aquanchicola creek comes from the east, flowing along the north foot of the Blue mountain, and empties into the river at the head of the gap.

At this point, a very interesting topographical feature presents itself. Standing at the head of the gap, and at the junction of the Aquanchicola with the Lehigh, is a beautifully rounded hill, isolated from the mountain by these two streams. At some time prior to the Glacial period the Aquanchicola probably emptied into the Lehigh river north of this little hill. The hill is itself a portion of the terrace of the mountain, and is formed mainly of Clinton red shale (No. V.) The small nose projecting southward, on which Mr. Craig's house stands, is formed by the outcrop of the Ore sandstone.

From the foot of this hill to the southern flank of Stony Ridge the old valley is filled to a height of eighty feet by a sort of moraine. The moraine matter consists of gravel, sand, and clay, with bowlders of Oriskany, Catskill, and Carboniferous sandstones, and some much older rocks. It obstructs the ancient water-course of the Aquanchicola; and thus, acting as a barrier, has forced the creek to erode the new channel through which it now flows.

Stoney Ridge or Devil's Wall.

Opposite to the Lehigh water gap this ridge is double.

East of the gap, it is a single-crested and characteristic *Oriskany* (*No. VII*) ridge. For when the structure is regular and when the Oriskany sandrock has a well-developed thickness, the resulting ridge is wild and rugged, the crest sharp and well defined, and the side slopes, especially the southern, covered with débris from the outcrop of the sandrock. Such is its character in this vicinity.

It is broken through at frequent intervals by streams flowing southward from the Hamilton (No. VIII) country.

When free from minor rolls, the dip is usually very steep.

East of Millport, and also westward to within a mile of the gap at Hazardville, Stony ridge is single crested and monoclinal, with the *Oriskany sandstone* dipping from 75° to 105° N. by W. (i. e. overturned to 15° S. by E.)

Immediately opposite the Lehigh water gap and about one mile east of Hazardville a sharp flexure enters the hill and produces a double ridge west of this point. The hill is here broken by a gap through which a small stream finds its way to the Lehigh. The exposures observed in this vicinity indicate the presence of a transverse fault as the probable cause of the peculiar shape of this gap. These exposures and the dips observed are as follows:

At the limestone (No. VI) quarry the dip is 50° N. 35° W.

At the sand tunnels the dip is flat; the Oriskany lying at the surface.

In the paint tunnel the dip is 5°–10° S. by W.

Half way between the paint tunnel and the cement quarry the axis of a gentle anticlinal is seen.

At the cement quarry the dip is 24° N. 20° W.

At the sandstone quarry, on the nose of the ridge, the dip is hard to determine accurately, but seems about 60°.

West of this point the hill is double.

The southern hill is a synclinal ridge, with the Oriskany SS. dipping nearly vertically on both sides of the flexure.

The northern hill is a monoclinal ridge with the Oriskany SS. *overturned* and dipping from 40° to 70° S. 15°–20° E.

By reference to the section from Parryville to Hazardville (Plate 4) it will be seen that this could not possibly have

been produced without the formation of a fault in the axis of the anticlinal. This fault is probably greatest in the soft Onondaga shales, (lower portion of No. VI.)

Hazardville overturned downthrow.

The most complicated part of the structure of this hill is that occupying the southern slope of the synclinal ridge.

Going up the railroad from Hazardville to Bowmansville, the first exposure seen is that of the Onondaga red and olive shales (lower portion of No. VI) dipping 20° S. by E. Going northward the dip steepens and we come to what at first sight seems to be an anticlinal axis, but what is in reality the axis of a fault, (see section, Plate 4.)

On its southern side and *underlying the Onondaga* are 25 feet of greenish and yellow (water lime) shales; on its northern side the red and olive Onondaga shales again appear. Going northward the dip becomes steeper, varying from 35° to 85° N. by W., and at 150 feet north of the fault the greenish and yellow shales of the water lime group again appear, this time *in situ*, overlying the Onondaga red and olive marls. This exposure establishes, without doubt, the existance of a fault, with the rocks upon its southern side *completely overturned.*

Fault in Marcellus Shale.

Going up the county road from Bowmansville the Marcellus shale (lowest member of No. VIII) are seen dipping 15°–20° S. by E. This dip varies but slightly for over 800 feet, when it suddenly changes to the northwest. If this was caused by an anticlinal flexure, we should find a repetition of the Marcellus upon its northern side. Such is not the case, the Hamilton flags and shales coming in immediately north of the axis.

We have no sufficient data to determine the amount of the upthrow or downthrow, but from the exposed thickness of the Marcellus it is demonstrable that it can *not be less* than two hundred feet.

This fault renders it impossible to estimate, in this locality, the total thickness of the Hamilton group.

II. Description of the Formations.

The following table shows the formation of Stony Ridge and the mountain in their natural order, together with the overlying and underlying rocks. The formations, whose thicknesses are appended, were measured, and will be described below:

No. XIII.	Coal measures at Summit Hill.		
No. XII.	Conglomerate, Pottsville conglomerate,		Mountain.
No. XI.	Mauch Chunk red shale,		Valley.
No. X.	Pocono sandstone,		Mountain.
No. IX.	Catskill sandstone, "old red,"		Mountain terrace.
No. VIII.	Chemung, thickness measured,	600′	Hilly country and valley.
	Portage,	320′	
	Hamilton and Genesee,	+1350′	
	Marcellus,	+1200′	
	Corniferous,	25′	
	Schoharie (?) paint ore,	1′ 8″	
	Cauda-galli (?) clay,	5′	
No. VII.	Oriskany sandstone,	150′	Stony ridge.
	Oriskany shales,	141′	
	Oriskany shales, unexposed	170′	
No. VI.	Lime shales, unexposed,		Valley.
	Lower Helderberg limestone,	59′	
	Water lime shales,	60′	
	Onondaga (?) shales,	150′+	

No exposures for 2,000 feet across the valley of the Aquanchicola and Lizard creeks.

Onondaga and Niagara,		?	
No. V.	Clinton Upper red shale,	650′+	Mountain terrace.
	Clinton Upper red and olive shale,	90′	
	Clinton Upper olive shale,	120′	
	Ore (?) sandstone,	125′	
	Clinton Lower red and olive shale,	290′	
No. IV.	Medina Upper sandstone, (No. 3,)	85′	Mountain.
	Medina Upper shales,	180′	
	Medina white sandstone, (No. 2,)	70′	
	Medina Lower shales,	330′	
	Oneida conglomeratic sandstone,	290′	
	Oneida conglomerate, (No. 1,)	170′	

No. III. { Hudson River slates, . { thickness in- } Valley.
{ Utica slates, . . . { determinate. }
No. II. Trenton limestone, etc.
No. I. Potsdam sandstone.

Chemung.

Only the lower portion of this formation was measured. Its lowest bands are a series of red sandstones and shales overlaid by greenish and bluish flaggy sandstone, with some intercalated olive shale, over which occurs a mass of soft red sandstone and indurated shale. The dip from Parryville southward varies from 15° S. by E. to 0°–20°–40°–50° N. by W. to 0°–60°–40° N. by W. (as shown in the section,) down to the top line of the Portage. Thickness of lower Chemung measured, 600′.

Portage (?)

The shales of this formation are rather hard and somewhat calcareous, of a dark-bluish color, sometimes resembling the cement layers of the Upper Helderberg. They form a slight terrace, but yield rather readily to erosion. Dip averages 60° N. to W. Thickness, 320′.

Genesee and Hamilton.

The upper part of this mass consists principally of flaggy sandstones and shales, tolerably hard, with very thin slaty partings, and of a bluish color, grading downwards into soft slates, below which are a series of hard, compact, dark-blue, silicious slaty shales. In going southward through this division the dip varies thus: 60°, 35°, 60°, 40°, 90° N. by W.

Near the house in the gully (see section) a small slip is observed, which, though of little importance, prevents any further measurement. Thickness measured 1,350′

Marcellus Slates and Shales.

These are so crushed that it is difficult to determine the dip with sufficient accuracy to determine the true thickness of the mass.

These slates and shales form the valley lying between the

Oriskany ridge and the hilly country formed by the Hamilton flags.

At Millport a rather slaty portion of that formation has been found with good cleavage planes and of sufficient hardness to answer for roofing purposes. Two quarries have been opened, (1875,) both of which have produced slate of fair quality. The dip is here slightly overturned.

The approximate thickness as determined by the cross-section, is 1200′+.

Corniferous Limestone, (*U. Helderberg.*)

At the Lehigh, this formation almost altogether loses its character as a chest-bearing limestone.

It is here composed of 20′ of hydraulic cement lime, overlaid by 5′ of cherty lime.

The cement has for many years been worked at a quarry near the paint tunnel at Hazardville. (See map.)

It is said to produce a superior quality of cement. All the masonry of the Lehigh and Susquehanna canal was laid with it, and the way it has worn certainly does not condemn it. It is burnt and ground by Mr. Prince of the Lehigh Metallic Paint Company, but at present (1875) very little is quarried.

The 5 feet of overlying cherty limestone is precisely like that seen to the N. E. at the Delaware river and in New Jersey.

The formation as a whole is soft, and presents but few natural exposures.

Paint Ore, (*Schoharie?*) *Upper Helderberg.*

This is nothing more than a ferruginous shale containing iron as pyrites and brown oxide.

The pyrites is found in concretionary masses, resembling the pyrites of the coal measure rocks.

The whole bed is sometimes altered near the outcrop to brown hematite wash ore, and the bog ore found in places on the north side of Stony Ridge owes its existence to this bed.

It varies from 12″ to 24″ inches in thickness, lying immediately between the clay and cement.

This ore is extensively worked for the manufacture of paint. It is burnt, ground, and bolted when it is ready for shipment. It makes a dull red paint, and is to be recommended on account of its cheapness and durability. Thickness, 1′ 8″.

Clay, (Cauda-galli?) Upper Helderberg.

Immediately overlying the Oriskany SS. is a bed of clay from 3 to 8 feet in thickness. This has its exact equivalent at the Juniata. (See Mr. J. H. Dewees' report for 1874–5.) Thickness, 5′.

Oriskany Sandstone.

In tracing this rock from the Delaware to the Lehigh, it is of gradually increasing thickness.

It consists of alternating fine-grained and coarse-grained sandstones, and pea conglomerates, most of which have a calcareous cementing matter.

At the outcrop some of the more calcareous layers have lost a large amount of their cement, reducing the rock to nothing more than a bed of loose sand, which crumbles at the touch.

All along its outcrop quarries or sand-pits are now opened (1875) from which the material is taken and sent to Catasaqua, Allentown, &c., where it is used in the manufacture of an excellent fire-brick.

Most of this sand is streaked yellow with iron, but there are a few thin beds that are of a very pure white color, and would probably make a good glass sand.

Oriskany Shales.

The upper portion of this formation is well exposed, but the lower layers present no exposures in the vicinity of the Lehigh.

The following section was compiled from the data obtained in a prospecting tunnel on the western side of the river, and from exposures along the tracks of both the L. and S. and L. V. R. R:

Oriskany SS.,		150′
Oriskany shales,	Flint beds, 1′ to 3′ thick, some sandy,	24′
	Stoney ridge block ore,	2′
	Flint, some beds sandy,	20′
	Clay,	14′
	Stoney ridge red hematite ore,	1′
	Sandstone, in two beds,	22′
	Clay and flint beds,	46′
	Conglomeratic sandstone,	12′
	Total exposed thickness,	141′
Oriskany and Lower Helderburg shales unexposed,		170′

The 12′ SS. is seen in the most southern part of the tunnel and is a conglomerate with pea-sized pebbles, but in some cases they are nearly as large as a hazelnut. The cementing matter is calcareous, and although on both sides it has very soft rocks, it makes no marked feature in the topography. It corresponds to the 15′ conglomerate at the Delaware gap.

Upon this rest 46′ of alternating clay and flint beds. This flint is amorphous and is regularly stratified. None of it presents a nodular structure. It is probably the source from which the Indians drew their supply for arrow and spear heads.

The beds vary from 1″ to 1′ in thickness and are separated by about equal thicknesses of a beautiful soft and unctuous clay. The latter is usually streaked with iron. The flint varies from reddish brown to white in color, the greater part being of a pale yellow color.

Upon this rests 22′ of sandstone. This rock is found in two nearly equal beds, one half being coarse grained and full of Oriskany fossils, the other half non-fossiliferous and fine grained.

It is upon this sandrock that the Stoney ridge red hematite ore rests. (Described further on.)

Upon this is a nearly homogeneous bed of clay 14′ thick, overlaid by flint beds 44′ thick.

These latter are massive, of a dark color and inclined to be sandy. They are divided into two members, 20′ and 24′ thick respectively, by the Stoney ridge brown hematite (block) ore. The upper division is much more sandy than the lower.

These flint beds are, in appearance, very unlike the flint interstratified with clay. They are very dark in color, varying from a steel color almost to black.

Lower Helderberg Limestone.

Very imperfect exposures of this rock are found along the track of the L. and S. RR. Another portion of the formation is seen at the quarry N. E. from Hazardville. It here yields a very fair lime, but the workable bed is quite thin. Twenty feet of limestone are exposed in the quarry overlaid and underlaid by slaty limestone and lime shale. It is much lighter in color than at the quarries opened at the Delaware gap, and is also softer, yielding much more readily to erosion. Its lower layers are hydraulic.

It has been found in several water wells near the pike, at Millport.

Its lower beds as seen along the L. and S. RR. consist of

Fossiliferous lime shale of a purplish color, which may belong to the water-lime group,	3′
Shaly limestone with nodular chert,	4′
Sandy lime shale containing some beds of workable limestone,	52′
Total,	59′

Over this mass occurs a series of lime shale and limestone beds classed as Lower Helderberg lime shale, which graduate upward into the Oriskany shales; but as the exposures are very poor, I have been unable to determine any line of demarkation between these two shale groups. The section stands:

Oriskany shales, measured	14′
Oriskany and Lower Helderberg shales, unexposed,	170′
Lower Helderberg limestone, measured	69′

Water Lime Shales.

These vary from yellow to green in color, and have usually a more or less slaty structure, with some beds of a sandy texture, while others are quite calcareous, but none sufficiently so to justify the name of lime shale.

They are well exposed along the railroad above Hazardville, and also in a prospecting tunnel on the west side of the river.

They are very soft, and yielding readily to erosion seldom present any important exposures. At the Delaware they are not exposed. Dip 70° to 90° N. by W. Measured thickness, 60′.

Onondaga Shales.

A mass of alternating, variegated, soft, red, and olive marls. Where seen at a cutting on the railroad above Hazardville, they are crushed and contorted, and one portion of the mass is seen *completely overturned* and resting on the water lime shales, instead of underneath them.

The upturned edges of these shales are overturned at the outcrop as by the action of a glacier moving southward, and upon them rests a mass of glacial bowlder and gravel drift.

The thickness of this formation cannot be measured, as it lies completely hidden from sight (except the small exposure just described) in the valley of the Aquanchicola, Lehigh and Lizard creek.

This valley is from 1,200 to 2,000 feet wide, and, except where filled by glacial drift, perfectly flat. Crossing the valley to the eddy hill standing at the head of the gap, we find the next exposures are of the Clinton Upper red shale, a considerable portion of which is probably hidden beneath the valley, or covered by drift matter on the northern flank of the hill.

Clinton Upper Red Shale.

This here shows its usual character as a very soft red shale. The thin beds of olive shale seen at both the Delaware and Schuylkill are also here found at what appears to be a corresponding horizon. It presents an exposed thickness of 650′.

Clinton Upper Red and Olive Shales.

At this point these shales are probably transition beds between corresponding horizons at the Schuylkill and Delaware. At the Schuylkill the rocks occupying this geological horizon are all *olive*. At the Delaware they are all *red;* and here we find, first, an underlapping of the Schuylkill

olive shales, and then transition beds between the two formations.

For this reason this member is enumerated only in this (the Lehigh) column, being included in the Clinton Upper olive shale at the Schuylkill, and the Clinton Upper red shale at the Delaware.

As its name indicates, it consists of an alternation of red and olive shales.

It is exposed upon the western side of the river, along the roadway of the Lehigh Valley railroad. Thickness, 90′.

Clinton Upper Olive Shale.

This member is a mass of true olive slaty shales, which probably contain a large percentage of calcareous matter. It is but poorly exposed upon the eastern side of the river, but upon the western bank it is well seen. This rock is absent at the Delaware, but at the Schuylkill is seen in much greater force. Thickness, 120′.

Ore Sandstone.

This is here a hard, compact, greenish-gray sandstone, with thin partings of olive shale. It is a rather fine-grained rock, but contains some slightly conglomeratic beds.

It outcrops along the railroad track above the station; along Aquanchicola creek (where it presents a perpendicular face,) and along the track of the Lehigh Valley RR.

It forms the terrace on the north side of the mountain, and the nose which projects southward from the Eddy Hill, and upon which the house of Mr. William Craig stands. Thickness, 125 feet.

Clinton Lower Red and Olive Shales.

These consist of an alternation of sandy red and olive shale, with red sandstone.

About one hundred and twenty-five feet of this division is hidden by the Aquanchicola, but this is well exposed in railroad cuttings along the L. V. RR.

The upper part of the mass is well exposed above the Gap

station, and the lower portion presents a fine natural exposure back of Craig's hotel. These shales form the terrace on the northern side of the mountain. Thickness, 290′.

Medina Upper Sandstone, (No. 3.)

This is a greenish-grey to steel-colored, fine-grained sandstone, with beds about fifteen inches thick. Its total thickness is exposed at an outcrop in the rear of Craig's Hotel, where it dips 42° to 58° N. 5° W.

It presents several bold outcrops in the gap, of which the "Devil's Pulpit" is the most prominent. Thickness, 85′.

Medina Upper Shales.

This is a soft mass of alternating olive and brownish shales, well exposed on the county road near Craig's store, and on the mountain side back of the store, where they are seen dipping 26° to 40° N. 10° W.

Their outcrop is found on the mountain side just north of the crest. Thickness, 180′.

Medina White Sandstone, (No. 2.)

This consists of an alternation of greenish-grey, olive, and steel-colored sandstones.

It is divided into two members by a parting of sandy shale, twenty feet thick.

Its outcrop forms the mountain crest. Thickness, 70′.

Medina Lower Shales.

These are not well exposed at the Lehigh. They consist, principally, of rather soft brownish shales, with a few sandy beds.

Immediately above the middle of the mass, there is exposed a white conglomeratic sandstone, from twenty-five to thirty feet thick, which may be a split from the lower portion of the Medina white sandrock of the Delaware gap.

These shales occupy the crest and southern slope of the mountain, above the outcrop of the Oneida. Thickness, 330′.

Oneida Conglomeratic Sandstone.

A mass of massive white and light grey conglomeratic sandstones. Some of its beds are true conglomerates, with quartz pebbles varying from the size of a hazelnut downwards to fine sand. These occupy the lower portion of the rock. In the upper part, fine-grained sandstones predominate, but the conglomeratic character of the rock is apparent throughout its entire thickness.

It is exposed in a long cut on the L. and S. railroad, where an anticlinal roll is seen, with dips of 21° N. 15° W.; 5° S. by E.; and 31° N. 20° W.,—the latter at its junction with the rock beneath.

It outcrops south of the mountain crest. It probably forms the top of the high cliffs seen at the "Devil's Bake Oven," a few miles west of the gap.

This rock probably includes the Oneida shales and Oneida grey sandstone of the Delaware section. It is absent at the Schuylkill. Thickness, 290′.

Oneida Conglomerate, (No. 1.)

This sandrock is here seen immediately overlying the Hudson river slates, and *dipping conformably to them.* On the eastern side of the gap it forms a cliff running up the mountain, and a steep declivity upon the southern side of the mountain.

The following section is seen along the railroad. The dip is 24°–31° N. 20° W. (Order downward:)

Conglomerate of quartz and slate pebbles from the size of a walnut to fine sand, parted with thin beds of finer grained S.S.,	62′
Sandstone; steel-colored, with an occasional bed of white S.S. sand of nearly a uniform size, with an occasional pebble,	45′
Egg Conglomerate of quartz and slate pebbles alternating with steel-colored S.S.,	55′
Egg Conglomerate of quartz, slate, chert, sandstone, and limestone (?) pebbles with one or two thin beds of grayish S.S.,	8′
The Hudson river slates are exposed 10 feet below last member, thus showing a total thickness of,	170′

Hudson River Slates.

At the Lehigh this formation wears its usual character of black and blue slates, with an occasional flaggy or sandy member. The upper portion of the mass is well exposed immediately underlying the Oneida conglomerate, and consists of hard sandy slates, and dark steel-colored fine grained sandstones, underlaid by soft shaly slates of a bluish black color.

Between this point and Slatington the slates are so twisted and broken that it is impossible to fix the horizon of any particular stratum in the formation. The geological position of the roofing slate bands is therefore indeterminate. But from the general structure we can assert that it is very low in the series, and may belong to the Utica. The roofing slate horizon probably does not include more than ten or twelve beds of good quality, but these are repeated so many times that the impression that there is a much greater number of beds present is given to the casual observer. The flexures are often so sharp that the dips on both sides of an anticlinal or synclinal are approximately parallel, and two beds are noted, where in reality but one exists.

The identification and classification of these beds is very difficult, and can only be accomplished by a careful and prolonged study of the subject. A minute examination of the physical character of each bed, and of the number and arrangement of its ribbons, when studied in connection with the structural geology might lead to their systematic arrangement.

The general structure has been obtained, and some of the most important beds identified and traced from point to point.

The data collected, together with a description of the exposures seen between the mountain and Slatington, will be found below. [These are published with the foregoing remarks on No. III, in Report D⁴, on Northampton and Lehigh counties.—J. P. L.]

Honesdale Bore-Hole Record Completed.

Since the text of this report was put in type the experimental boring of the Wayne County Development Company has been continued to a depth of 2165′, where the rocks become so hard and silicious that further progress became impracticable, and the well was abandoned.

Mr. E. F. Torrey, the president of the company, has kindly furnished me the rest of the record not given in the body of this report, which is as follows:

	Thickness.	*Depth.*
Red shale,	5′	1505′—1510′
Greenish-gray sandstone,	15′	1510′—1525′
Light gray fine grained sandstone,	20′	1525′—1545′
Sandstone, greenish-gray,	10′	1545′—1555′
Shale, red,	5′	1555′—1560′
Sandstone, light gray,	15′	1560′—1575′
Sandstone, dark red,	35′	1575′—1610′
Sandstone, light gray,	25′	1610′—1635′
Shale, red, sandy,	35′	1635′—1670′
Sandstone, dark gray,	10′	1670′—1680′
Sandstone, light gray,	35′	1680′—1715′
Sandstone, greenish-gray,	15′	1715′—1730′
Shale, blue, sandy,	30′	1730′—1760′
Sandstone, greenish-gray,	60′	1760′—1820′
Shale, red, sandy,	5′	1820′—1825′
Sandstone, light gray,	10′	1825′—1835′
Shale, dark, sandy,	30′	1835 —1865′
Sandstone, dark gray,	20′	1865′—1885′
Sandstone, greenish-gray,	15′	1885′—1900′
Sandstone, very hard, gray,	25′	1900′—1925
Shale, dark, sandy,	5′	1925′—1930′
Sandstone, greenish-gray,	20′	1930′—1950′
Sandstone, very hard, greenish-gray,	60′	1950′—2010′
Sandstone, yellowish, very silicious,	30′	2010′—2040′
Sandstone, dark gray,	10′	2040′—2050′
Sandstone, greenish-gray, very hard to bottom of hole,	115′	2050′—2165′

Fresh water cased off at 778′.

Slight vein of salt water at 1140′.

Heavy vein of water, slightly salty at 1240′ where a gas vein was also struck and the hole filled with water, which was finally cased off at 1310′. "Black soot" came up on water at 1240′.

Show of *amber oil* bubbles, 1715′—1730′.

The record of this well shows that the *Catskill* beds increase in thickness southward from the northern line of Wayne with great rapidity, since the bore-hole stopped in the middle of the *Starrucca* sandstones, the transition series between the Catskill and Chemung, which are 600′ thick at the southern line of Pike county along the Delaware river; so that the boring would very probably not reach the genuine *Chemung beds* under a depth of 2500′. Adding to this the 800′ of *Catskill* above the level of the derrick floor would give a thickness of 3300′ for these beds six miles north from Honesdale, a size even greater than we find along the Delaware in Pike county. (See section A.)

It thus appears that the *Catskill* thickens southward not in a regular manner, but that the plane of its base runs downward like the side of a saucer rapidly burying the *Chemung* to a great depth.—[I. C. White.]

I. NOMINAL AND GEOGRAPHICAL INDEX.

II. GEOLOGICAL INDEX TO G⁶.

[NOTE.—The figures in parentheses refer to the township numbers.]

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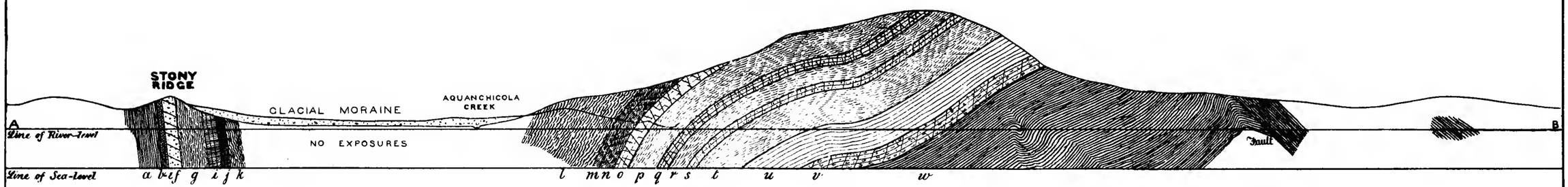
SECTION MADE ALONG THE LEHIGH RIVER.

G.[6]

Second Geological Survey of Pennsylvania, Report of 1874'5. J.P.Lesley, State Geologist.
Section made along the Lehigh River through the Water Gap; by H. Martyn Chance, Ass't. Geologist.



	a	Marcellus slates		VIII
5'	b	Chert	Corniferous	
20'	c	Cement	Corniferous	
18"	d	Paint ore - Schoharie ?	Upper Helderberg	
5'	e	Clay Caudi-galli ?	Upper Helderberg	
150'	f	Oriskany Sandstone	Oriskany	VII
375'	g	Oriskany shales; ore bearing	Oriskany	VII
	i	Lewistown Limestone		VI
70'	j	Water-lime shales		VI
+155'	k	Onondaga shales		VI
		Glacial Moraine; Valley of Aquanchicola Creek		

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400 0 400 800 1200 1600 2000
1/8 1/2
MILES

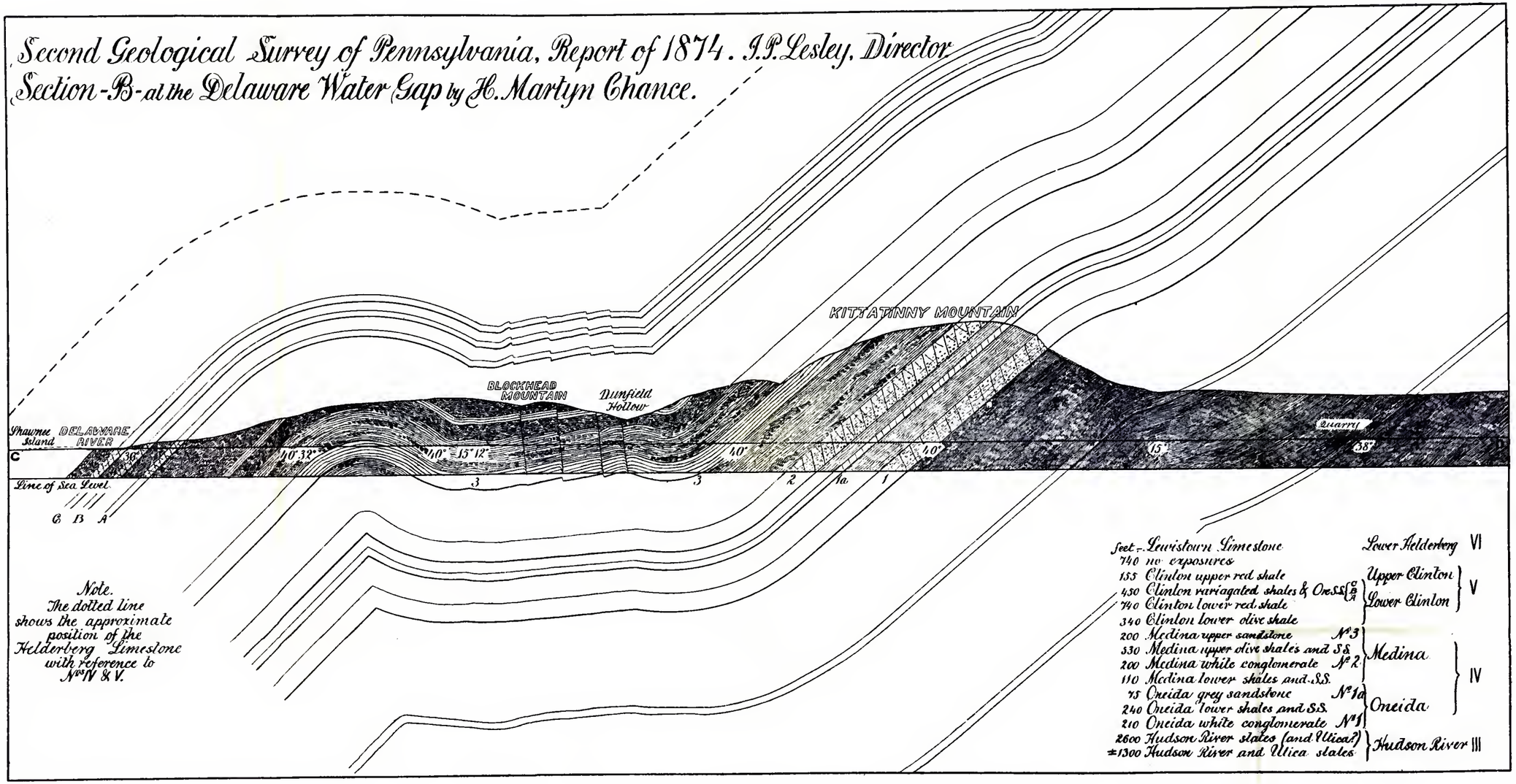
		Valley of Aquanchicola Creek		
l	+650	Clinton upper red shale	Clinton	V
m	90	Clinton variagated shale	Clinton	V
n	120	Clinton upper olive calc' shale	Clinton	V
o	125	Ore Sandstone No 4.	Clinton	V
p	290	Clinton lower red & olive shale	Clinton	V
q	85	Medina upper sandstone No 3	Medina	IV
r	180	Medina upper shale	Medina	IV
s	70	Medina grey sandstone No 2	Medina	IV
t	330	Medina lower shale	Medina	IV
u	290	Oneida conglc sandstone	Oneida	IV
v	170	Oneida conglomerate No 1	Oneida	IV
w	?	Hudson River slates	Hudson	III

QE
157
A116
no. G 6

SECTION B.--AT THE DELAWARE WATER GAP.

G.[6]

Second Geological Survey of Pennsylvania, Report of 1874. J.P. Lesley, Director.
Section -B- at the Delaware Water Gap by H. Martyn Chance.



Note.
The dotted line shows the approximate position of the Helderberg Limestone with reference to Nos IV & V.

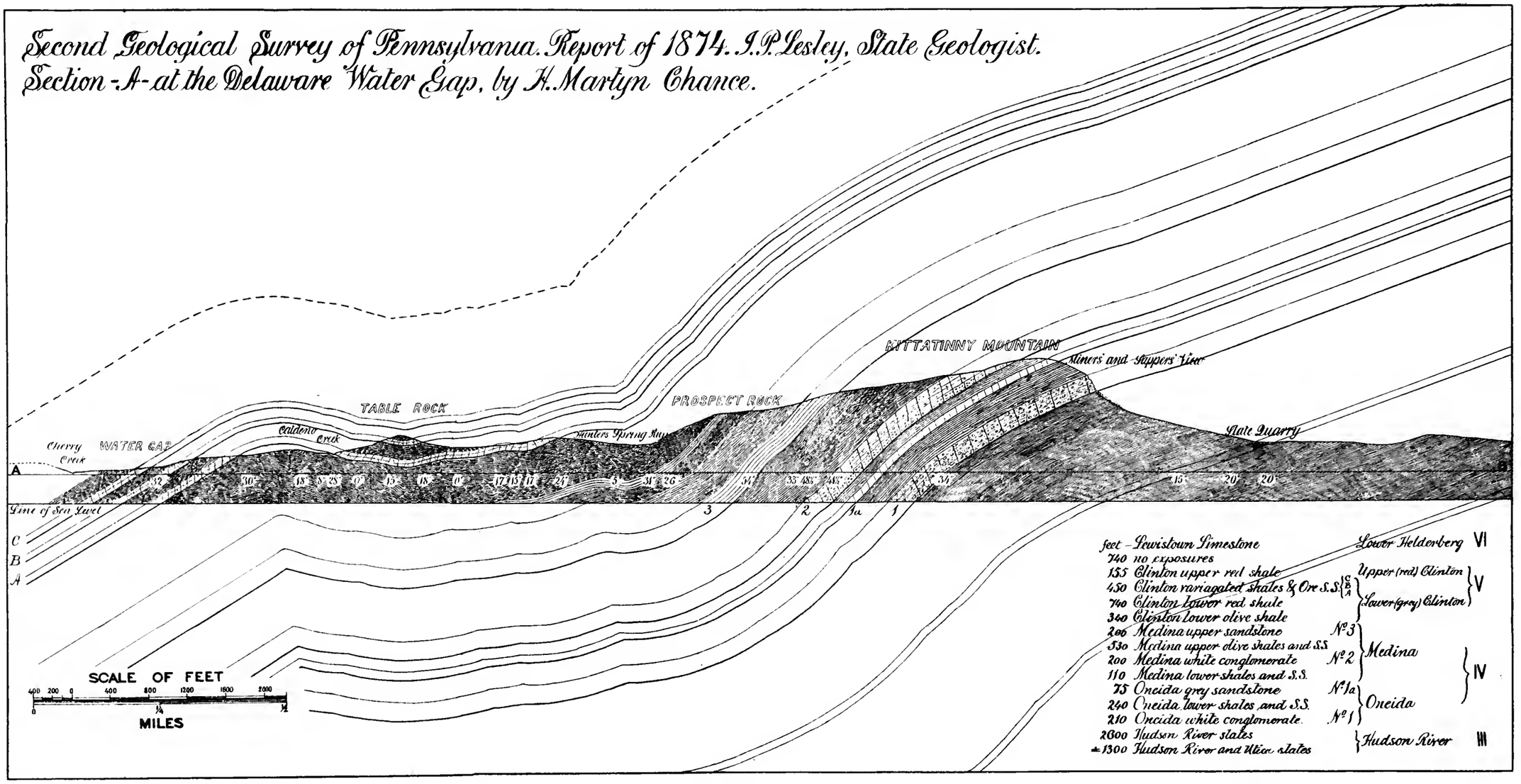
Feet				
	Lewistown Limestone		Lower Helderberg	VI
740	no exposures			
155	Clinton upper red shale		Upper Clinton	V
450	Clinton variagated shales & Ore SS	C B A	Lower Clinton	
740	Clinton lower red shale			
340	Clinton lower olive shale			
200	Medina upper sandstone	No 3	Medina	IV
330	Medina upper olive shales and SS			
200	Medina white conglomerate	No 2		
110	Medina lower shales and SS.			
75	Oneida grey sandstone	No 1a	Oneida	
240	Oneida lower shales and SS.			
210	Oneida white conglomerate	No 1		
2600	Hudson River slates (and Utica?)		Hudson River	III
±1300	Hudson River and Utica slates			

QE
157
A116
no G4

SECTION A.--AT THE DELAWARE WATER GAP.

G.[6]

Second Geological Survey of Pennsylvania. Report of 1874. J.P. Lesley, State Geologist.
Section -A- at the Delaware Water Gap, by H. Martyn Chance.



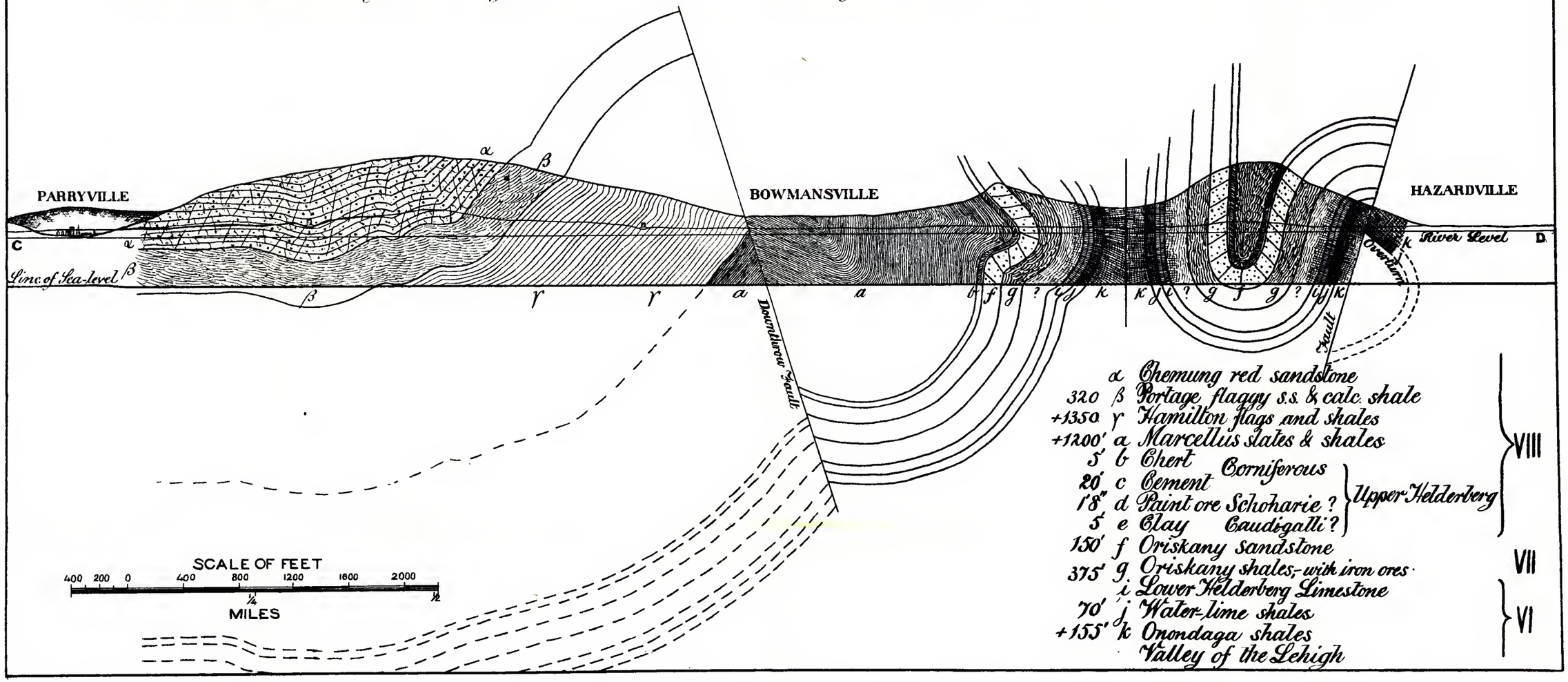
feet –	Lewistown Limestone		Lower Helderberg	VI
740	no exposures			
155	Clinton upper red shale		Upper (red) Clinton	V
450	Clinton variegated shales & Ore S.S.	C B A		
740	Clinton lower red shale		Lower (grey) Clinton	
340	Clinton lower olive shale			
206	Medina upper sandstone	No 3	Medina	IV
530	Medina upper olive shales and S.S.			
200	Medina white conglomerate	No 2		
110	Medina lower shales and S.S.			
75	Oneida grey sandstone	No 1a	Oneida	
240	Oneida lower shales and S.S.			
210	Oneida white conglomerate	No 1		
2600	Hudson River slates		Hudson River	III
± 1300	Hudson River and Utica slates			

SECTION MADE ALONG THE LEHIGH RIVER, IN CARBON COUNTY.

G.[6]

Second Geological Survey of Pennsylvania, Report of 1874'5. J.P.Lesley, State Geologist.

Section made along the Lehigh River in Carbon county; by H. Martyn Chance, Asst. Geologist.



	α	Chemung red sandstone	
320	β	Portage flaggy s.s. & calc. shale	
+1350	γ	Hamilton flags and shales	
+1200'	a	Marcellus slates & shales	VIII
5'	b	Chert — Corniferous	
20'	c	Cement	Upper Helderberg
18"	d	Paint ore Schoharie?	
5'	e	Clay Caudigalli?	
150'	f	Oriskany sandstone	VII
375'	g	Oriskany shales, with iron ores	
	i	Lower Helderberg Limestone	VI
70'	j	Water-lime shales	
+155'	k	Onondaga shales	
		Valley of the Lehigh	

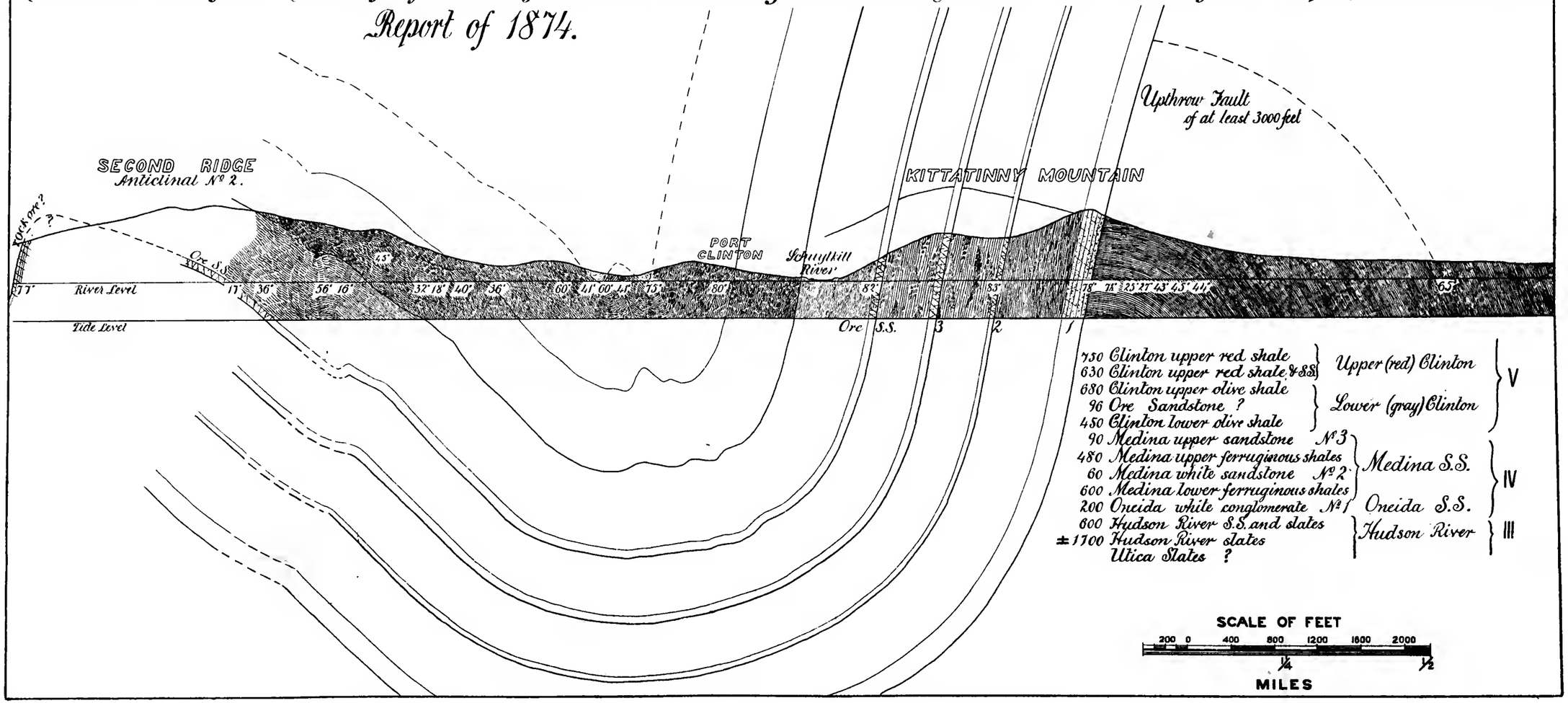
QE
157
A116
no. G6

SECTION AT SCHUYLKILL GAP.

G.[6]

Second Geological Survey of Pennsylvania, J. P. Lesley, Director. Section at the Schuylkill Gap, by H. M. Chance.

Report of 1874.



QE
157
A11c
no. G6

POCONO MOUNTAIN PLATEAU AND DELAWARE RIVER VALLEY.

G^{6}

(All covered by the ice, but no observations of Striæ as yet reported.)

LACKAWANA RIVER

Country covered by Drift nearly 2,000 A.T.

Highest Striæ observed.

MONROE

CARBON

NORTHAMPTON CO

STA

Wallenpaupack

Escarpment runs on

Shohola C

Bowlder on Summit of Knob

Falls 168

Falls 435'

Bushkill Creek

Pocono Creek

Brodhead's Creek

STROUDSBURG

Great Drift Plain 1100' A.T.

Terminal Moraine

Terminal Morain

PLATEAU MOUNTAIN

POCONO MOUNTAIN

LEHIGH R.

MAUCH CHUNK

KITTATINNY MTN.

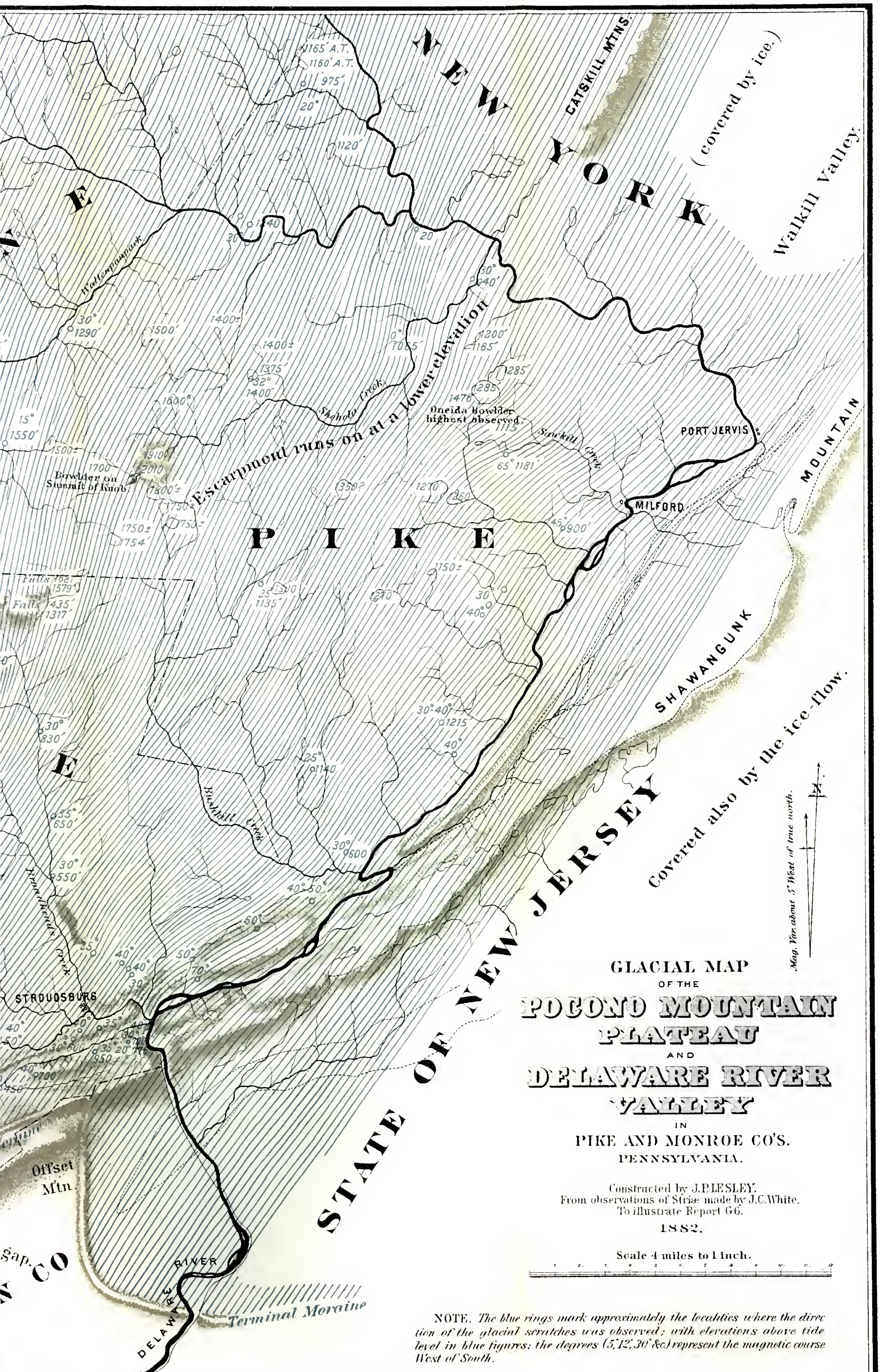
Wind gap.

Offset Mtn.

DELAWARE RIVER

1165' A.T.
1160' A.T.
975'
1120'
1400±
1375'
1400'
1600'
1910'
2010
1800±
1750±
1754'
1579
1317'
1970
1575'
1250
2150
1500'
1835' A.T.
1875
2225'
1850'
875'
620'
1135'
1290'
1185'
1475'
1550'
1700
1754'
830'
650'
9550'
9600
9700'
950'
450

LANE S. HART, STATE PRINTER.


NEW YORK
CATSKILL MTNS.
(covered by ice.)
Walkill Valley.
PIKE
Escarpment runs on at a lower elevation
Shohola Creek
Oneida bowlder highest observed.
Sawkill Creek
PORT JERVIS
MILFORD
MOUNTAIN
SHAWANGUNK
Covered also by the ice-flow.
STATE OF NEW JERSEY
Bowlder on Summit of Knob
Wallenpaupack
Bushkill Creek
Brodheads Creek
STROUDSBURG
Offset Mtn.
DELAWARE RIVER
Terminal Moraine
Mag. Var. about 5° West of true north.
GLACIAL MAP
OF THE
POCONO MOUNTAIN
PLATEAU
AND
DELAWARE RIVER
VALLEY
IN
PIKE AND MONROE CO'S.
PENNSYLVANIA.
Constructed by J.P. LESLEY.
From observations of Striæ made by J.C. White.
To illustrate Report G6.
1882.
Scale 4 miles to 1 inch.
NOTE. The blue rings mark approximately the localities where the direction of the glacial scratches was observed; with elevations above tide level in blue figures; the degrees (5°, 12°, 30° &c.) represent the magnetic course West of South.

QE
157
A116
no. G 6

DELAWARE WATER GAP.

G.[6]

SECOND GEOLOGICAL SURVEY
OF
PENNSYLVANIA,
1874.
J.P. LESLEY, State Geologist.

A MAP OF THE

DELAWARE WATER GAP

IN THE COUNTIES OF

NORTHAMPTON AND MONROE

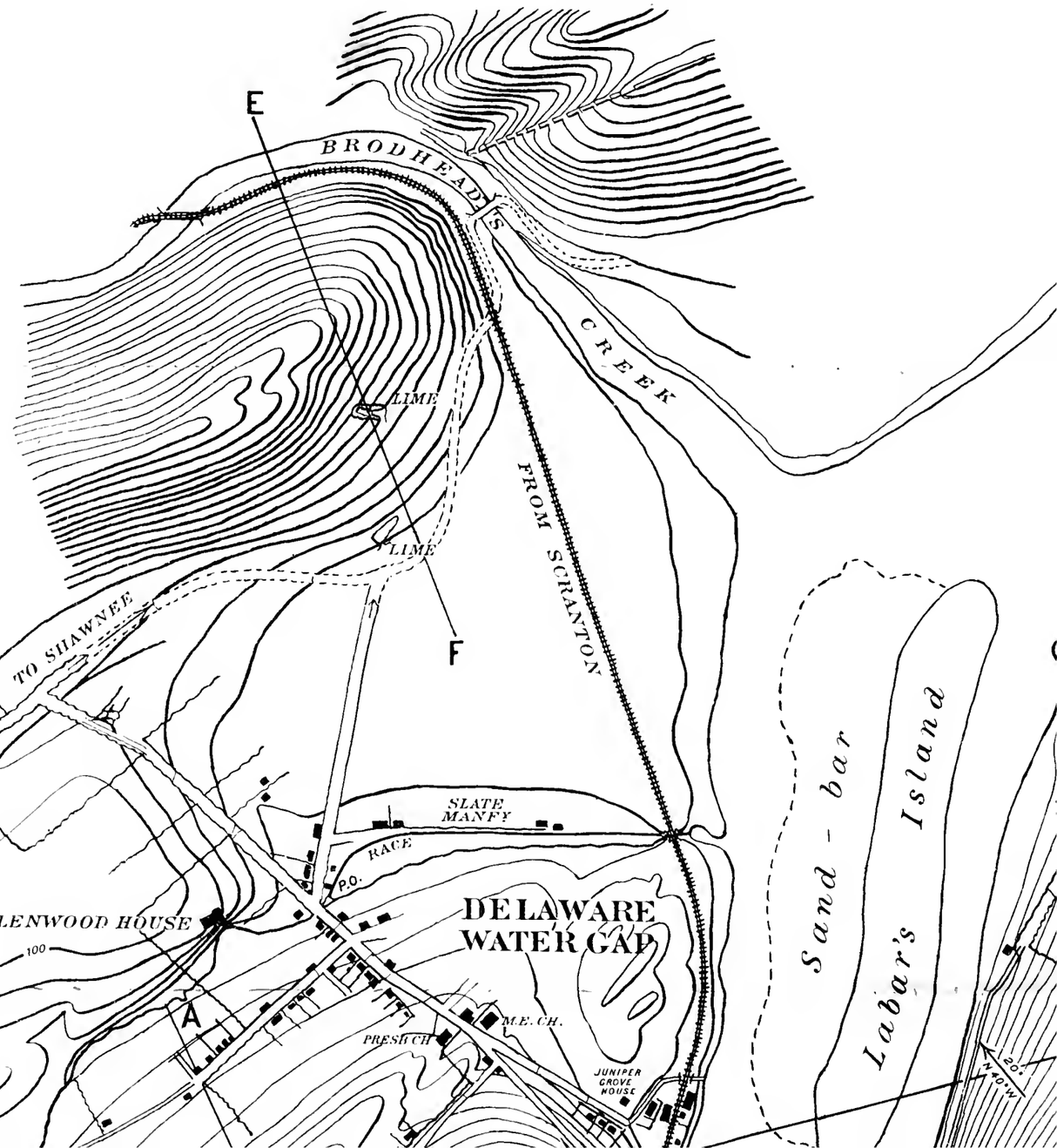
PENNSYLVANIA,

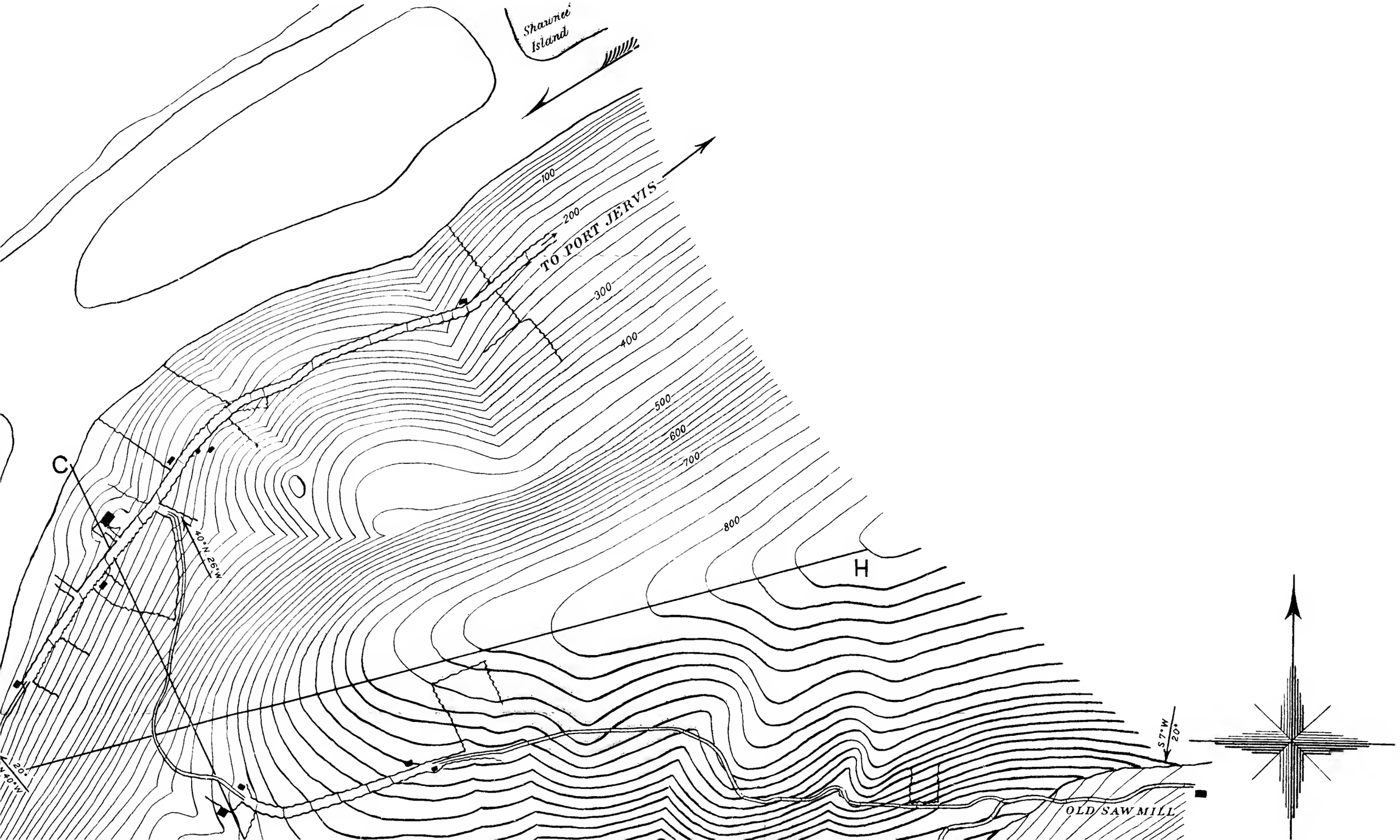
AND WARREN COUNTY

NEW JERSEY.

Surveyed and Drawn by H. Martyn Chance

Assisted by J. Warner Edwards.




Shawnee Island
100
200
TO PORT JERVIS
300
400
500
600
700
800
C
O
H
40°N 26°W
20°
N 40°W
S 7°W
20°
OLD SAW MILL

FROM STROUDSBURG
LIME KILN
CHERRY CREEK
M.E. CH.
PRESB.CH
JUNIPER GROVE HOUSE
BRICK YARD
WATER GAP HOUSE
LENAPE LAKE
KITTATINNY HOUSE
Sand - bar
DAM
TABLE ROCK
SCHOOL HOUSE
CALDENO CREEK
HUNTERS SPRING
BLOCK
100
200
300
400
500
600
700
800
900
1000

LOCKHEAD MOUNTAIN

DUNFIELD HOLLOW RUN

OLD SAW MILL

DAM

RACE

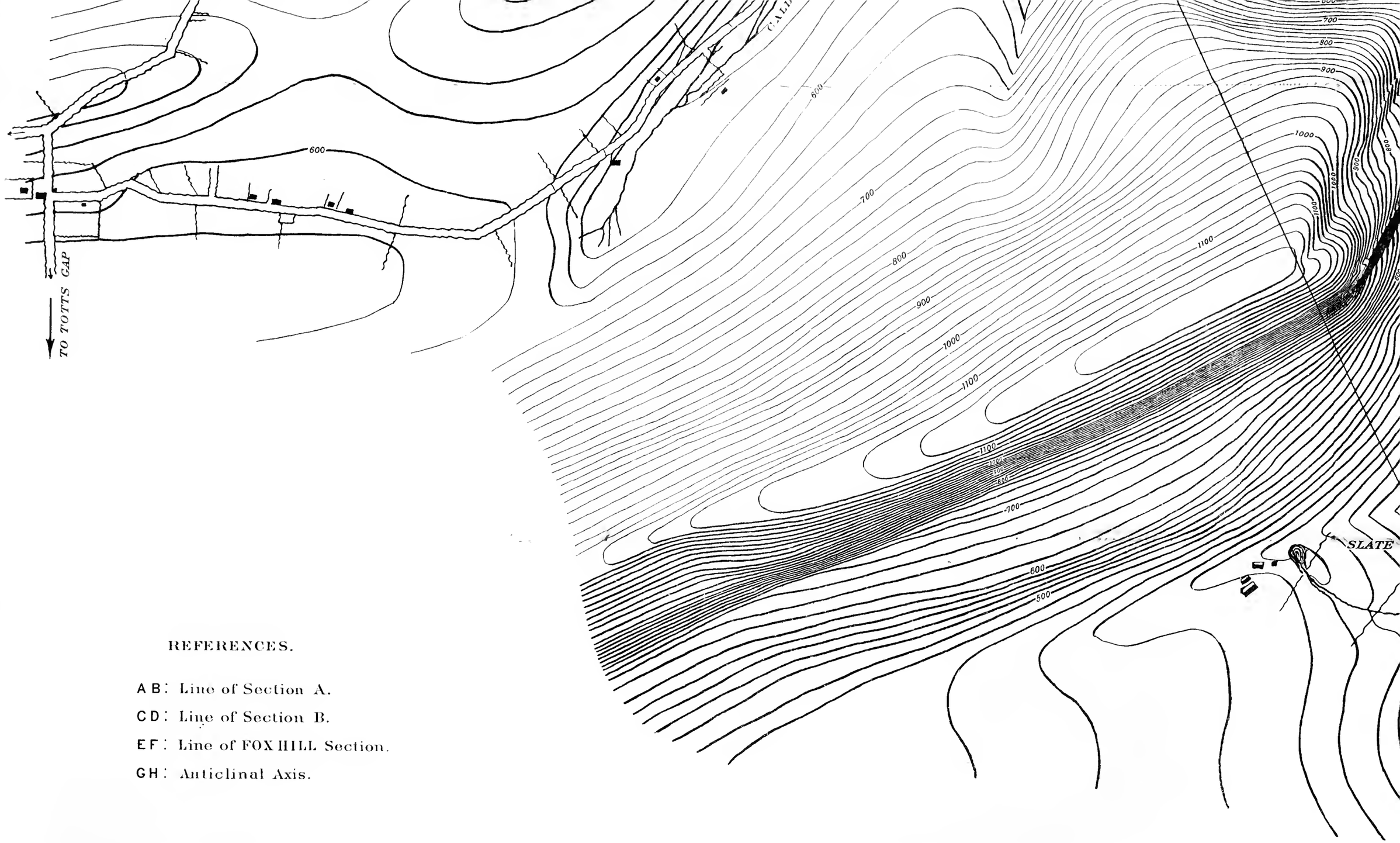
SLATE MANEY

SLATE

BROWNTOWN

SLATE

1300
1200
1100
1000
900
800
700
600
500
400
300
200
100



REFERENCES.

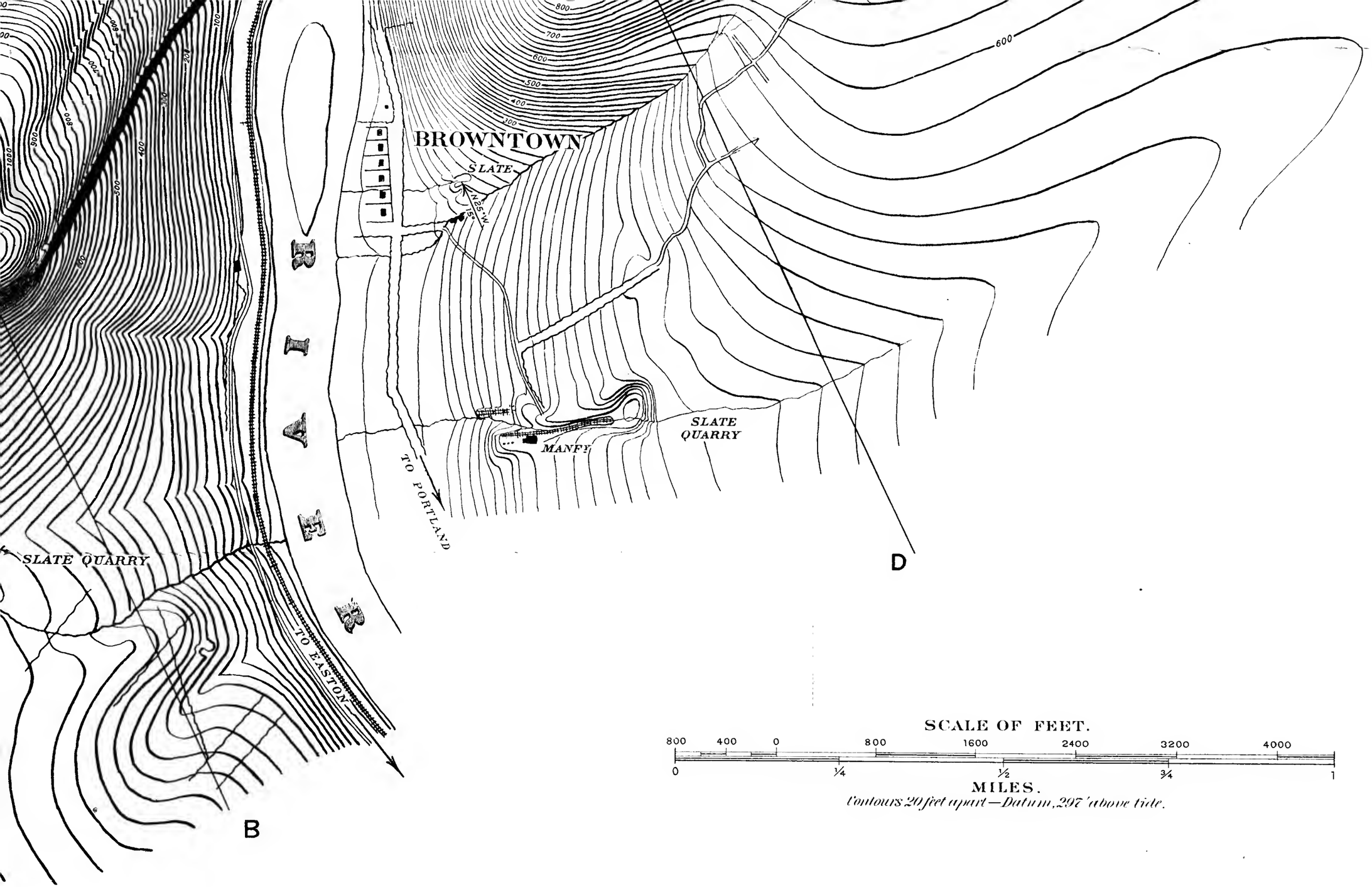
AB: Line of Section A.

CD: Line of Section B.

EF: Line of FOX HILL Section.

GH: Anticlinal Axis.

LANE S. HART, STATE PRINTER.



SCALE OF FEET.

800 400 0 800 1600 2400 3200 4000

0 ¼ ½ ¾ 1

MILES.

Contours 20 feet apart—Datum, 297 ′ above tide.