COMPARATIVE COLUMNAR SECTIONS CALCULATED ALONG VARIOUS CROSS-SECTION LINES IN HUNTINGDON COUNTY, PENNSYLVANIA.

T3

COMPARATIVE COLUMNAR SECTIONS CALCULATED ALONG VARIOUS CROSS-SECTION LIN

To Illustrate Report of Progress T3, 1885 by I.C.Wh

NOTE.

The figures in these columns are merely references to those in the text.

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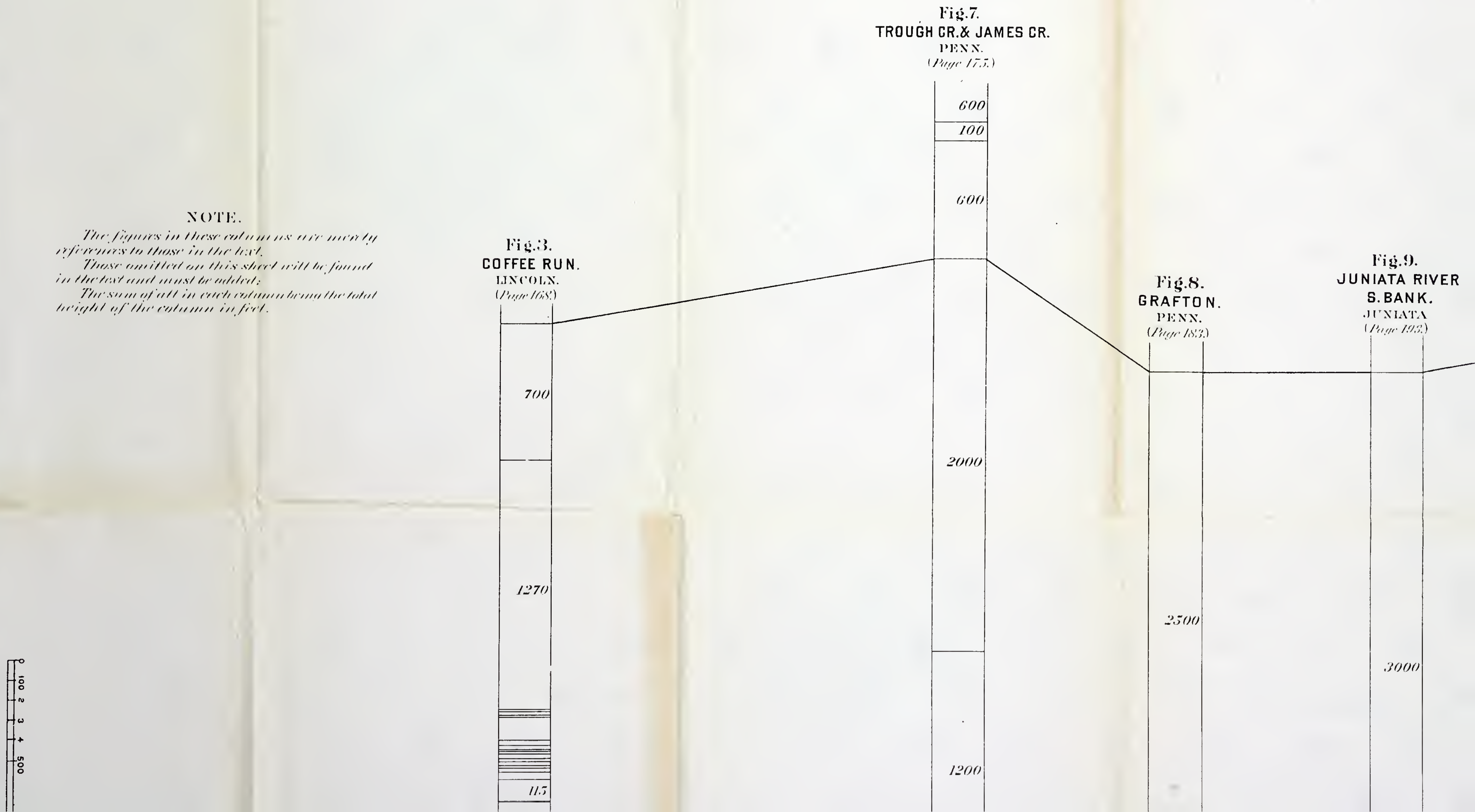
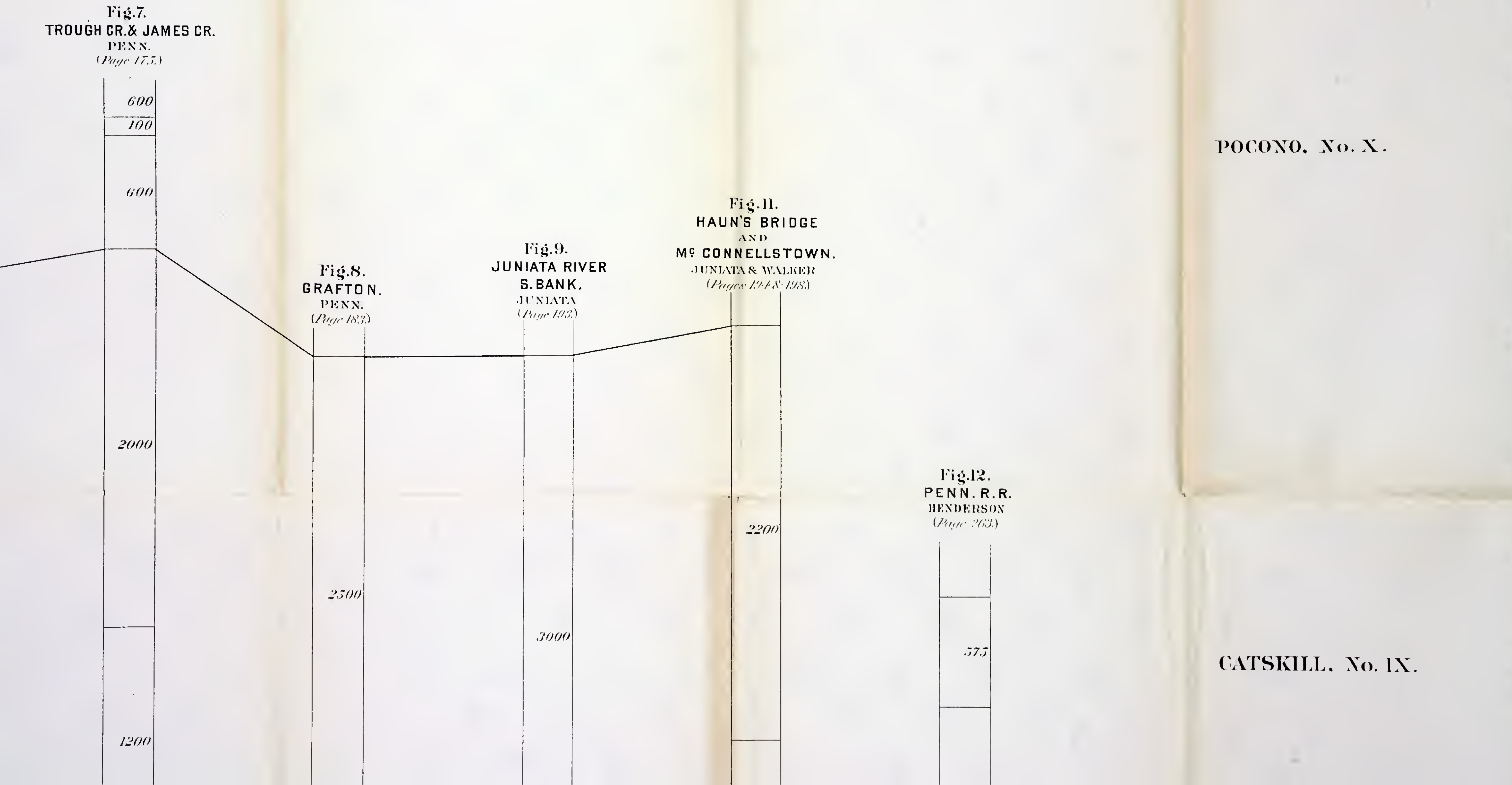
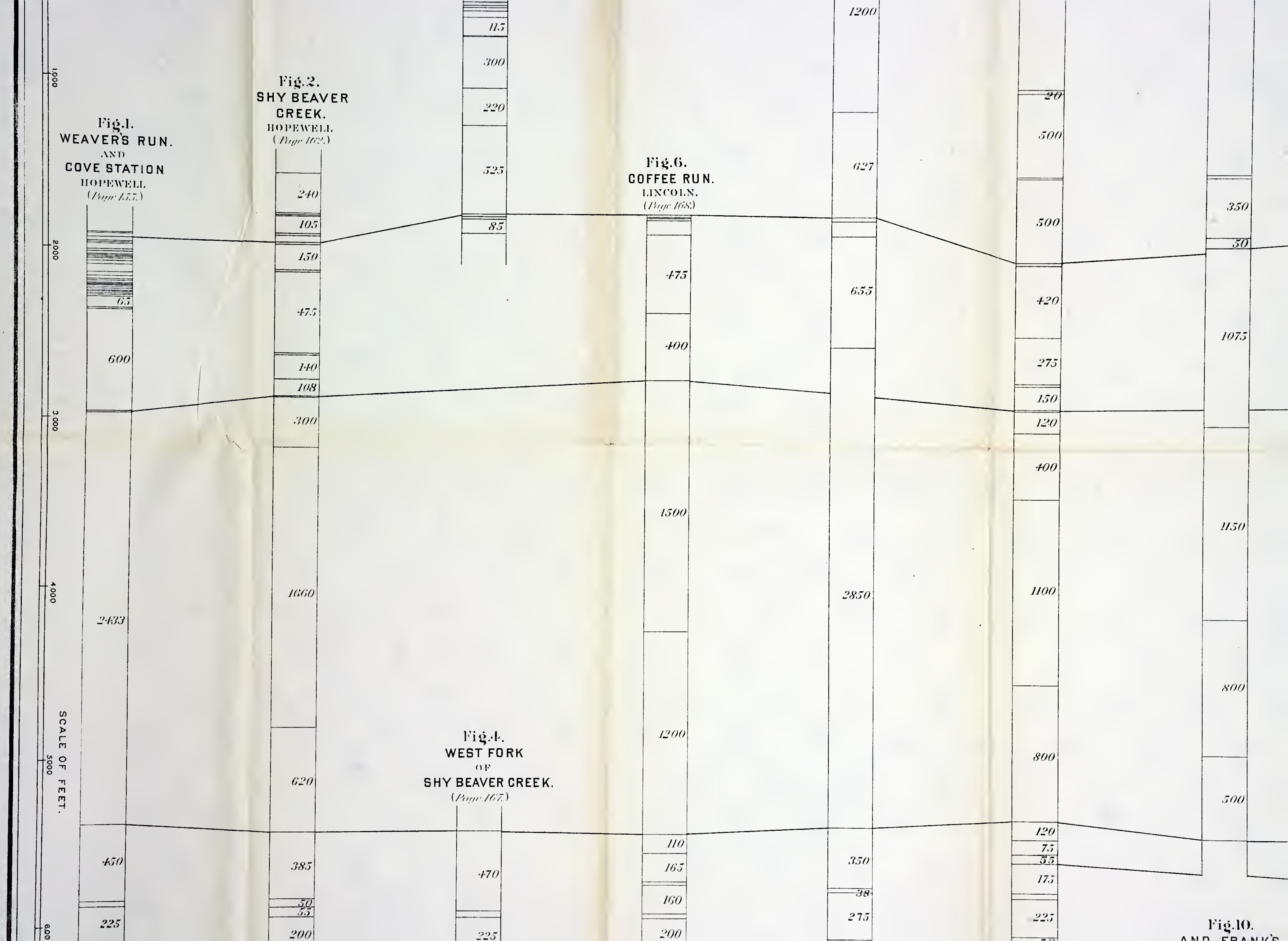


LATED ALONG VARIOUS CROSS-SECTION LINES IN HUNTINGDON COUNTY, PENNSYLVANIA.

To Illustrate Report of Progress T3, 1885 by I.C.White.

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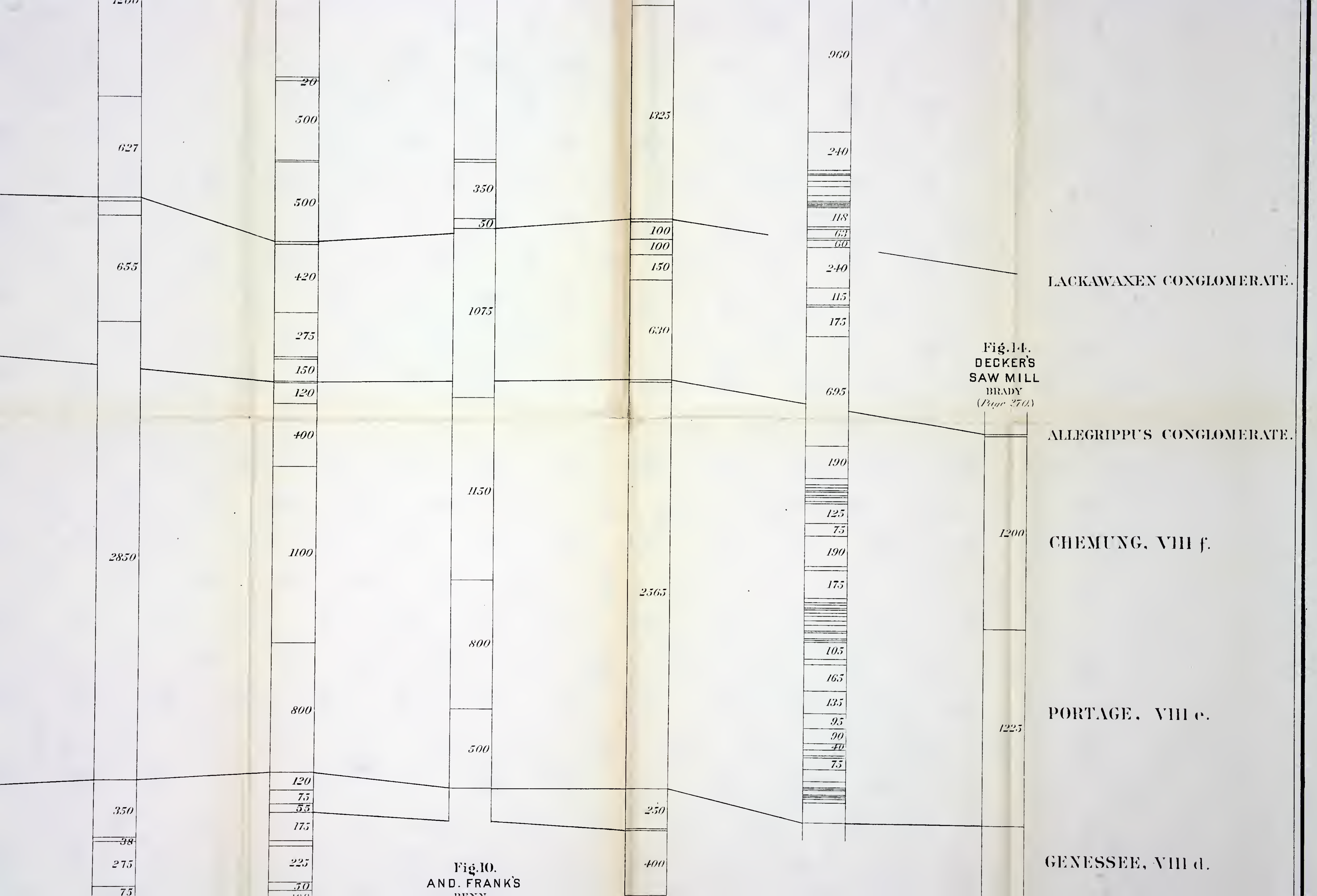
1000
2000
3000
4000
5000
6000
65
600
2433
450
225
240
105
150
475
140
108
300
1660
620
385
50
55
200
115
300
220
525
85
470
225
475
400
1500
1200
110
165
160
200
1200
627
655
2850
350
38
275
20
500
500
420
275
150
120
400
1100
800
120
75
55
175
225
350
50
1075
1150
800
500



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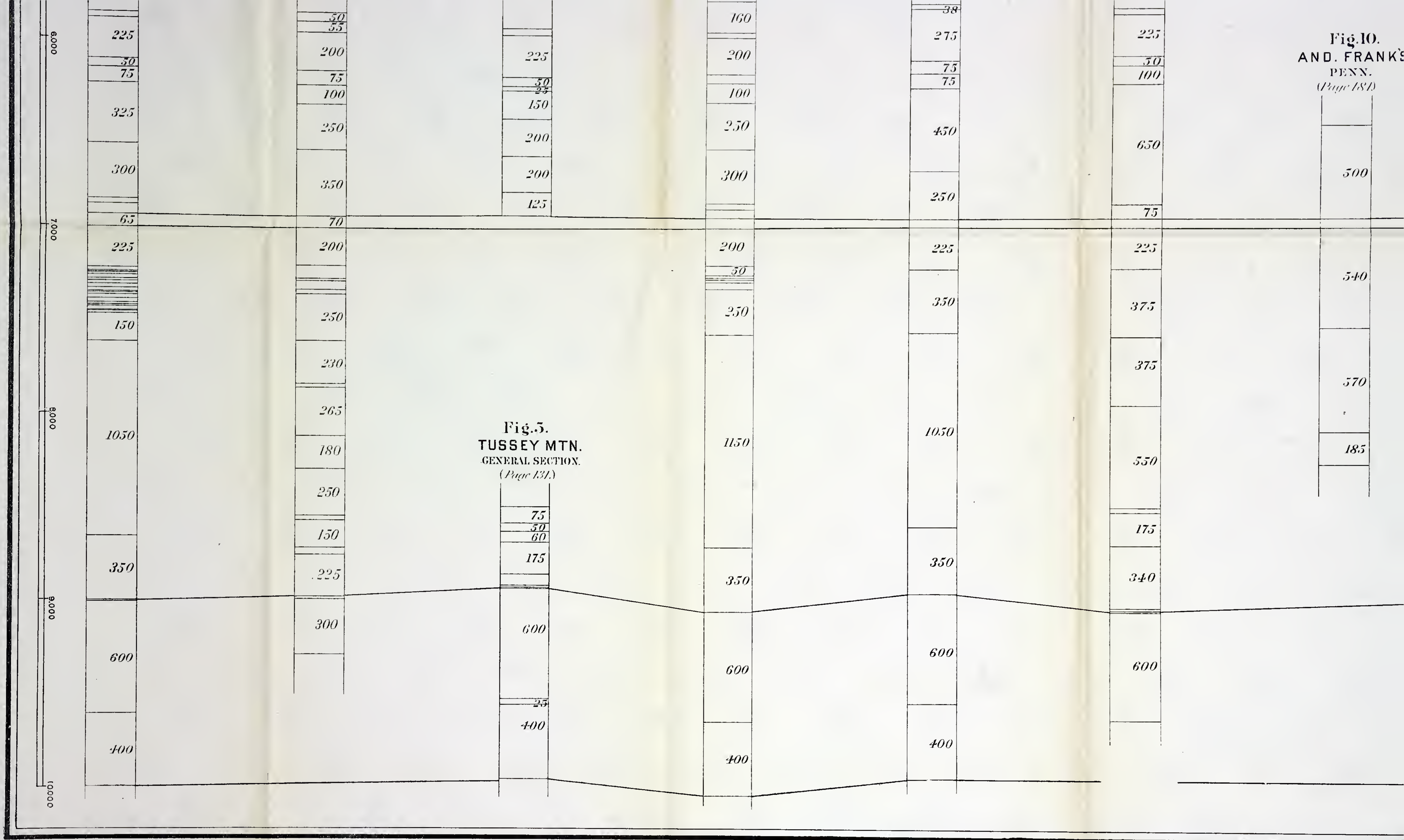
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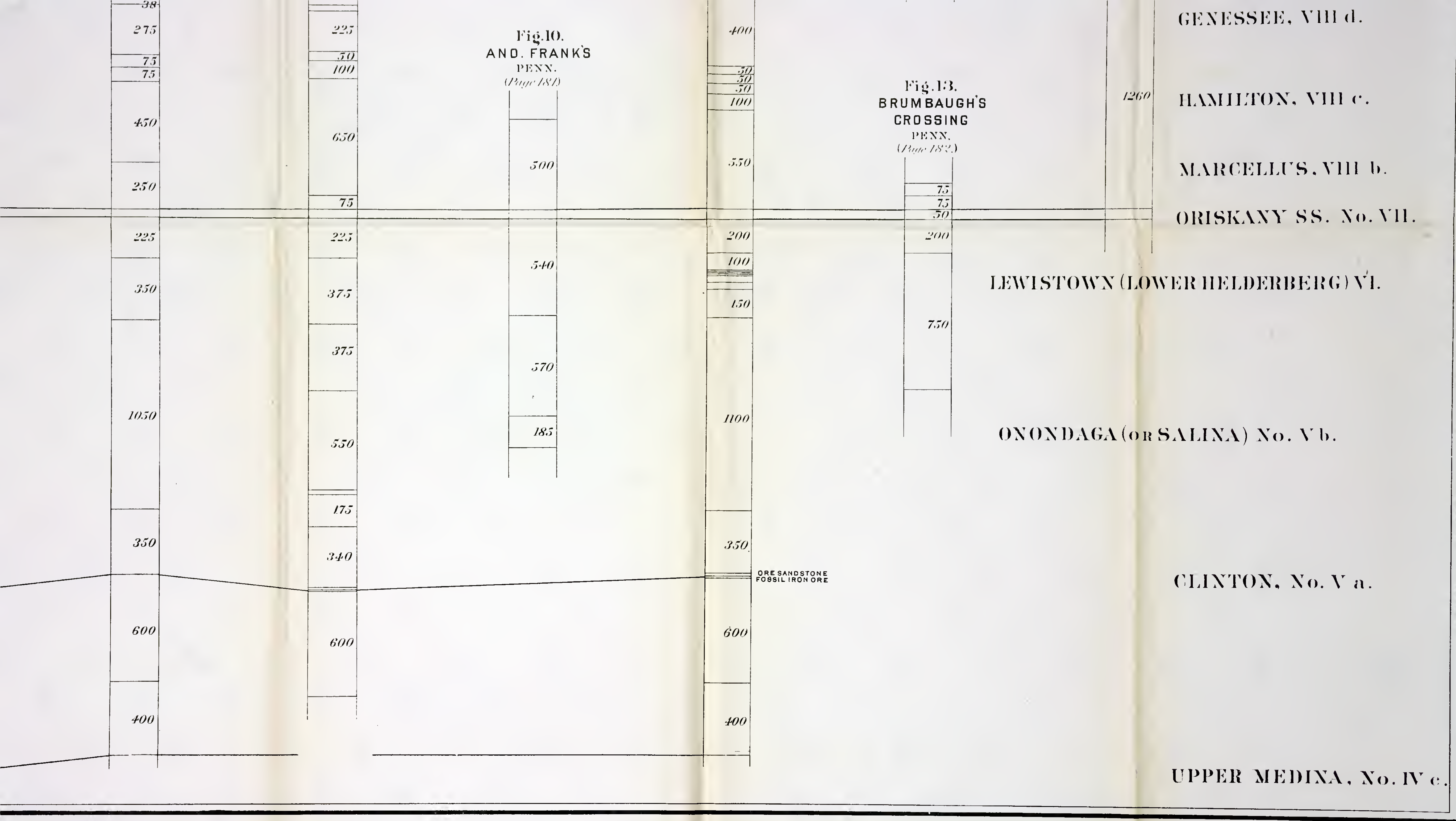
9000
10000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38
275
75
75
450
250
225
350
1050
350
600
400
225
50
100
650
75
225
375
375
550
175
340
600
500
540
570
185
400
50
50
50
100
550
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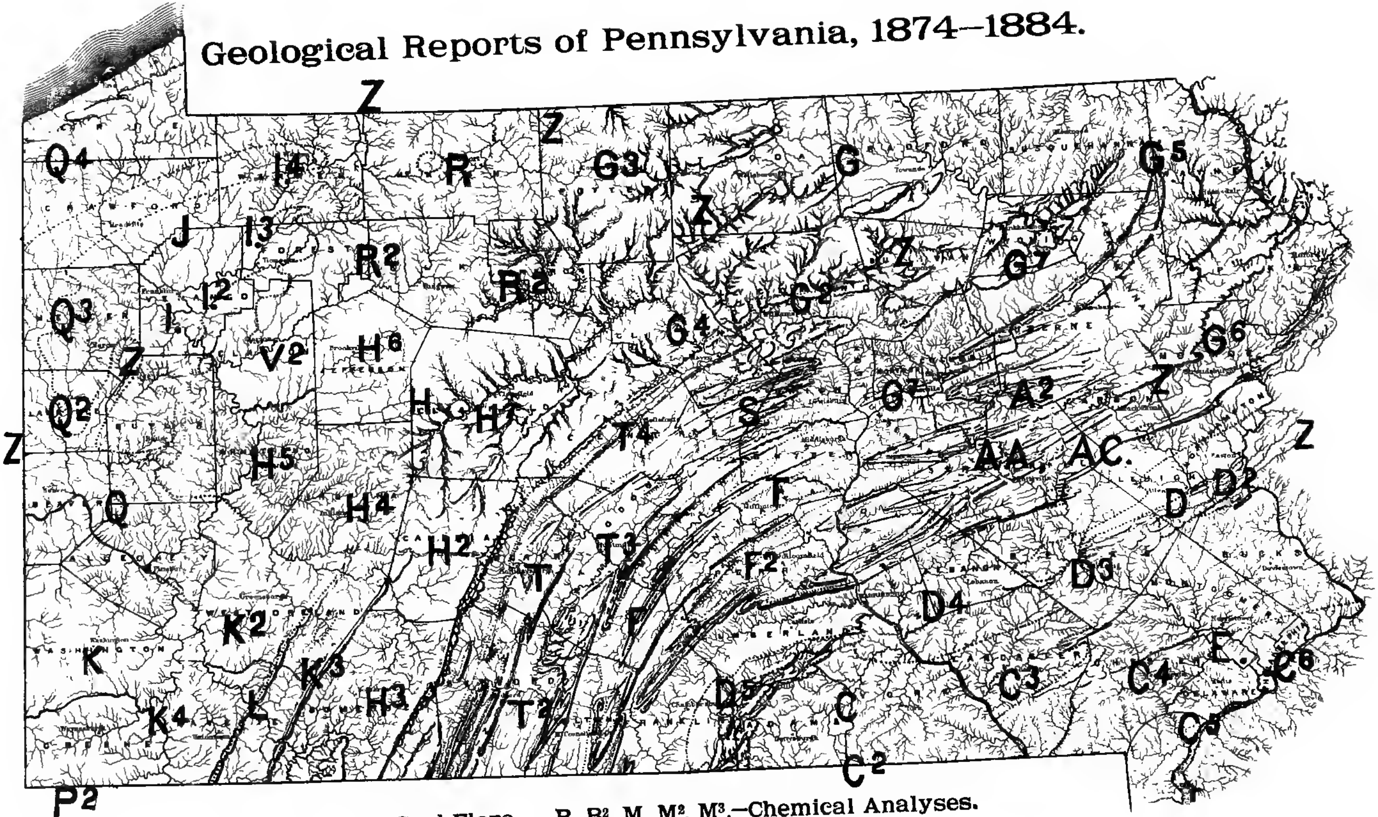
150
1100
350
600
400
75
75
50
200
750
1260

Geological Reports of Pennsylvania, 1874–1884.



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N.–Levels.

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SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

REPORT OF PROGRESS T[3].

THE

GEOLOGY

OF

HUNTINGDON COUNTY.

BY

I. C. WHITE

AND OTHER ASSISTANT GEOLOGISTS,

EDITED BY J. P. LESLEY.

ILLUSTRATED

BY

A COLORED GEOLOGICAL MAP OF THE COUNTY;
A TOPOGRAPHICAL MAP OF PART OF BALD EAGLE MOUNTAIN;
A TOPOGRAPHICAL MAP OF PART OF NITTANY VALLEY;
A SHEET OF COAL MEASURE COLUMNAR SECTIONS;
A SHEET OF PALÆOZOIC COLUMNAR SECTIONS;
TWO HELIOTYPE PAGE PLATES,
AND 64 PAGE PLATE MAPS AND SECTIONS.

HARRISBURG:
PUBLISHED BY THE BOARD OF COMMISSIONERS
FOR THE SECOND GEOLOGICAL SURVEY
1885.

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PREFATORY LETTER.

To His Excellency, Governor ROBERT E. PATTISON, *ex-officio Chairman of the Board of Commissioners of the Second Geological Survey of Pennsylvania:*

SIR: I have the honor to submit the following report on the geology of Huntingdon county, compiled from the descriptions and illustrated by the maps and sections of Prof. I. C. White, Messrs. C. A. Ashburner, C. E. Billin, E. B. Harden, O. B. Harden, R. H. Sanders, E. V. d'Invilliers, Franklin Platt, and myself, all of whom have at various times previous to the commencement and subsequently during the progress of the survey of the State done field work in this interesting county. It is in fact a continuation of Report of Progress F, published in 1878, which described and illustrated the geology of the Juniata and Aughwick valley in Snyder, Mifflin, and Huntingdon counties.

Black Log Mountain, Jack's mountain, Sideling hill, and parts of Trough Creek valley and Broad Top mountain are described in that report. From the data thus published I have extracted for this report what was necessary for comparison with the geology of the rest of the county.

I have first made a general statement of the topography of the whole county, its system of drainage, and surface features. Then follows a sketch of its geological structure; then a condensed revision of Prof. White's report on the whole series of formations, with reference to measurements and sections by other assistants.

Prof. White's special survey of the townships included between Tussey mountain on the west and Sideling hill on the east, exclusive of Barree and Jackson's townships which he did not survey, is described and illustrated in Chapter VI. And in this part of the book I give reduced copies of Ashburner and Billin's unpublished topographical map and cross sections of the northern part of the East Broad Top coal basin, and two local maps illustrative of the geology of the Shoup's Run coal-field; but other important local maps and sections made by myself in various parts of Broad Top are reserved for a special report on this important and very difficult coal region.

In the page plate map of the western part of Porter township, I have drawn enough of Morris township to show the remarkable structure of Tussey mountain, and the extraordinary error of the county and township maps in the "Atlas of Huntingdon county," by which the mountain, the loop, and the county line are distorted. This error would have been fatal to the right comprehension of the geology of Porter, West, and Morris townships but for the elaborate topographical survey of Blair county published in the atlas to Report of Progress T, in 1881; and it furnishes additional evidence if any were required of the urgent need of a complete topographical survey of the State.

Barree and Jackson townships I have described in the same chapter (VI) in their proper order, and included Mr. Billin's report of the fossil ore ranges and Greenwood furnace mines, properly belonging to his yet unpublished Report of Progress S on the Seven Mountains.

Returning to Jackson township I have described, in Chapter VII, the Stone Mountain fault, and given reduced copies of Mr. Billin's (unpublished) sections across the fault, of his map of the vicinity of Greenwood furnace to show the place of the fault, and of six of his thirteen sections across the Seven mountains, but only in skeleton, to explain the rise of the great basin eastward, and the cause of the zig-zags of the fossil ore ranges.

I describe, in Chapter VIII, Morris, Franklin, and Warrior's Mark townships, the Canoe Mountain fault, the Spruce Creek Tunnel fault, the exposures of limestone strata along the Little Juniata river the Bald Eagle Mountain faults, the anticlinal arches traversing Nittany valley, and the brown hematite ore mines of Warrior's Mark, Dry Hollow, and Kale Hollow. Little remained to add to my private report on these ores to Lyon, Shorb & Co. in 1872, the year before the commencement of the State survey; but what could be said in addition was furnished by Mr. d'Invilliers' recent report, just received. I have thought it unnecessary to repeat the geological descriptions of the formation already published in Mr. d'Invilliers' Report in Centre County, T[4], 1884. But I have added a short special memoir on the rate of erosion of the limestone country, by Prof. Ewing, for the value of which he is responsible.

In spite of the care which I have bestowed on the preparation of this report for publication numerous omissions and perhaps more or less serious errors may be discovered in it; but a vast amount of time and labor has been spent in making it a useful guide to the citizens of the county, whose natural and no doubt agreeable task it will hereafter be tc discover all its errors and supply its deficiencies.

As to the Broad Top region, I can only say that when my topographical map of it shall be finished by additional field work a very complete and satisfactory account of its geology can be prepared for publication, but not until then.

Respecting the colored geological map of the county, I must confess that it falls very far short of what such a map should be. The county is so extensive, so irregular, covers so many and such varied areas, is traversed by the outcrops of so great a number of formations and subdivisions of formations, and by so many arches, basins and faults, that nothing short of an entire year exclusively spent in tracing the contact lines would suffice to get the color belts exactly into their geographical places. Nor would any amount of time thus spent suffice until correct township maps be obtained; and these can only be furnished by a State topographical survey.

But an inherent difficulty in coloring geologically even a good map of the county must be noticed. There are no well defined limits to most of our formations; and the drawing of color belts is necessarily directed chiefly by the prejudices of each individual geologist in favor of his own method of subdividing the column of formations.

Thus Prof. Stevenson in his report on Bedford and Fulton (T[2]) preferred to fix the top of the Chemung formation at the *upper* of the two remarkable conglomerates which traverse middle Pennsylvania. Prof. White prefers in this report, as in his published reports on the north-eastern counties, to fix the top of the Chemung formation a thousand feet lower, namely, a hundred feet beneath the *lower* of the two conglomerates.

I have noticed in this report similar *differences of classification* (for they do not at all affect the observation of facts, and are therefore of very little importance) between the limits of the Pocono formation, top and bottom, fixed by Mr. Ashburner and by Prof. White. It is well for non-professional geologists to know that while professional geologists agree in their descriptions of the rocks, they differ in the special names by which to call them; and that the color belts on a geological map merely represent such names. To call a thousand feet at the top of the *Chemung* formation by the name of *Catskill*, does not change the nature of that mass of rocks in the least degree; it merely narrows the Chemung color belt and widens the Catskill color belt on the map that much.

J. P. LESLEY.

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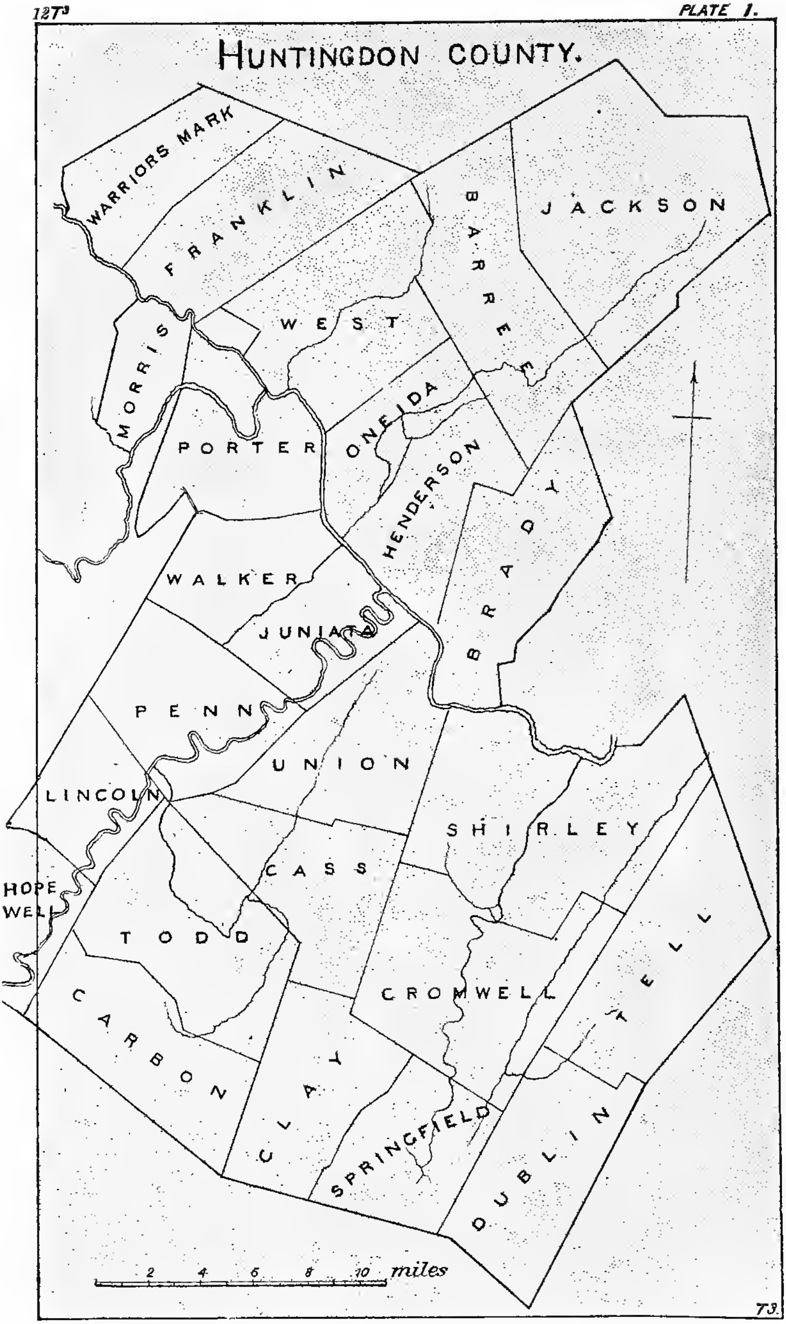
CHAPTER VII.


HUNTINGDON COUNTY.
WARRIORS MARK
FRANKLIN
JACKSON
BARREE
MORRIS
WEST
ONEIDA
PORTER
HENDERSON
BRADY
WALKER
JUNIATA
PENN
UNION
LINCOLN
HOPE WELL
SHIRLEY
CASS
TODD
CROMWELL
CARBON
CLAY
TELL
SPRINGFIELD
DUBLIN
2 4 6 8 10 miles
T3.

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Heliotype page plates.

Illustrations in pocket.

HUNTINGDON COUNTY:

CHAPTER I.

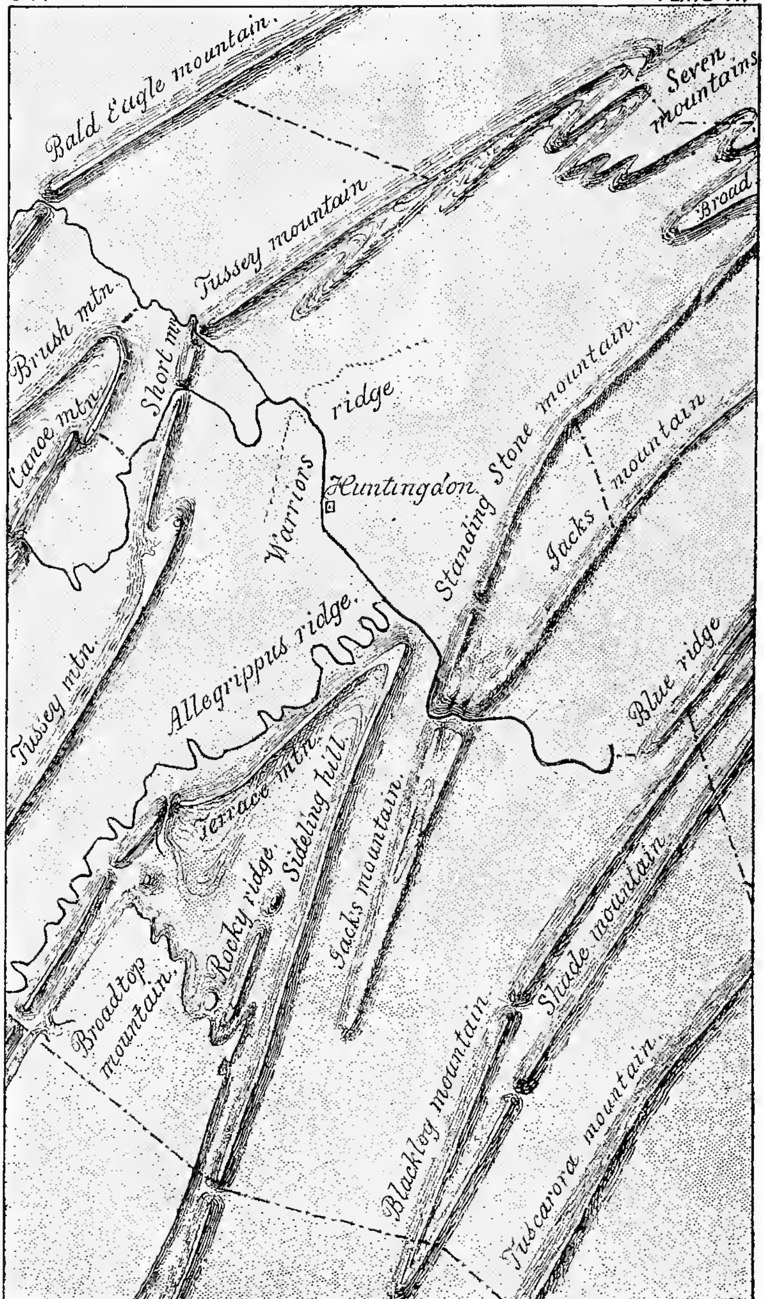
General description.

Huntingdon county occupies a large and irregular area in Middle Pennsylvania, lying south of Centre, east of Blair, north of Bedford, west of Franklin, and crossing the southern ends of Juniata and Mifflin counties.

Its western boundary follows the crest of Tussey mountain 21 miles; crosses Canoe valley to Canoe mountain; follows its crest to the Little Juniata river; ascends the river to Tyrone gap, and follows the Bald Eagle mountain crest 8 miles to the Centre county corner.

Its northern boundary starts at the Bald Eagle mountain and crosses Warrior Mark and Spruce Creek valleys, diagonally, 9 miles, to Tussey mountain; follows it 9 miles, and zigzags across the Seven mountains, 9 miles (in an air line,) to Standing Stone mountain, at a point 8 miles northwest of Lewistown.

Its eastern boundary follows Stone mountain crest, southwestward, 11 miles; crosses Kishicoquillis valley, 4 miles, to Jack's mountain back of McVeytown; follows Jack's mountain crest, 9 miles, to the narrows of the Juniata river; descends the river to the bend; keeps on eastward across Black Log mountain, and Black Log valley, in all 10 miles, to the top of Shade mountain; follows the crest, northward, one mile; then strikes diagonally across Tuscarora valley,


Bald Eagle mountain.
Seven mountains.
Broad
Tussey mountain
Brush mtn.
Short mt.
Canoe mtn.
ridge.
Warriors
Huntingdon
Standing Stone mountain.
Jacks mountain
Jacks mountain
Tussey mtn.
Allegrippus ridge.
Blue ridge
Terrace mtn.
Sideling hill.
Rocky ridge.
Jacks mountain.
Shade mountain
Broadtop mountain.
Blacklog mountain
Tuscarora mountain
T.S.

7 miles, to Tuscarora mountain; and, finally, follows the crest of Tuscarora mountain, southward, 16 miles to the northeastern Bedford county corner.

Its southern boundary is a tolerably straight line about 28 miles long, from Tuscarora mountain, across Cabin valley, Shade and Black Log mountains, Great Aughwick valley, Sideling hill, Ground Hog valley, Broad Top mountain, Terrace mountain, and the Raystown branch, to the crest of Tussey mountain.

Huntingdon county was set off from Bedford county, September 20, 1787, about four years after Bedford had been constituted out of Cumberland, and twenty-seven years after Cumberland had been set off from Lancaster.

Its area is given by Gray & Walling as 840 square miles, or 537,600 acres; by the Census report of 1880, as 900 square miles; and by Walker's statistical tables as only 730.

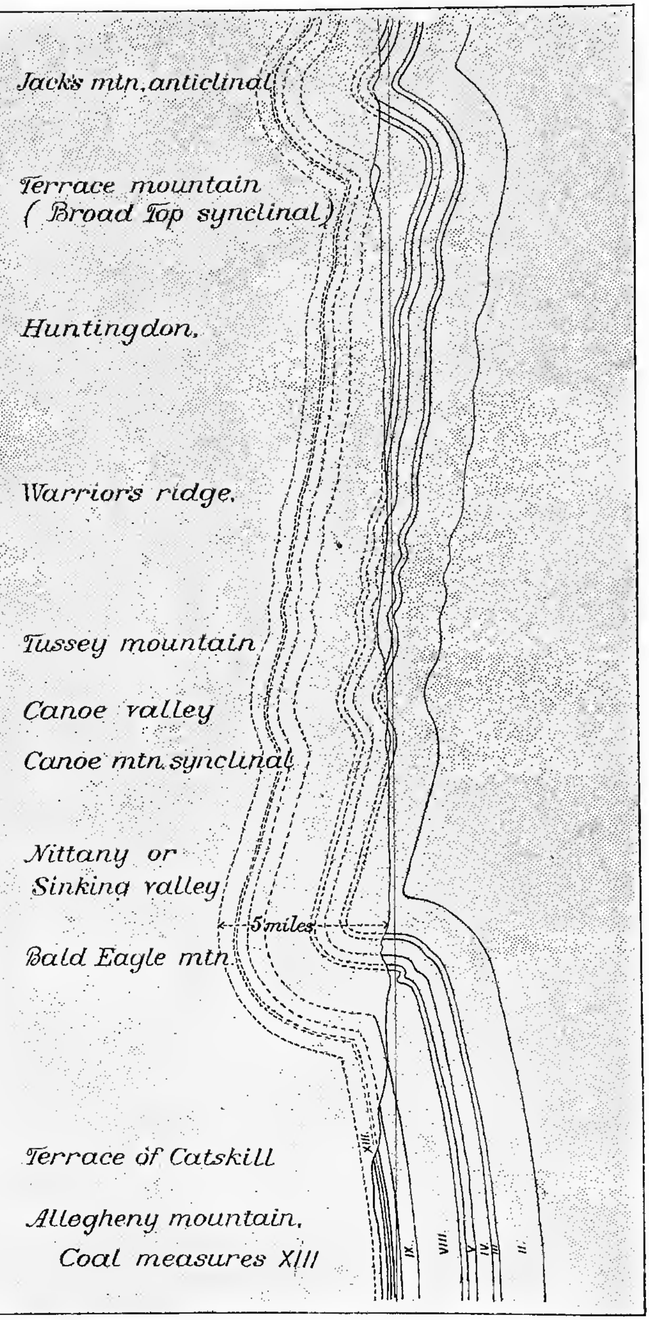
By the Census reports it had in 1860, 28,100; in 1870, 31,251; and in 1880, 33,954 inhabitants; of whom 33,674 were whites, and 7,251 native white males.

In 1880 its production of maize in bushels (and acres) was 760,000 (21,517); of wheat, 354,000 (33,610); of oats, 231,000 (11,157); of Rye, 53,300 (6,955); of buckwheat, 31,000 (3,282); of barley, 4,200 (271.)

It is subdivided into 25 townships, of which a geological description is given in this report of 13, viz: (1) *Hopewell*, (2) *Lincoln*, (3) *Penn*, (4) *Walker*, (5) *Juniata*, (6) *Porter*, (7) *West*, (8) *Oneida*, (9) *Henderson*, (10) *Union*, (11) *Cass*, (12) *Todd*, and (13) *Carbon*.

The rest of the county embraces (14) *Norris*, (15) *Franklin*, and (16) *Warrior's Mark*, west of Tussey mountain; (17) *Barree* and (18) *Jackson* in the north, between Tussey and Standing Stone mountains; (19) *Brady* in Kishicoquillis valley; (20) *Shirley*, (21) *Cromwell*, (22) *Springfield* and (23) *Clay* in the Aughwick valley; and (24) *Tell* and (25) *Dublin* in Tuscarora (Shade, or Cabin) valley next to Franklin county. (See Plate I.)

The townships described in this volume occupy the western half of the county; between Tussey mountain on the



Section of Palæozoic formations along the Little Juniata river.

west and Jack's and Stone mountain on the east; from the Bedford county line on the south to Barree township line on the north; the Huntingdon valley, Warrior's ridge, Trough Creek valley, and part of Broad Top.

The points of chief geological interest therefore are . the Clinton fossil ore range at the foot of Tussey; the Oriskany pulpit-rock sandstone range of Warrior's ridge; the Marcellus brown hematite ore range of the Yellow Creek mines; the Allegrippus, Chemung and Catskill ranges; and the Broad Top coal field.

Drainage.

Huntingdon county belongs wholly to the water-basin of the upper Juniata river. None of its rainfall flows into the Potomac except at one or two points on its southern line. (See Plate II.)

The Juniata river is constituted in the heart of the county by the union of three branches:—the Frankstown branch from Blair county, the Raystown branch from Bedford county, and the Little Juniata and Bald Eagle creek from Centre county.

The Frankstown branch enters the county by a gap in Tussey mountain at Water Street and makes a great bend below Alexandria. The old State canal from Harrisburg to Hollidaysburg followed this branch; but its bed is now occupied by a branch of the Pennsylvania railroad.

The Raystown branch flows from the south, along the foot of Terrace mountain, in so meandering a manner that although the air-line distance from its crossing the Bedford county line to its junction with the main Juniata (4 miles below Huntingdon) is only 21 miles, a measurement of the distance in the bed of the Raystown branch would make it nearly 50 miles. This peculiar crookedness of current is due to the fact that it flows all the way along a belt of the soft *Catskill* formation (No. IX), crossing incessantly from side to side, and rebounding from the ridges of Upper *Chemung* sandrocks on the left, to the solid *Pocono* sandstone mass of Terrace mountain on the right.

The Little Juniata, on the contrary, is comparatively straight, crossing all the formations at right angles to the beds, and flowing through Tyrone gap in Bald Eagle mountain, and Spruce Creek gap in Tussey mountain, to join the Frankstown branch a mile above Petersburg, or 6 miles above Huntingdon.

Of the principal smaller rivers, *Spruce creek* enters the Little Juniata behind Tussey mountain; and *Shaver's creek* in front of it. *Standing Stone creek* drains the country back of Stone mountain into the Juniata at Huntingdon. *Crooked creek* drains Walker township into the river opposite Huntingdon. *Goslin run* drains the south end of Kishicoquillis valley into Mill creek, and *Mill creek* into the Juniata 6 miles below Huntingdon.

Trough creek drains the red shale synclinal trough surrounding Broad Top mountain, through a gap in Terrace mountain, into the Raystown branch, half way between Huntingdon and the Bedford county line. The course of this creek is very remarkable. It heads on the south slope of the high knob which overlooks Huntingdon; flows south down the center line of the trough between Sidling hill and Terrace mountain, 12 miles; turns northwest and flows out through a gap to the river, 7 miles; and then by the river back to within a mile of where it started; having made a complete circuit of at least 45 miles, and a descent of 1000 feet.

Little Trough creek heads upon the East Broad Top mountain plateau and cuts a remarkable ravine to the base of the mountain, before it joins Trough creek. The topographical map of the region made by Messrs. Billin & Ashburner can alone make this curious phenomenon intelligible. (See Plate III.)

Aughwick creek drains all the southern part of the country, northward, into the great bend of the Juniata, 4 miles below Mount Union.

Tuscarora creek has its headwaters, flowing north, along the eastern border of the county.

Mountains.

The mountains of Huntingdon, like those of the neighboring counties (which are merely their continuations along the strike of the rocks) fall under three heads, and cannot be described without reference to the three great sandrock formations Nos. IV, X, and XII of the Palæozoic series, of which these mountain ridges are the upturned edges at the present general surface of the country.

To understand this the reader is referred to the account of the geological structure of the county further on.

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1. *The mountains of No. IV, Bald-eagle, Tussey, Stone, Jack's, Blacklog, Shade, Tuscarora,* have all the same shape and average height; are all sharp-crested ridges, running for miles in nearly straight lines, and uniting with one another at their ends—if not in this, then in some neighboring county.

Thus *Bald-eagle mountain* runs northeast through Centre and Clinton counties into Lycoming, and returns to Huntingdon county as Tussey mountain. It also runs southwest many miles into Bedford county and returns as Tussey mountain. Thus it incloses Warrior's Mark and Franklin townships, and large areas of similar limestone valley land to the northeast and southwest.

Tussey mountain can be seen on the county map running northeast around Jackson township and returning as Stone mountain. Where it makes the turn it loses its name and is called the *Seven mountains* of Clinton county.

Stone mountain unites with Jack's mountain at the Juniata river below Huntingdon. South of the river the double mountain (called Jack's mountain) keeps on southward through Union and Cass, and ends in Clay township.

Blacklog and Shade mountains, separated only by a narrow valley, run side by side across the county, and come together in two points, like the stem and stern of a canoe; one in Juniata county near Mifflintown, the other in Fulton county near Fort Littleton.

Tuscarora mountain runs east all the way to Millerstown, in Perry county, and returns as the *Blue* (*North*) mountain of Franklin county.

The rib-rocks of the Bald-eagle mountain sink underground westward, underlie all western and northern Pennsylvania, and come up to the surface in the States of Ohio and New York.

But the rib-rocks of Tussey mountain sink eastward, pass under Huntingdon valley and the Broad Top coal region, and come up again in Stone and Jack's mountains. They underlie the town of Huntingdon at a depth of about a mile; and they underlie the village of Coalmont in the Broad Top coal field at a depth of nearly three miles, say 14,000 feet. (See table of formations at the end of Chapter V.)

Stone and Jack's mountains come together because their rib-rocks rise to the surface and immediately roll over and go down again to a depth of a mile under Aughwick valley, and then rise again to the surface in Blacklog mountain.

In like manner the rib-rocks of Shade mountain sink to a great depth beneath Tuscarora valley, and rise again to the surface in Tuscarora mountain.

All these mountains are therefore one and the same, made out of the same rib-rocks, and therefore of the same general shape and height along their whole extent.

The average height of the crest above the valley is usually less than 1000 feet, and above tide nearly 2000 feet.

Tyrone station is 907′ A. T., and the *Bald-eagle crest* just south of it 1900′ A. T.

Spruce Creek station is 777′ A. T., and the *Tussey mountain crest* just south of it 1840′ A. T. But the knob in Walker township rises to 2300′ A. T. The crest slowly sinks (southward) to 2200′ and 2100′; runs at 2000′ several miles, rises suddenly to 2200′ and continues at 2300′, 2200′, and 2100′ to the county corner. (See key map in Atlas to report T.)

Jack's mountain crest, in Mifflin county opposite Lewistown, is 1760′, further on, (southward,) 1823′; back of McVeytown, 1894′; approaching the Juniata, 2212′; 1¾ miles northeast of the Mt. Union bridge, 2354′; the level of the bridge being 584′ A. T.

Jack's mountain crest in Huntingdon county (2¼ miles northeast of Three Springs) is 2220′, while the railroad track at Three Springs in the valley is only 717′ A. T.

Black-Log mountain crest on the north side of the Orbisonia gap is 1727′; on the south side, 1584′; Orbison's mill at Orbisonia being 654′ A. T. (See report F, pp. 285 to 287.)

This will give a good idea of the usual height of all these mountains of IV. But it must be remembered that the valleys which they surround have a general surface level several hundred feet above that of the rivers which flow through them, and that these rivers flow at their own special levels from valley to valley through gaps in the mountains cut down from crest to base.

It is a remarkable fact that a mountain of IV is higher when its rocks dip 45° than when they are vertical, and it is on this account that Tussey mountain is usually higher than Bald Eagle mountain.

It is also true that where two mountains are united in an arch, like Jack's and Stone in Huntingdon county, the crest is higher than where each mountain runs on alone; and this fact is specially evident at the brow and stern of a mountain canoe, or at the point of a zigzag like the knob in Walker township mentioned above.

All these peculiarities can be explained by paying attention to the formations which make the mountain, and the way the rock-beds are folded.

The shape of a mountain of IV is not quite the same in the western, middle and eastern parts of the county; for the Bald-eagle mountain has two crests, of nearly equal height; Tussey; Stone, Jack's, Black Log and Shade, one high crest and another lower one, making a bold terrace on one side of the mountain; while Tuscarora (and the Blue mountain also) has only the one crest and little or no terrace at all.

The reason for these peculiarities is a very simple one. Formation No. IV in the region of the Allegheny mountain has three subdivisions, *Upper, Middle and Lower;* the upper and lower being hard, massive white sand rocks; the middle division being softer red sandstone and shale beds.

And of the two hard divisions the upper one (*white Medina*) is the most massive, and therefore forms the main crest of the mountain; the lower one (*Oneida*) forms the crest or brow of the terrace; and the middle soft (*red Medina*) forms the step of the terrace, often worn into concealed ravines.

This triple division of formation No. IV gradually disappears going southeastward towards the Cumberland valley. The middle (*red Medina*) changes; its shales become sandrocks; and all three divisions fall practically into one; the whole formation consisting of a series of thick sandrocks, one of which sometimes makes the crest, and sometimes another; but no terrace is possible.

The two extremes of this change are seen in the Bald-eagle mountain at the west border, and in Tuscarora mountain at the east border of Huntingdon county; and the intermediate steps of the change are seen in the mountains between them; but not so much in Tussey as in Stone, nor so much in Jack's as in Black-Log and Shade.

The terrace side of Black-Log faces east, that of Tussey west, that of Stone east, that of Jack's west, that of Black-Log east, that of Shade west, that of Tuscarora east.

This terrace side is the lower or bottom-rock side. in all cases, and overlooks the limestone valley. It may be called the No. III side.

The upper or top-rock side is of course the reverse, and is characterized by a longer and gentler slope, by a smooth red soil, and by a range of fossil iron ore. It may be called the No. V side, because it is made by Formation No. V (*Clinton* and *Salina* or *Onondaga.*)

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2. *The mountains of X*, *Terrace mountain*, and *Sideling hill*, are the only ones of this kind in Huntingdon county. To find others like them one must go into eastern Pennsylvania; to the Cove mountains in Perry county, and the mountains which surround the anthracite coal fields.

Terrace mountain and *Sideling hill* surround in a similar manner the Broad Top coal field. They unite in a high point at the Juniata river below Huntingdon. From this point Terrace mountain runs first southwestward and then southward past the west side of Broad Top, into Bedford county; Sideling hill runs southward past the east side of it into Fulton county; the two reunite and run on to Maryland.

The terrace from which Terrace mountain is named differs in appearance from the terrace of a mountain of IV, although it has a similar geological cause. The crest of the mountain is the edge of a great gray sandstone rib-rock, called Formation No. X (*Pocono;*) the terrace is made by hard red sandstone beds in the underlying formation No. IX (*Catskill.*) Had the Catskill formation one thick solid mass of sandstone instead of many thin separate red sandstone beds, the terrace of a mountain of X would be like the terrace of a mountain of IV, scolloped by scores of small double-headed ravines, cutting the brow of the terrace off from the backbone of the mountain, and making it stand out, as a separate feature from the general slope of the mountain. As the case stands, however, the mountain of X has a steep slope near the top, and then a flatter place, and then another steep slope lower down, ending in a long slope to the foot. The terrace of Terrace mountain is just as visible in the landscape when seen from Tussey mountain, as is the terrace of Tussey mountain when seen from Bald-eagle mountain; but its aspect is so entirely different that the geologist recognizes the different structure of the two at a glance.

The height of the mountains of X does not exceed that of the mountains of IV; but the country at the west base of Terrace mountain is higher and more rolling than the limestone plain at the west base of Tussey mountain, and therefore the crest line of Terrace does not look so high as the crest line of Tussey. No exact measurements have been made of the height of Terrace mountain; but Sideling hill is the same as Terrace mountain, and its crest height is known, at one point, viz: 1360′, over the East Broad-top railroad tunnel; and 1517′ at the road north of the tunnel; the tunnel itself being 1232′ A. T.*

The steepness of the sandstone rib-beds in Sideling hill should make it lower than Terrace mountain. When the two mountains come together, the end-knob overlooking the Juniata is very high, probably over 2000′ A. T., but it has never been accurately measured. The prospect from its top over the Huntingdon valley westward and northward is very fine.

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3. *The mountain of XII, Broad Top*, is the only mountain of this kind in Middle Pennsylvania. To find others like it one must go to the Anthracite coal region. But there is a marked difference between the conglomerate ridges which surround and support the great anthracite coal basins and the oval patch of high land called the Broad Top in Huntingdon county. The nearest like it is the mass of mountain land on top of which lie the Beaver meadow, Dreck creek, Hazleton, and Black creek anthracite basins, the encircling brow of which is formed by No. XII (*Pottsville conglomerate*) there, as here in Broad Top, only 200 or 300 feet thick. At Pottsville No. XII is 1000 feet thick, and therefore forms a separate mountain.

There is no terrace to Broad Top. From the top edge of solid rock the mountain-side slopes steeply down all round to the bottom of a valley hollowed out in No. XI (*Mauch Chunk red shale*) 400 to 500 feet below.

The height of Broad Top mountain has been determined in past years at many hundred points. The upper stations of the East Broad Top railroad are on nearly the highest ground—Robertsdale, 1785′; Terminus, 1817′ A. T.

A long prong of conglomerate runs north from the main mass of mountain, and is called locally Rocky hill. It is separated from the south wall of the Broad Top mountain, called Wray's hill; and on it there is a high knob 2304′ A.

*In the Pipe line survey (See tables below) the summit of Terrace mountain at some undescribed point north of Broad Top, is called 1684′; Little Trough creek 1250′; and Sideling hill summit 1652′. This shows at least the nearly equal height of the two crests; and that Trough creek Valley is excavated only 400 or 500 feet beneath them.

T. (overlooking Cook's station, E. B. T. R. R., which is 1541′ A. T.) which is called *Round Knob.* (See Report F, page 288.)

Round Knob, in the center of Broad Top mountain (but in Bedford county) is given by Prof. Stevenson as 1990′; and the summit at the head of Six-mile run as 1805′ A. T. (See Report T^2, page 6.)

The back-bone summit of the mountain is 2054′; the Mountain House hotel in Broad Top city, 1997.2′; the Church at Cross-roads, 1996′; Trough creek at the road crossing, 1848′; the east brow of the mountain (Wray's hill) at the road leading down to Sideling gap, 2151′; and New Granada in the red shale valley at the foot of the mountain at the gap, 939′. The steep slope of this *mountain of XII*, then, on its eastern side, is nearly 1200 feet. (See Report F, page 288.)

Minor ridges and valleys.

The valleys of this part of middle Pennsylvania are as varied as its mountains. There are valleys of limestone (No. II,) valleys of red shale (No. V,) and valleys of gray shale (No. VIII.)

Nittany (Spruce creek) valley.

Warrior's Mark and Franklin townships stretch across the broad, rolling, cavernous (and therefore more or less waterless) valley of *Cambro-Silurian limestone, No. II*, between Bald-eagle and Tussey mountains. It has a border of *Utica and Hudson river slate, No. III*, making a terrace in front of each mountain, behind which many pairs of small runs meet and flow down, through the terrace, into the valley.

The limestone formation being more than 6000 feet thick, and containing several subordinate sandy formations, two or three indistinct ridges, scarcely visible above the general level of the valley, run lengthwise of it, the principal one being called the Barrens. (See Report T^4.)

Spruce creek, the main stream of the valley, keeps pretty close to the foot of the terrace of Tussey mountain and enters the Little Juniata near the gap. It receives the drain-


WATER STREET
1000
Topographical Map
of
Water-Street Narrows.
Contours 20 ft. apart
by R. H. Sanders
Scale 3200 ft. to an Inch.
T3.

age of the Bald-eagle side of the valley, by means of *Warrior's Mark creek*, which crosses the valley and the two townships nearly at right angles.

Logan's run flows along the foot of Bald-eagle terrace about 4 miles, into the Little Juniata at the Tyrone gap.

Canoe valley.

Morris township covers the continuation of the Spruce creek limestone valley south of the Little Juniata between Canoe mountain and Tussey mountain. But while the Spruce Creek valley is 7 miles wide, Canoe valley (its continuation) is only 2½ miles wide. But it has two terraced mountain walls just the same, Canoe mountain taking the place of Bald-eagle mountain. The flow of Canoe valley is, however, considerably higher above the river; and as its rocks are very steeply upturned, half of them dipping northwest under Canoe mountain and half dipping southeast under Tussey mountain, the whole 6000 feet of limestone No. II comes here also to the surface.

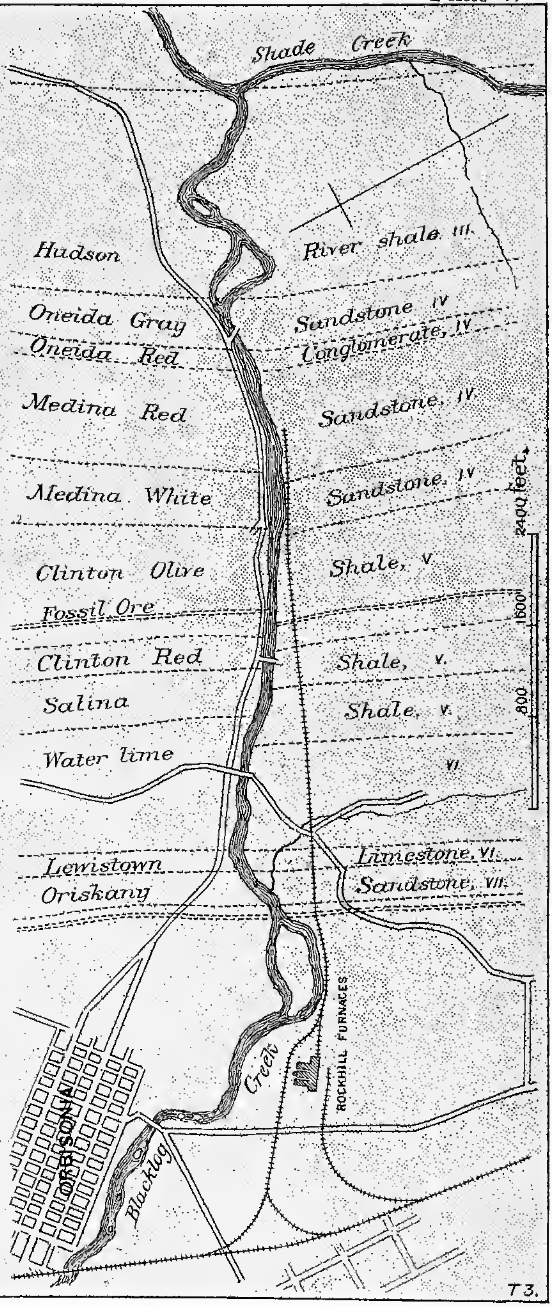
The Frankstown branch, or main Juniata river, flows through this township and out through Tussey mountain by a gap of its own, at Water Street. Both rivers cut their beds from 300 to 400 feet below the general level of the valley floor, in other words they are bordered by limestone hills of that height. (See the topographical map in Report T.)

Canoe mountain is at its end 2200′ A. T.

The two knobs of its end terrace (overlooking the Little Juniata) are 1660′ and 1620′; the next knob south facing Canoe valley, 1520′; the next, 1680′; the two little ones opposite Ætna furnace, 1440′; the long terrace opposite Yellow Springs, 1500′; the next long terrace running to the Juniata river 1600′ above tide.

The highest part of the floor of the valley, a mile or two south of the Little Juniata, is 1020′; the highest west of Water Street, 1060′; the round hill to the west of the road half way between Water Street and Yellow Springs, 1160′; that on the east of the road. 1200′; the hill between Fox run and Church run, (northwest) back of Ætna furnace,

Transverse fault through Blacklog Mountain gap,
at Orbisonia in Huntingdon county.
Measures vertical. Maximum upthrow 90 feet westward.



1160′; the Church hill north of Yellow Springs, 1040′; the hilltop south of Yellow Springs, 1260′; and the hilltops at Clark's ore bank, 1080′, and at Ætna ore bank, 1200′ and 1260′ above tide.

The Juniata river bed is cut down at Cove forge to 820′; at Ætna furnace to 800′; below the second dam to 780′; below the first dam to 760′; and in the Water Street mountain gap to 740′.

The limestone hill west of the pool between the second and first dams (*i. e.* a mile north of Ætna furnace) rises steeply from 780′ to 1100′=320′. This will give a fair idea of the general topographical relation of the Juniata river to the floor of the valley.

The Little Juniata river bed is in like manner cut down at Bridge No. 2, east of Union furnace R. R. station (799′) and west of Spruce Creek R. R. station 777′—to 760′; while the limestone valley floor a mile south of the river is pretty level at 1020′ and 1040′ = a difference of nearly 300 feet.

Tussey mountain crest S. of Spruce Creek gap is 1840′. This —740′, the Little Juniata in the gap, =1100′, the depth of the cut through the mountain.

Tussey mountain crest N. of Water Street gap is 1840′. This —740′, the Juniata in the gap, =1100′, the depth of the cut through the mountain.

Tussey mountain terrace top south of Spruce Creek gap is 1740′, and the No. III slate slope is steep down to the flat floor of the valley 1060′=a steep descent of nearly 700 feet.

A remarkable phenomenon occurs in connection with the Water Street gap. (See Plate IV, page 14.)

The Juniata river hugs the foot of the mountain for about five miles, both in Blair county and in Morris township Huntingdon county, until it has passed Ætna furnace on its way to the Water Street gap. Its channel is cut in the upper limestone of No. II, (*the Trenton formation.*) Some of its sharp bends cut into the terrace slate formation No. III, but so short a distance as to expose only the lowest (*Utica slate*) beds. It looks as if the river expected each time to make its gap through the mountain, was disappointed, and had to return to the limestone, keep on north, and try again. At Ætna furnace it cuts west for half a mile into the valley, turns suddenly and makes straight for the face of the slate terrace, cutting into it this time deeper than before, *i. e.*, nearly one third through the slate formation. But it again recoils into the limestone and flows on about a mile. Now, apparently without an effort it slides diagonally entirely through the formation III into the heart of the sandstone formation IV. But, instead of completing its gap through the whole mountain, it turns and runs lengthwise of the mountain, splitting the terrace entirely off from the central rib, all the way to Water Street, where it bends at a right angle and makes its gap.

The explanation of this curious river channel is twofold: 1, there is a fault in the structure (described in the township report;) and 2, formation No. IV is triple; the upper member making the mountain crest; the lower member making the terrace brow; the middle *soft* member making the ravines of the terrace; and it is in this soft middle member that the Juniata has cut its *narrows.**

These *Water Street narrows* are two miles long, commencing at the first dam above the gap. Here the Juniata water level is 760′ A. T. and the crest of the terrace hogback, 1160′, (difference 400 feet;) half way of the narrows, 1220′; opposite Water Street, 1200′ A. T.

On the other (east) bank of the river, the steep mountain slope rises 840′, to 1620′ A. T.

Black-log valley.

This is constructed precisely like Canoe valley, but has no river running through it. It is nearly straight, 45 miles long, by 1½ miles wide, and inclosed between Black-log mountain on the northwest side, and West Shade mountain on the southeast side; and the two mountains come together in two sharp points at each end of the valley.

Black-log creek heads near the northeast end and flows 20 miles through the valley, as in a ditch, to gap Orbisonia, where it turns west and cuts out through Black-log mount-

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*See Mr. E. B. Harden's photograph views of the wild scenery of these narrows. (Not published in this volume.)

ain, precisely as the Juniata cuts out of Canoe valley through Tussey mountain. (See the topographical map of Orbisonia, in Report F.)

All this distance there is no water gap through either of the two walls of the valley, composed of No. IV sandstone, and lined inside by two very slight terraces facing each other, with a narrow strip of No. II limestone along the center line of the valley, in which the creek flows.

Orbisonia gap is precisely half way between the Juniata county and Fulton county lines, 9½ miles distant from each.

South of Orbisonia gap the valley itself has the same shape as north of the gap and in Juniata county; but its drainage is curiously different. Instead of one long creek coming from the south end of the valley into Fulton valley and keeping in the limestone rocks of its floor to meet Black-log creek at the Orbisonia gap, there are two streams—one, flowing *into* the valley through a gap in Shade mountain, diagonally opposite to and three miles due south of Orbisonia gap; the other heading in the valley and flowing *out* of it, through a gap, also in Shade mountain, a mile or so south of the Fulton county line. These two streams are:

Shade creek, the heads of which bring the rainfall of the north half of Dublin township (in Tuscarora valley) through *Shade creek gap* into Black-log valley, and to Black-log creek at Orbisonia gap;—and

Sideling Hill creek south branch, which heads in Black-log valley, at its south end,—flows out through a gap in Shade mountain opposite Burnt Cabins—makes a complete loop around the south end of the mountains (united) opposite Fort Littleton—turns north along the west or outside foot of Black-log mountian—reënters Huntingdon county and unites with the north branch at Madisonville. No item of the drainage system of middle Pennsylvania is more curious than this.

Orbisonia gap is one of the few mountain gaps in Pennsylvania that have been carefully studied and mapped in contour lines. (See Report F.)

It is the only gap in Pennsylvania through which a *trans-*

verse fault has been certainly proved to run. But the fault is so small that there is no sure ground for believing that it played an important part in locating the gap. The country *south* of the gap has been *thrown west* at the most only 90 feet; and the throw does not seem to affect the inner (No. III) side of the mountain, only its outer (No. V) side; and the throw does not seem to extend to the outcrops of No. VI and No. VII. (See Plate V, page 16.)

The topography of Black-log valley and Orbisonia gap shows that the limestone floor (No. II) has been worn down to 680′ A. T. where Black-log and Shade creeks meet and enter the gap. This is at the bottom beds of the No. III slate. In the heart of the gap, water level is 660′; at Orbisonia bridge 590′.

Black-log mountain central rib-rock outcrop rises steeply *northward* to the crest at 1660′, then slowly to 1700′ A. T. Southward steeply to 1560′, then slowly to 1580′. The similarity between the erosion at Orbisonia gap and at Water Street gap (in Tussey) is therefore striking. There, a large river flows through a gap at 740′, the crest of the mountain being 1620′. Here, a small creek flows through a gap at 660′, the crest of the mountain being 1560′. The depth of cut in both cases is about 900 feet, irrespective of the quantity of water at present flowing through the gap.

It is noteworthy that *Tussey crest between its two gaps* is 1840′, but opposite the narrows where the river has reduced the *width* of the mountain by splitting off from it its terrace, the crest height is only 1620′. Now, Black-log mountain has scarcely any terrace, and its maximum crest height north of Orbisonia gap is only 1700′.

Valleys of V, VI, VII, VIII, IX.

Between the mountains of IV and the mountains of X the country is always comparatively low or valley land; narrow, where the strata are steeply upturned and the outcrops are narrow; broad, where the strata dip gently and cover a great breadth of surface.

In all cases the valley, whether broad or narrow, is subdivided into three parallel vales by two subordinate ridges made by the outcropping rough sandrocks of VII (*Oriskany,*) and by the coarse sandstone and conglomerate strata of the upper part of VIII (*Chemung.*)

Hopewell, Lincoln, Penn, Walker, Juniata, Porter, West, Oneida, Henderson, Barree, and Jackson township all lie in one great valley between Terrace mountain (X) and the surrounding mountains of IV, Tussey, Seven mountains, and Stone.

It is divided into an outer range of vales of V, a middle range of vales of VIII, and an inside range of vales of IX.

Warrior's ridge is the outcrop of VII (*Oriskany sandstone*) which we may follow from the Bedford county line all the way to the Juniata at Petersburg. Behind it *i. e.* between it and Tussey mountain runs *Woodcock valley*, excavated in the red shales (*Onondaga or Salina*) and gray shales (*Clinton*) of formation No. V.

It is a low ridge for much of its course, gapped at intervals to let out the drainage of Woodcock valley. But as it approaches the Juniata its rocks get to dipping very gently (southeast), and the crest of the ridge becomes about 300 feet high, with a bold escarpment facing Tussey mountain. The river cuts square through Warrior's ridge above Huntingdon, where it is nearly two miles wide, making a very picturesque gorge, the side walls of which are vertical cliffs of *Lower Helderberg limestone* (VI) supporting the *Oriskany sandstone beds* (VII), which have been weathered into isolated masses and slender columns, called "Pulpit rocks." These tower above the trees which cover the heights and slopes and conceal the cliffs of the gorge.

From the Juniata river on, northward, *Warrior's ridge* continues of the same character, with a west escarpment, crowned with *Pulpit rocks* and isolated masses, across West and Barree into Jackson township, where it ends ; or, rather, where it turns the center line of the great Huntingdon synclinal trough, and runs back (southward) across Barree, East Henderson, and West Brady townships to the Juniata and Jack's narrows. In this part of its course the sandrock dips very steeply the other way (west), and, therefore, the ridge is narrow and low, and at last forms merely the foot of Stone mountain. The Oriskany quarries at the west entrance to the gorge of Jack's narrows look as if they were opened in the mountain itself; but in reality the quarry face represents Warrior's ridge on this eastern side of the great trough.

From the river southward the Oriskany ridge runs on through *Hare's valley*, comes out into the open country of Cass township, swings round the south end of Jack's mountain, and returns to the river at Mount Union.

A similar ridge of *Oriskany sandstone* (No. VII) crosses the county in front of and about a mile from Black-log mountain, past Orbisonia.

Two similar ridges of No. VII traverse the length of Tuscarora valley, one at the foot of each of its inclosing mountains.

Allegrippus ridge is the name given to the rougher part of the great Huntingdon valley lying just west of the Raystown branch in Juniata and East Penn township. It is really one of three parallel ridgés or ranges (the one next the river) composed of the hard and massive sandstone strata of VIII (*Chemung and Hamilton* rocks) greatly spread out by low rolling dips, just as Warrior's ridge is spread out further west.

These ridges are little mountains, at least 500 feet high, and making a very rough country, which ends opposite Marklesburg.

From this on (southward) through Lincoln and Hopewell into Bedford county the steeper dipping rocks of VIII make but one ridge with a rather broad top.

Between this Allegrippus range (upper VIII) and the Warrior ridge range (VII) lies the regular valley (lower VIII) which the Huntingdon and Broad Top railroad follows.

Between the Allegrippus and Terrace mountain flows the Raystown branch with many sharp curves and horse-shoe bends from side to side in the soft rocks of IX.

North of the Juniata river the Allegrippus range fills up most of Henderson county. At its western foot flows Standing Stone creek, which drains the whole lower country between it and Warrior's ridge; and the narrow vale between it and Stone mountain is the water-way of Mill creek.

South of the Juniata the steep strata of the Allegrippus are named *Clear ridge*, which keeps on into Bedford and range (Lick ridge) run the whole length of Hare's valley, county.

Two similar and parallel ranges of the hard rocks of VIII (Chemung) cross the county, one on each side of great Aughwick creek.

Two more traverse the county in Tuscarora valley.

All these ridges of VIII (*Chemung*) differ entirely in their character and appearance (being broader and higher, and having more gently rounded outlines) from the ridges of VII (*Oriskany*.)

It is remarkable that the two largest minor rivers of the county, Standing stone creek and Aughwick creek, drain the two largest areas of rocks of No. VIII.

Standing Stone creek collects most of the waters of the four townships north of Huntingdon.

Aughwick creek and its main branch *Sideling Hill creek* collect most of the waters of the five townships south of Mt. Union, besides considerable areas in Fulton county.

Valley of XI.

The red shale valley of Trough creek is a large cove secluded within the circuit of Terrace and Sideling mountains, and extending two arms—two narrow valleys—southwards, one on each side of Broad Top mountain, one into Bedford, the other into Fulton counties. The folds which divide up the coal field into separate troughs or basins, and cause projecting spurs of the mountain, are felt in the red rocks of the valley below to such an extent as not only to give it its great breadth and to repeat its outcrops, but to make its surface irregularly uneven, and its drainage complicated.

Great and Little Trough creeks, and Rock run (heading close to the Bedford-Fulton-Huntingdon county corner) drain East Broad Top mountain and the whole of Trough valley, to a gap in Terrace mountain at the Tod-Cass township corner, opposite Marklesburg, and so into the Raystown Juniata.

But, another gap in Terrace mountain 3 miles further south lets through a small stream, which enters the river a mile above Coffee run.

Faults.

The Orbisonia gap fault and Three Springs fault, are described and illustrated in Report F.—The Water Street and Spruce creek gap faults, will be described in the special reports on Porter township.—The faults of the Bald-eagle mountain, shown on Mr. Harden's map, and the great Birmingham anticlinal fault, will be described with Warrior's Mark township.

Railroad levels.

The Pennsylvania railroad follows the Little Juniata river from its head at Altoona in Blair county, past Tyrone City and Birmingham, to its junction with the main Juniata river at Petersburg; and then it follows the Juniata river down to its junction with the Susquehanna river. The following tables of heights of grade at stations above sea level, with distances of stations from Philadelphia is taken from Report N (1878,) pages 3, 4.

Two of the large sheets of the topographical contour-line map of Sinking creek valley, Canoe valley, Morrison's cove, and other parts of Blair county (see Atlas, Report T) give an accurate representation of the course of the Little Juniata,—of the limestone slopes and cliffs between which it flows,—and of the railway cuts, fills, and bridges.

Mr. E. B. Harden's small contour map of the Bald Eagle mountain and Logan's run (in this Report T^4) furnishes similar data for part of the north side of the river.

The railroad grade keeps about 30 feet above the ordinary water level of the river, to be safe from the floods which swell its volume always in the spring, and sometimes at other seasons of the year.

Between Tyrone and Petersburg the track crosses the Little Juniata from side to side by many bridges; but from Petersburg down, past Huntingdon, it keeps to the left (N.) bank as far as the entrance to Jack's narrows. Here it crosses to the right bank, and recrosses at Mt. Union, where it enters Juniata county.

The datum is U. S. Coast Survey *Mean Atlantic ocean level* at Hoboken; which is *7 feet below mean high tide at Philadelphia.*

Pennsylvania railroad.

	Stations.	*Miles.*	*Ocean level.*
	Gallitzin,	249	2161′
	Tunnel, (east end,)	—	2126′
	Altoona,	237	1178′
	Tyrone,	223	907′
Huntingdon County.	Birmingham,	220	866′
	Union furnace,	216	799′
	Spruce creek,	215	777′
	Tunnel, (west end,)	—	761′
	Barre forge,	212	724′
	Shuman's bridge,	—	699′
	Petersburg,	209	678′
	Warrior ridge,	—	677′
	Huntingdon,	203	622′
	Mill creek,	198	604′
	Mapleton,	194	593′
	Jackstown,	—	595′
	Mount Union,	191	597′
	Newton Hamilton,	188	599′
	McVeytown,	173	522′
	Lewistown,	166	498′
	Newport,	133	395′
	Duncannon,	120	356′
	Susquehanna bridge,	110	350′
	Harrisburg,	105	320′
	Philadelphia,	0	32′
	Ocean level at New York, established by U. S. Coast Survey,		0′

The Huntingdon and Broad Top railroad leaves the Pennsylvania railroad in Huntingdon, crosses the Juniata to the south bank, follows up Crooked creek to its head, keeps on south across the runs which drain Woodcock valley into the Raystown branch, reaches and crosses the river at Saxton, follows it up through a gap in Terrace mountain into the red shale valley of XI to Hopewell, and so on up the river to Bedford and Maryland.

At Saxton it sends its first branch up *Shoup's run*; at Riddlesburg its second branch up *Six-Mile run;* and at Hopewell its third branch up *Sandy run;* all to coal mines. The last two are in Bedford county; but the Shoup's run branch railroad reënters Huntingdon county, in which are the mines described in this report.

A table of the main line is given in Report N (1878,) page 17; but the levels of the three coal railway branches have never been published. They were furnished too late for publication (Dec. 9, 1878) by Mr. C. B. Finley, C. and M. E. Bedford, Pa., together with a revised table of the main line which is here substituted for the one in Report N.

The distances are from Hollidaysburg.

Huntingdon and Broad Top railroad.

	Stations.	*Miles.*		*Ocean level.*
Huntingdon co.	Huntingdon,	0		621.0′
Huntingdon co.	McConnellstown,	5		673.7′
Huntingdon co.	Grafton,	7		747.5′
Huntingdon co.	Marklesburg,	11		790.4′
Huntingdon co.	Coffee run,	—		872.4′
Huntingdon co.	Rough and Ready,	17		888.3′
Huntingdon co.	Cove,	—		918.1′
Huntingdon co.	Fisher's summit,	21		972.2′
	Saxton, (new depot,)	25		859.0′
Shoup's run.	Coalmont,	—	1106.0′	
Shoup's run.	Crawford,	—	1237?	
Shoup's run.	Old M. P.,	—	1278?	
Shoup's run.	Mine No. 3,	—	1400?	
Shoup's run.	Barnet mine,	—	1379?	
Shoup's run.	Dudley stat.,	—	1414.3′	
Shoup's run.	End of track,*	—	1861.6′	
	Riddlesburg,	30		864.7′
	Defiance,	—	1008.0′	
	Coaldale, (Fairplay,)	—	1131.1′	
	Northpoint,	—	1311.0′	
	Hopewell,	32		898.0′
	Chivington coal mine,	—	1297.5′	
	Piper's run,	—		946.0′
	Tatesville,	41		1094.8′

* Cook coal bank (according to J. M. Africa) is 1875′.

Everett,	44	1118.7′
Mt. Dallas,	—	1054.0′
Bedford,	—	1063.0′
Buffalo summit,	—	1357.0′

The East Broad Top narrow-gauge railroad leaves the Pennsylvania railroad at Mount Union and runs south, through Aughwick valley, to Orbisonia; thence west across the valley up Three Springs creek, past the south end of Jack's mountain, to a high tunnel through Sideling Hill mountain; crosses the red shale valley divide; enters the gorge of Little Trough creek between Rocky hill and Wray's hill; to the East Broad Top coal mines on the flat top of the mountain.

The following table is taken from Report N, (1878,) page 13.

East Broad Top railroad.

The distances are from Mount Union junction.

Stations.	*Miles.*	*Ocean level.*
End of railroad on E. Broad Top mountain,	—	1817′
Robertsdale,	30	1785′
Cook's station,	—	1541′
Cole's station,	24½	1359′
Sideling Hill tunnel,	—	1232′
Saltillo,	19	781′
Scottsville,	—	717′
Beersville,	—	658′
Jordan's summit,	—	709′
Rock hill,	11	624′
McMullen's summit,	—	669′
Douglas summit,	—	598′
Shirleysburg,	7	572′
Aughwick creek,	4	560′
Morrison's summit,	—	615′
Mount Union, (Penn. R. R. junction,)	0	597′

The topographical survey of a cross belt of country extending from Orbisonia to the East Broad Top mines, executed by Messrs. Billin and Ashburner and published in Report F in 1878, furnished the Table 8*b* to Report N, pages 14, 15, and 16, from which the following points are selected:

Aughwick and Black-log creeks, junction,	578′
Aughwick and Three Springs creeks, junction,	618′
Aughwick and Sideling Hill creeks, junction,	762′±
Sideling Hill creek at T. Wilson's,	800′

Sideling Hill cr. Dublin Mills dam,	815′
Sideling Hill cr. at the (Jack's mt.) anticlinal,	838′
New Grenada, inside the Sideling Hill gap,	939′
Stream level in Clear ridge gap,	885′
Clear ridge summit at Sol. Taylor's,	1144′
Bagdad bridge over the run,	1136′
Trough cr. dam surface, between Rocky ridge and Shirley's Knob,	1144′
Trough creek, at road, below Stapleton's,	1200
Trough creek bet. Hoover's and Anderson's,	1848′
Petriken's coal mine, (Rocky ridge,)	1456′
Curfman's (Savage) coal mine, (Rocky ridge,)	1531′
Dougherty's old coal mine, (1 m. S. W. Stapleton's,)	1607′
Rocky ridge crest, on road W. of Stapleton's,	1467′
Road summit between Rocky ridge and Round Knob,	1750′
Round Knob top, (near Cook's station,)	2304′
Wray's Hill crest, (over tunnel,)	1740′
Iron Knob, (just south of tunnel,)	1860′
Road summit from Sideling Hill tunnel to Cook's station,	1760′
Road summit from Cook's station to Eagle foundry,	1683′
Eagle foundry,	1261′
Grave mountain top,	2170′ ±
Cross-roads summit between J. Diggens' and Broad Top city,	2054′
Broad Top city pavement, Mountain House,	1997′
Chert bank, (Orbisonia map,)	782′ ±
Hawk mine,	937′
N. fossil mine No. 2,	762′
S. fossil mine No. 1,	669′
S. fossil mine No. 2,	728′
Orbison slope,	762′
Jordan bank,	778′
Drift in Marcellus ore,	941′
Drift and slope,	817′
Drift and shaft,	730′
Royer and Dewees tunnel,	770′

The Lewisburg and Tyrone railroad leaves the Pennsylvania railroad in the Bald-eagle mountain gap below Tyrone city; crosses the Little Juniata; ascends the little valley of Logan's run; passes Warrior's Mark village, the Pond ore banks, and the Pennsylvania furnace, and ends at present at Scotia, in Centre county. (See Report T[4], 1884.)

The line has been surveyed on eastward, through Brush valley and Pine Creek narrows, to the Susquehanna river.

The following table of elevations* shows both the heights of the stations above the *datum* adopted by the railroad engineers ;† and also their heights above *ocean level:*

Lewisburg and Tyrone railroad.

Stations.		*Ocean level.*
Junction with main line, P. R. R.,	465.7	892′
Weston's summit,	543.2	969.5′
Logan's run,	516.0	942.3′
Guyer's bridge,	592.0	1018.3′
Pennington summit,	810.4	1236.7′
Warrior's Mark, (trestle,)	653.8	1080.1′
Lowrie's summit,	679.0	1105.3′
East branch,	649.6	1075.9′
Dry Ridge summit,	781.0	1207.3′
Forks of Dry Hollow,	710.8	1137.1′
Pond ore bank summit,	836.8	1263.1′
Half Moon Run bridge No. 8,	677.6	1103.9′
" " No. 7,	699.8	1126.1′
" " No. 6,	677.6	1103.9′
" " No. 5,	656.0	1082.3′
Geist's,	655.0	1081.3′
Half Moon Run bridge No. 4,	655.0	1081.3′
" " No. 3,	645.0	1071.3′
" " No. 2,	635.0	1061.3′
" " No. 1,	619.4	1045.7′
Spruce Creek,	625.0	1051.3′
Pennsylvania furnace,	640.0	1066.3′
Tadpole run,	640.0	1066.3′
Fairbrook,	698.5	1124.8′
Scotia,	912.5	1338.8′

The Seaboard Pipe Line, from the oil regions of Western Pennsylvania to Baltimore, was surveyed in 1877 by Mr. O. Barrett, Jr., and others, under the direction of Hermann Haupt, chief engineer. A list of points leveled was published in the Proc. Amer. Philos. Soc. Philadelphia, Vol. XVII, page 145, and in Report N, pages 234 to 243.

No map was furnished for publication, and only the general course of the line can be traced by reference to counties

* Copied by Mr. E. B. Harden from profile in office of Pennsylvania Railroad Company, October 27, 1884.

† Allen and Ames established the following level at Lewisburg in 1877, (see N, page 123)—Lock No. 15 (upper lock in Cross-cut canal from Lewisburg dam) top of coping, west wall, 457.21′.

and towns mentioned in the lists. A specially complete list of stations and distances through Indiana county was obtained from Mr. Barrett, and published as Table 204 in N, and also in Report H⁴ on Indiana county; but for the accuracy of levels at points in Cambria, Blair, Huntingdon, Cumberland, Franklin, and Adams counties there is no special guarantee;* nor can the course of the line be exactly obtained by the courses and distances given in the tables for want of reference points. But the line evidently crossed the widest part of Trough Creek valley, *north* of the spurs of the Broad Top, and *south* of the Trough Creek gap. Orbisonia is mentioned as on the line.

The following items are selected:

Seaboard pipe line.

Tussey mountain summit,	2328′
Run,	1143′
Run,	936′
†Creek,	660′
Creek,	630′
Pine ridge summit,	1138′
Creek,	769′
Run,	912′
Creek,	886′
Spring,	762′
Raystown branch of Juniata,	819′
Terrace mountain summit,	1684′
Little Trough creek,	1250′
Sideling Hill summit,	1652′
Creek,	1100′
Creek,	969′
Creek,	950′
Creek in Hare's valley,	803′
Jack's mountain summit,	1840′
Creek,	1513′
Creek,	1036′
Creek,	741′
Great Aughwick creek,	670′
Orbisonia,	725′
Rock Hill gap,	726′
Creek,	835′

*In the part of the line in Huntingdon county a note to the lists reports "a uniform error of 161 feet which should be uniformly distributed—as from tests the variation is constant and uniform." See Note to N, page 237.

† Here the error commences, and gradually increases to the Bench mark at the end of this list of extracts; see below.

Creek, (20′ wide) (=Black-log creek,)	890′
Creek,	910′
Creek,	1095′
Creek,	1105′
Creek,	1162′
Creek,	1200′
*Tuscarora * mountain summit,*	2020′
Conodogwinet creek,	949′
Creek,	810′
Creek,	750′
Conodogwinet creek,	700′
Line of Franklin and Cumberland counties,	849′
BM. E. Div.=821′. Error 161′,	821′

Surface geology—Transported bowlders, &c.

The surface features of this county have been entirely unaffected by *glacial action*—at least no traces of such agency were observed anywhere within the county. Great heaps of bowlder trash, both rounded and angular, are often to be seen along the valleys of the principal streams; and these often very much resemble genuine drift heaps; but no *striated* bowlders or *striated* fragments of the country rock are to be found in the region.

One such large deposit of transported blocks covers the surface of the low plain between the Juniata and Little Juniata rivers near Petersburg and Alexandria; in fact, the whole space between those two towns. Along the main road, leading from one to the other, bowlder-deposits extend up to the summit of the divide, at 100′ above the Little Juniata, (750′ A. T.)

They consist of stones of all sizes from an egg up to 2′ and 3′ in diameter, many of which have been rounded and polished in running water. Others are quite angular. *Medina and Oneida sandstones* largely predominate, but fragments of the *Clinton iron sandstone* are not rare.

Bowlder deposits are also quite conspicuous along the south bank of the Juniata river opposite Huntingdon, where they form a beautiful terrace just south from the Middle Penitentiary at an elevation of 65′ above the river, (670′.)

* Called Kittatinny mountain in the list.

Some of them are from 3′ to 4′ in diameter, mostly *Medina sandstone*. Others are much smaller, the most abundant size being 3″ to 5″. The smaller are generally rounded and polished, the larger ones angular.

The highest point at which *rounded bowlders* were observed within the county is on the western slope of Warrior ridge, in Walker township, at 950′ A. T.*

Here, about one mile east from Mr. Livingstone Robb's, small well-worn pieces of *Iron sandstone* (V) were seen. No other such observation was made anywhere else in the county. As these water-worn bowlders occur in considerable numbers, it is not likely that they were brought to the spot by human hands.

Bowlder deposits occur along the Raystown branch, but never more than 60′ above the level of the water.

One of these near Haun's bridge, on the land of J. B. and M. L. Shenefelt, extends to 55′ above the river, (670′ A.T.†)

At this level the exhibition of *rounded bowlders* suddenly ceases, although the upward slope continues unchanged more than 200′ higher. The Shenefelt Bros., who have noted the uppermost sharp limit of these rounded bowlders, tell me that they have never observed them at a higher level than the one they occupy in the vicinity of their barn, though they have plowed over all the hill slopes along the river in that vicinity where the farming land rises to 250′–300′ above water level.

The rounded bowlders along the Raystown branch consist largely of *Pocono sandstone*, a great ledge of which almost overhangs that stream at many points along its course through this county.

This phenomenon of rounded bowlders extending up far above where the present Juniata waters have ever been known to rise, (30′ being the greatest flood height recorded,) calls for some explanation. Five suggest themselves.

(1.) *A heavier ancient rainfall.*—The bowlder beds might

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* By barometer.

† This is exactly the elevation of the Huntingdon deposit as given above. The elevation at Shenefelt's was got by barometer from the Sea-Board Pipe Line spirit-level determination of the river (625′ A. T.) near Hann's bridge.

indicate a time in the history of the country when rivers, owing to climatic conditions greatly different from the present, were compelled to bear seaward the product of a much greater precipitation of moisture, the surface level of the flood being above the bowlder terraces at Huntingdon and Shenefelt's, even if the channel beds were at the same level as now.

(2.) *The melting snows of the glacial age.*—Of the effects produced by the melting away of the great American ice-sheet we know very little, but it may have kept our rivers at a much higher level than at present for some time. (See Report Z.)

(3.) *The deepening of the present river channels.*—We do not know how far the bed of the Juniata has been cut down since the glacial age. This may be quite sufficient to explain all the phenomena of these bowlder deposits.

(4.) Prof. Lesley has suggested that a dam may once have existed at Jack's narrows high enough to make a large lake in which bowlder deposits, deltas, &c., would be created. Or a dam in the narrows of the Juniata through Warrior ridge, behind which would spread, between Petersburg and Alexandria, a wide expanse of water, into which the two rivers would dump the bowlder trash which we now find extending up to 100′ above the present streams.

(5.) *Ocean submergence.*—If, however, the abnormal deposit of *rounded iron sandstone bowlders*, at 950′ A. T., be taken into consideration, it leads to the inevitable conclusion that the Juniata country has been in comparatively recent times covered by the ocean 1000′ or more above present sea level.

The coincidence of the upper limit (950′ A. T.) of rounded bowlders in this district with the elevation (900′ to 950′ A. T.) of the highest transported bowlders found in the upper Susquehanna river region (See Report G⁷) is in this view important.

The principal objection to such submergence by the ocean comes from the absence of such deposits as would naturally be left behind after the lowering of the sea to its present level. This objection cannot be estimated without a better knowledge than we possess of the length of time such a submergence lasted, nor can this knowledge be obtained without a previous comprehension of the character and causes of such a submergence if it ever really took place.

No buried valleys in the county.

In a foot-note to his Prefatory Letter to Report G[7], Prof. Lesley states that a great buried depression exists along the Juniata river at Huntingdon.*

As no borings or other explorations to any considerable depth have been made (so far as I could learn) in the vicinity of Huntingdon, it is probable that the belief in a deeply buried valley arose from the superficial aspect of the present valley, which is worn out of the soft *Hamilton rocks* at the junction of the river with Crooked creek. Its unusual width indicated unusual depth.

The facts observed by me with regard to the water-ways of the county seem to render the existence of a deeply buried channel at Huntingdon highly improbable; since at hundreds of localities the Juniata and all its tributaries are floored with bed-rock, where the topography renders a buried channel impossible.

Along the Raystown branch the rock floor may be seen for miles at a stretch, while rocky cliffs rise from either bank, and the same condition of affairs is often found along every stream in the county.

It is true, the valley of the Juniata in front of Huntingdon is filled with transported trash, but this we find wherever two streams unite, and under it at a moderate depth the bed rock is always present; in fact the *Hamilton upper sandstone* comes up through the silt which lines the Juniata valley a few rods south from the H. & B. T. R. R.; while at the "narrows," just below Huntingdon, the rocky

* Prof. Lesley says in a letter to the writer that his authority for the statement in G[7] was the late Dr. Robert M. S. Jackson, of the First Geological Survey, who was a native of Huntingdon county, and that the belief in it is a tradition of the first survey; but that no one now lives who could furnish the facts from which Dr. Jackson drew his conclusion. Dr. A. A. Henderson knew the ground well; but he also is dead.

strata close in on both sides of the stream and floor its channel as well, so that we may dismiss the supposed deeply buried channel at Huntingdon as not only unsupported by any direct evidence but contradicted by the facts observed along every other stream in the county.

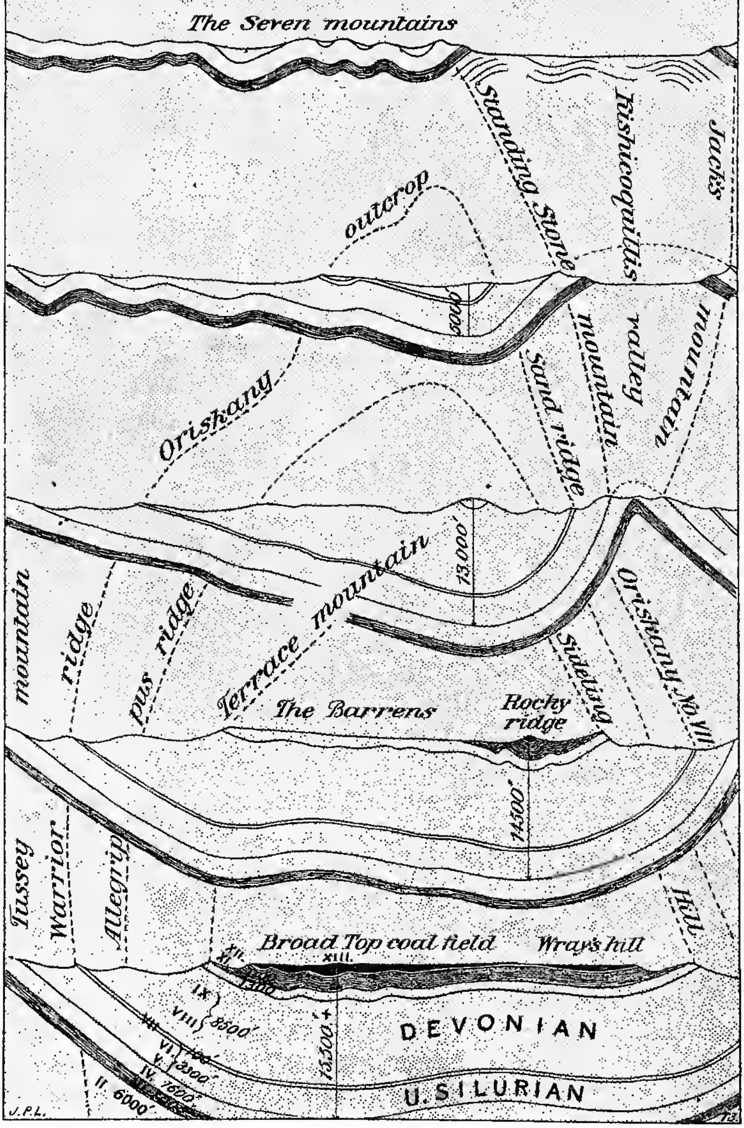
[NOTE.—I feel reluctant to dismiss the question in this summary manner, for two reasons: (1.) the opinions of a good field geologist like Dr. Jackson must be respected, at least until disproved by the positive testimony of facts; and in this case confessedly no facts are now at hand to disprove the supposed considerable depth of wash-deposits under the Huntingdon flat; and (2) because the reference to all the other streams of Huntingdon county goes for nothing under the peculiar circumstances of the Huntingdon flat. It is evidently an exception to the general rule of narrow valleys. The Petersburg flat is another exception. To produce such broad flat alluvial surfaces there must be a considerable depth of reservoir. The depth may be little or great; its measure is not the point in question If the Juniata has cut its channel 100, 50, or even only 20, or 10 feet lower at Huntingdon, than at the first rock-bed-barrier further down the valley, an explanation of its ability to do this is called for. A reference to ordinary valley-erosion is insufficient. The mere statement of the coincident fact of the junction of two branch rivers at the locality is not an explanation of the process of producing such a flat; because the flat is not properly a delta-deposit in open water. The subject has the greater importance, because there are a number of such river flats in the State, all of them on the line of outcrop of some thick soft formation (No. V, VIII, or IX), and all of them behind hard rock barriers.

P. R. R. grade at Huntingdon is 622′;

P. R. R. grade at Mapleton 9 miles down the river (where the Oriskany outcrop crosses and the gap through Jack's mountain begins) is only 19 feet lower, viz: 593′.—J. P. L.]

Sections across the Huntingdon synclinal
1, in Jackson ; 2. in Barree ; 3, in Juniata ; 4, in Cass and 5, in Carbon townships.

Scale vertical and horizontal 32000' : 1"



CHAPTER II.

Geological Structure.

The rocks of this county are nowhere horizontal, but have been folded into a series of anticlinal and synclinal arches as grand as in any other district in the State.

Four great upfolds (anticlinals) pass across the county with an equal number of great downfolds (synclinal) and several subordinate ones.

These will now be described in order from west to east.

The Canoe Valley anticlinal.

This has been fully described in the Blair county report (T) by Mr. Franklin Platt.

After crossing the Little Juniata its central line runs on northeast, through Franklin and Warrior's Mark townships, along the broad limestone valley of Spruce creek.

The crest of the arch in Canoe valley is doubled by a sharp infold.

Tussey mountain is made by the hard sandstones of *No. IV* (*Medina and Oneida*) dipping east-southeast. It runs along the county line from the Bedford corner almost perfectly straight, north-northeast, 18½ miles, to the end of the "Loop," where a subordinate anticlinal fold from Canoe valley comes through the mountain, and forms a spur and a cove, setting the mountain back about a mile, and the county line with it. From the Loop the mountain runs north 10° east, three miles to the gap of the Juniata, and three miles further to the gap of the Little Juniata. Thence it runs northeast (curving gently to east-northeast) 19 miles, to the Centre county corner.

An exact representation of Tussey mountain crest and west slope in Blair county, the whole length of Canoe valley, from the Little Juniata gap southward, will be found in the atlas to Report T. A topographical survey of it was made by Mr. R. H. Sanders. The map, in 20-foot contour lines, shows all the peculiar features of the west or terraced side of the mountain—its straight, unbroken crest of Medina gray sandstone (IV *c*)—its numerous forked ravines on Medina red slates (IV *b*)—its terrace knobs of Oneida white sandstone (IV *a*)—the little anticlinal and synclinal which make the Loop—and the remarkable downthrow faults at the two gaps between which a fragment of the mountain 3 miles long has been thrown slightly askew.

All this will be better seen on the smaller one-sheet index sheet (in Atlas T) which accompanies the series of larger sheets. As the survey was not carried beyond the Little Juniata the Spruce Creek tunnel fault at that gap and the sudden change of direction of the mountain from N. 10° E. to N. 45° E. is not shown.

Subordinate anticlinal folds are found along the eastern foot of Tussey mountain. Sometimes there are three or more of them; but when numerous they are quite small. None of them have an amplitude of more than 500′, but they exercise an important influence upon the economic wealth of the county by repeating the *Clinton fossil ore outcrops.*

The Little Juniata river cuts across two such flexures near Barre Forge. I have named the one next the mountain the *Barre anticlinal*, the other the *Alexandria anticlinal.* See the township reports further on.

The Barre axis at the Little Juniata brings up only the *Clinton Middle shales*, underlying the *fossil ore;* but from the Little Juniata north-eastward it rises rapidly and brings up the *Medina sandstone* (*IV c*) in a lofty spur of the mountain, the syncline west of it rising also, and the spur uniting with the mountain.

The Alexandria anticlinal develops very rapidly southward into the point of Tussey mountain at the "Loop."

Northward of the river it soon brings up the *Medina sandstone* in a long ridge at the foot of the Tussey slope.

This ridge is cut through by *Globe run*, a branch of *Shaver's creek*, at Stull's mills, in West township, where its anticlinal structure is clearly shown, the rocks dipping 30° southeast and 20° to 25° northwest.

The subordinate flexures which exist along the base of Tussey mountain south of the "Loop" could not be followed eastward, and it is not known what connection they have, if any, with similar rolls occupying a similar position northeast of the Loop. But there are the same number northeast and southwest of the Loop.

From *Given's run*, in Walker township, southward to Marklesburg at the southern margin of Penn, we find *three well marked flexures* at the base of Tussey. They are well shown on Given's run.

The first anticlinal roll crosses Given's run 1100′ from the forks of the road near Mr. Robb's; and it barely brings the top of the *Barre limestones* above water-level.

The second anticlinal roll crosses Given's run near Mr. Given's house. Here the *Clinton Upper fossil ore* is barely brought to the surface. It turns over into a trough so deep that some of the *Salina Middle limestones* are preserved in it. The crest of this *second roll* is one half mile from the crest of the first one near Mr. Robb's.

The third anticlinal roll, which is very small, runs along about one fourth mile northwest of the second.

On *Kurtz's run*, two miles west from McConnellstown, the *first roll* of Given's run has already carried up the *fossil ore* to a considerable elevation. This *Grubb's hill* is made by the hard calcareo-siliceous roof-rock of the *fossil ore*. West of Grubb's hill two other rolls are seen at about the same distance apart as those on Given's run.

The same three rolls cross the *Clinton measures* on the Patterson estate two miles northwest from Grafton station. But here the western (third) roll is crumpled up into several still smaller flexures.

Southward from Grafton the deep synclinal troughs between these rolls shallow up and are crumpled; so that after passing Marklesburg the three rolls can no longer be identified, being in a measure flattened out upon the long slope of Tussey mountain. There is here an almost uninterrupted eastward dip from the summit of Tussey to Terrace mountain; merely crumpled locally by small low flexures, which are encountered in the tunnels driven through the soft *Clinton rocks* along the base of the mountain. None of these are sufficiently pronounced to form troughs on the mountain slope deep enough to contain the fossil ore, which therefore has but the one outcrop.

The Broad Top synclinal.

The dip on the eastern slope of Tussey mountain is 45° at the southern border of the county, and the rocks of all the formations from No. V up to No. X (*Pocono*) in Terrace mountain keep about this dip, but near the top of No. X they flatten to 25° or less.

This steep dip at the Bedford line grows less and less going towards Huntingdon, where it varies from 25° to 10° in all the rocks from the *Salina* (*V*) up to the *Pocono* (*X*).

The profound depression between the great arch of Canoe valley on the west, and the great but lower arch of Jack's mountain on the east, in which the Broad Top coal-measures have been preserved, has the appearance of a deep dimple in the earth's crust, rather than that of an ordinary long and even synclinal trough.

But this appearance is deceptive. In fact the Broad Top coal-measures lie in one of the two deepest places in what is the longest and widest of the great synclinal troughs which traverse the State, extending as it does from Wayne, in the northeast corner of the State, all the way to the Maryland line. The Wilkesbarre anthracite coal field occupies another and still deeper part of the same great trough in which the Broad Top coal field lies, and both fields are similarly sub-divided into groups of connected coal-basins by folds in the floor of the trough.

The eastern side of the great synclinal is very steep in Huntingdon county, and therefore very straight, and is best represented by Sideling hill.

The western side varies in dip and strike, and is best represented by Terrace mountain.

These two mountains of X (*Pocono gray sandstone*) come together in the high synclinal knob opposite Huntingdon.

The axis or center line of the great synclinal is drawn upon the map by Trough creek from its head to Tod P. O. where the flexures of the coal-field begin to show themselves.

The axis line of the synclinal is marked in the banks of the Juniata river below Huntingdon by the change of dip in the rocks from eastward to westward just opposite the high knob.

The red *Catskill rocks* (IX) dip about 25° on both sides of the knob.

But further down the river the *Hamilton and Oriskany rocks* dip west 65° towards the knob.

Still further down, at Jack's narrows, the *Medina* sandstone (IV) in Stone mountain, dips 75° west.

Going up the river from the center line through the knob the *Hamilton rocks* of Huntingdon dip only 15° to 10° east, and the *Oriskany* rocks in Warrior's ridge lie still flatter, and in some places are slightly reversed (dipping gently west.)

After passing the *three anticlinal rolls* already described (page 39) the dip increases in Tussey mountain to 30° and 35° east.

It thus happens that the synclinal axis is only 2½ miles from Stone mountain, but 9 miles from Tussey mountain.

This central line can be traced through Henderson and so into Barree township; on between Greenwood furnace and Ennisville, in Jackson township; to the point where Huntingdon, Centre and Mifflin counties corner.

All the way from the county line on Broad Top to this point—a distance of 42 miles—the great synclinal is very gradually shallowing northward, and retaining less and less of the full number of formations.

At Broad Top it holds them all, up to the coal-measures. In Trough valley, No. XI is at the surface; in the high knob No. X; in Henderson township very little of IX is left in the trough; by the time Ennisville is reached No. VII and VI crop out; beyond this No. V is the highest rock; and along the Clinton-Mifflin county line all the formations above No. IV, the Medina, are washed away. This is the shallowest part of the synclinal. After passing through the Seven mountains (IV) the red rocks of V come in again; VI and VII at the Susquehanna river; then VIII fills the trough; IX and X come in at the Orangeville high knob in Columbia county (which corresponds exactly to the high knob at Huntingdon,) and finally XI, XII and the coal measures of the Wilkesbarre basin.

To all appearance the shallowing of the synclinal northward is as regular as it is gradual. Its average rate—that is, the average rate at which the different formations rise northward into the air—can be measured by the total thickness of strata from the *coal measures* (XIII) down to the *Medina* (IV)—say 14,000 feet.

This divided by 42 (miles) gives a general rate of rise for the bottom of the synclinal of 333′ per mile—between 3° and 4°.

It is very evident, then, why the only coal field in middle Pennsylvania is that which occupies the Broad Top mountain. It so happens that the deepest rock-depression in middle Pennsylvania is along the center line of the great Wilkesbarre-Huntingdon synclinal trough, where the three counties of Huntingdon, Bedford and Fulton meet.

The Jack's Mountain anticlinal.

The axis of this great fold crosses the Juniata river at the aqueduct of the Pennsylvania canal below Mapleton.

Here the *Oneida conglomerate* (bottom of IV) is exposed in a superb arch in the north bank of the river; the *Medina white sandstone* (top of IV) dipping eastward and westward from it, making Jack's and Stone mountains. These get farther apart going north, as the axis rises and brings to the surface the slates of III and the limestones of II in Kishicoquillis valley.

South from the Juniata river however, the axis becomes

JACK'S MT. ANTICLINAL CROSSING, SIL

Plate I.

)E LING HILL CREEK IN HUNTINGDON CO. PA.

lower, and the two outcrops of *Medina sandstone* come together and form one anticlinal mountain which dies away into the valley near Saltillo. (See Report F.)

The Aughwick Valley synclinal.

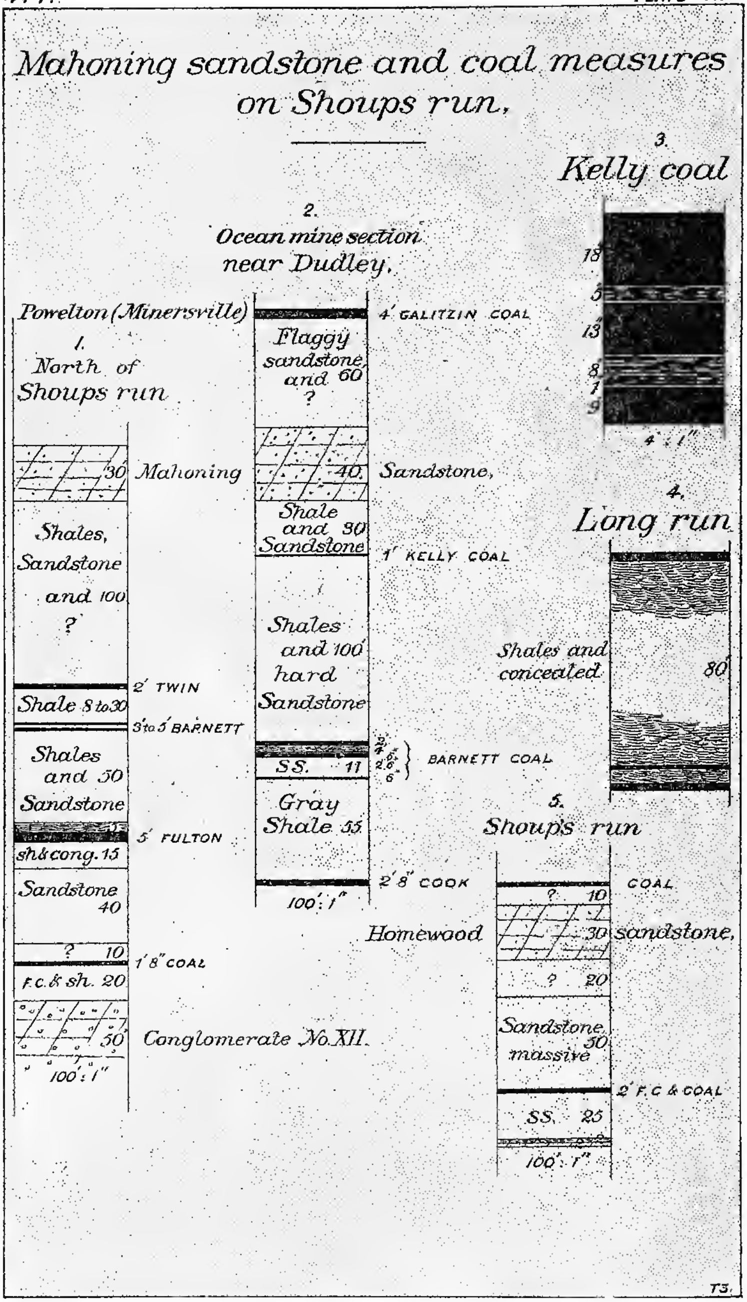
—The center line of this great trough crosses the Juniata river below Mt. Union. The synclinal itself can be traced from Luzerne county all the way into Maryland.

The Blacklog anticlinal.

This long sharp flexure runs between Blacklog and Shade mountains, and can be traced far into Fulton county. In Blacklog valley it brings up Trenton limestone, (No. II,) but in Fulton county it is covered by the various formations of No. VIII. In the opposite direction, northward, it is also covered by No. VIII, and can be identified with the Selinsgrove anticlinal arch described in Report G7.

The Tuscarora Valley synclinal.

This remarkably regular trough has preserved to Huntingdon county the rocks of VIII. It grows deeper in Fulton county—almost deep enough to be a coal basin—for it holds in its deepest place the *Mauch Chunk red shale, No. XI.* In the other direction, northward, it deepens so greatly after passing the Susquehanna river as to preserve the coal measures of the Shamokin and Mahanoy anthracite coal field.


Mahoning sandstone and coal measures on Shoups run.
1. North of Shoups run
Powelton (Minersville)
30 Mahoning
Shales, Sandstone and 100 ?
2' TWIN
Shale 8 to 30
3' to 5' BARNETT
Shales and 50 Sandstone
5' FULTON
sh & cong. 15
Sandstone 40
? 10
1' 8" COAL
F.C. & sh. 20
50 Conglomerate No. XII.
100' : 1"
2. Ocean mine section near Dudley.
4' GALITZIN COAL
Flaggy sandstone, and 60 ?
40. Sandstone,
Shale and 30 Sandstone
1' KELLY COAL
Shales and 100 hard Sandstone
BARNETT COAL
SS. 11
Gray Shale 55
2' 8" COOK
100' : 1"
Homewood
3. Kelly coal
18
5
13
8
1
9
4' : 1"
4. Long run
Shales and concealed 80
5. Shoups run
COAL
? 10
30 sandstone,
? 20
Sandstone massive 50
2' F.C. & COAL
SS. 25
100' : 1"
T3.

CHAPTER III.

The Palæozoic Formations.

The carboniferous beds of Huntingdon county belong to that part of the geological column between the middle of No. XIV, or the *Barrens*, and the base of the *Pocono* No. X, including the *Pocono-Catskill.* The *Upper coal measures* once covered the entire county, but they have been completely removed by erosion, even from the central line of the great *Broad Top trough*, except in Round Knob of Bedford county, where a small patch of the *Pittsburgh coal* and 350′ of still higher rocks remain.

The Coal measures.

The rocks of this period cover a small area in Carbon township on the southern edge of the county, being the northern part of the *Broad Top coal field.*

The Broad Top field is separated by the *Broad Top anticlinal* into two well defined portions, that east from the anticlinal being known as the *East Broad Top coal field.*

The East Broad Top region of Huntingdon county is drained by Trough creek, and was described by Mr. Ashburner in Report F; hence the only work done by the writer in the *East Broad Top field* was to study the section there in order to compare it with that obtained in the main *Broad Top region* further west.

The Broad Top coal region has always been invested with great interest both to geologists and others. To the former because of its isolation from all other coal deposits, occupying as it does a deep synclinal basin separated by an arch of 15,000 to 20,000 feet of rocks, from the *Allegheny mountain coal region* to the west, and yet retaining the general structure of the latter coal field so faithfully as to demonstrate its former connection with the Allegheny field across the great arch which has been destroyed.

Its economic importance is due to its position east from the other bituminous coal fields; since a continuous down-grade haul to the tide-water cities gives the products of the Broad Top mines a special advantage.

For more than thirty years the number and order of the coal beds in the Broad Top region has been a study. Many mistakes have been made, and some of them are still persisted in. The difficulties encountered by the pioneer workers were truly insurmountable; and the wonder is, not that some mistakes were made in the identification of coal beds, but that they were not more numerous.

These difficulties were of two kinds: first, the rocks within the great *Broad Top syncline* are thrown into a series of sharp folds by subordinate axes which separate the coal field into well defined basins, across the rims of which the coals had not yet been mined.

A second reason rendering the work difficult, was the poverty of natural exposures. The outcrops of the rocks are everywhere covered up by a thick coat of débris which effectually conceals them from view, except at a few localities where the streams have cut gorges down through the strata.

At the present time, however, the field has been very thoroughly explored by the several mining companies; and from the data thus furnished and from my study of the outcrops in Huntingdon county, I have constructed the following generalized section of the measures:

General section of Shoup's run.

Sandstone and shales,		50′
Coal, Dudley,		4′
Shales, sandstone and concealed (Upper Mahoning SS.,)	65′	125′
Sandstone, massive, pebbly, (Lower Mahoning,)	35′	
Shales,	25′	
Coal, Kelly, maximum,		1′
Sandy shales and sandstone, (Freeport,)		100′
Coal, Twin,		2′ 6″
Shales and sandstone,		2′ to 30′

Coal, Barnett,	3′ to 5′
Shales, shaly limestones, &c.,	50′
Coal, Cook (Fulton,)	6′
Shales and concealed,	20′
Pottsville conglomerate No. XII.	
Barren Measures,	179′
Lower Coal Measures,	200′

The general agreement of the above section with that constructed by Prof. Stevenson, in the Bedford county portion of the field, will be made apparent by reference to pages 59, 60 T², as follows:

General section in Bedford county.

Kelly coal bed,	5′ to 14′	
Shales and sandstone,	65′ to 120′	
Twin coal bed,		1′ 6″
Clay,		2′
Sandstone,		28′
Barnett coal bed,	1′ 9″ to 5′	
Clay,	3′ to 9′	
Sandstone and shale,		50′
Cook coal bed,		2′ 6″
Clay,		3′
Pottsville conglomerate No. XII.		
Total average thickness of the *Lower coal measures* in Bedford,		200′

The following section, taken by myself in the East Broad Top field at Robertsdale, shows the essential agreement of the measures exposed there with the above sections:

Robertsdale section (I. C. White).

Mahoning lower massive sandstone, pebbly, [30′]		
Concealed sandy shales and sandstone to mouth of shaft,		65′
Shales and sandstone in Robertsdale shaft,		60′
Twin coal,	2′ 4″ to	3′
Slate and rock,	0′ 6″ to	7′
Barnett Coal,	2′ 6″ to	3′ 6″
Sandstone and black slate,		30′
Cook (Fulton) coal, { coal,		2′ 6″
{ rock,	4″ to	25′
{ coal,	1′ 6″ to	2′
Concealed, about		25′
Pottsville conglomerate No. XII.		
Thickness of lower coal measures,		206′

Robertsdale section (C. A. Ashburner).

Mahoning sandstone, "Top rock," [90′]			
Sandstone and shale—small *coal E* near top,			45′
Coal D (worked in Mine C),	coal,	2′ 1″	7′ 9″
	slate and coal,	0′ 4″	
	coal,	2″	
	slate and SS.,	2′ 1″	
	coal,	3′ 1″	
Sandstone V shale; bottom black slate,			50′
Coal C (worked in Mine B),	coal,	1′ 6″	3′ 10″
	black slate,	0′ 4″	
	coal,	2′ 0″	
Sandstone shale and slate,			18′
Coal B (worked in mine A),	coal,	1′ 6″	4′ 8″
	rock, fire-clay,	1′ 4″	
	coal,	1′ 10″	
Sandy fire-clay,			2′
Sands'one and shale,			33′
Coal A (upon black fire-clay),			2′
Total Productive coal measures,			166.3′

The Barren coal measures.

The highest beds of the *Barrens* left in Huntingdon county are in the *Dudley syncline*, the same basin in which Round Knob is found in Bedford. But the uppermost part of the section could not be seen in detail anywhere, except a massive sandstone, somewhat pebbly, which comes about 75′ above the *Dudley coal.* It makes a bluff along the west bank of the run, one half mile south-west from Dudley, where its pebbly blocks are scattered over the surface.

The same sandstone was observed on Six Mile run in Bedford county, on the property of Messrs. Sweet and Brown.

The Dudley coal bed.

This local designation has been given to an impure, slaty *bed* which occurs a few feet above the top of the *Upper Mahoning sandstone*, and at an interval of 100′–125′ above the *Kelly coal bed.*

The Dudley coal was once opened just south from that village by Mr. W. T. Watson who mined some coal from it for local use, but found it too slaty for shipment.

Several small trial holes have also been sunk to this coal on the east side of the small run above Dudley, but in none of them was it found in sufficient purity to warrant mining.

This coal was passed through in a well dug by Mr. W. H. Sweet, on the high ground back from the Catholic church in the southern part of Dudley village. Mr. Sweet reports it 4′ thick, and struck 35′ beneath the surface. It was there apparently clean coal, and overlaid immediately by a sandstone.

This coal was once exploited on the New York Coal Company's land, in the Powelton basin, near the Bedford county line, where it was miscalled the "*Pittsburgh*" *coal*.

The Dudley coal in the Powelton basin on Six Mile run, in Bedford county, makes a large blossom at the roadside a short distance below the store of Messrs. Sweet and Brown.

The Mahoning sandstone.

The Mahoning sandstone as exhibited in the Broad Top field of Huntingdon county, consists of two well defined members. The *Upper* is a buffish-gray, rather massive sandstone, seldom pebbly, and sometimes inclined to be flaggy or even shaly, thickness 50′–60′.

The Lower Mahoning is a very massive, gray rock, often a perfect mass of white quartz pebbles, thickness 25′–30′. This stratum has largely determined the topography of the *Broad Top coal region*, and can be traced everywhere by lines of ridges and cliffs, It is the "Top rock" of the Broad Top miners, protecting a large part of the coal field from erosion.

This *Lower Mahoning* is seen in a cliff just below the Catholic church, at Dudley, where it is 40′–50′ thick. It is also finely exposed in the vicinity of the Ocean mine one half mile above Dudley, and from that point makes a long high cliff eastward toward Broad Top city, on the south side of Shoup's run. On the north side of the same run it makes another line of cliffs from Dudley to Moredale.

In the *Powelton basin* this rock makes the high hill on which Mr. Bradley's house is situated, and at several localities on the R. H. Powel property shows at the surface.

The same rock makes a long, high ridge which extends from Shoup's run southward to Six Mile run in Bedford county in an unbroken line, except where it is cut through by streams.

The Mahoning sandstone seems more massive, or rather the massive portion is thicker in Bedford county than it is in Huntingdon, the *Upper* division being massive there as well as the *Lower*.

A small patch of this rock is caught in the East Broad Top coal field, on the bluff just above the shaft of the Rock Hill Coal Company. Mr. Sleeman informs me that it is also caught in the Rocky Ridge syncline.

The Spear coal bed.

In Bedford county a small coal bed 1½′–3′ thick occurs between the two plates of *Mahoning sandstone*, and has long been known near Broad Top City as the *Spear bed;* and it is described under that name by Prof. Stevenson in Report T², who states that it is also frequently called the "*Twin*" *seam.* This bed is nowhere of workable size in Huntingdon county, and it may be considered practically absent from the section, having thinned away northward like the greater Kelly bed below.

In Sweet and Brown's tunnel on Six Mile run in Bedford county, completed since T⁴ was published, this coal was struck about 40′ above the *Kelly bed*, and it had a thickness of 2½′ to 3′, but impure and slaty.

The Kelly coal bed.

One of the most important results affecting the economic interests of Huntingdon county coal field is the determination of the fact that the *Kelly coal bed* of Six Mile and Sandy runs in Bedford county, thins away almost completely, and becomes practically absent from the section in Huntingdon county, thus leaving that area with only *two* workable coal beds, instead of *three* or *four* as was supposed.

It is probable that the confusion of ideas which so long prevailed with regard to the identity of the coal beds of

Huntingdon county, was largely due to the fact that the early observers took it for granted that the *Kelly seam*, the most important coal bed by far in Bedford county, must necessarily be present in the Huntingdon county section, only 3 or 4 miles distant.

The *Kelly coal* thins away somewhere between Six Mile run in Bedford, and the Huntingdon county line, so that only a *trace* of this coal has been found in the latter county, though it has been sought for with shafts and drifts at many localities.

The bed is cut by the Ocean mine tunnel about 30′ under the *Lower Mahoning sandstone*, and 100′ above the *Barnett bed*, but is only 8″ to 12″ thick. Its blossom is also visible along the H. & B. T. switch just below the Ocean mine tipple; and the same *thin coal* was struck in an air shaft a few rods above the tipple; but it has not been found at any other locality in Huntingdon county. It may exist elsewhere concealed by the débris of the *Lower Mahoning sandstone.*

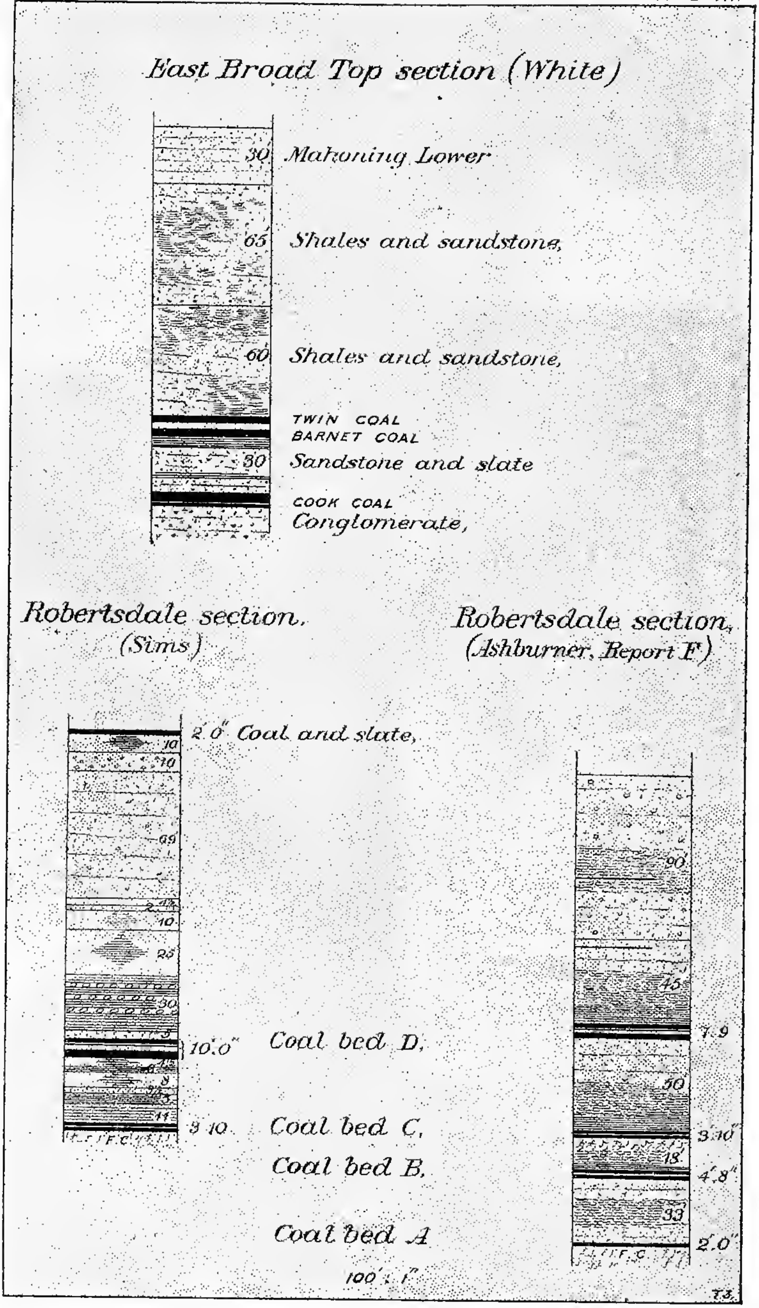
On the R. H. Powel property, one mile below Dudley, much labor was once expended in sinking holes and otherwise exploring for this coal bed, but so far as I could learn *not even a thin representative* of it was found.

Two extensive openings into this bed have been made in Bedford county since Dr. Stevenson made his report (T²) on that region, one by Messrs. Sweet and Brown, one mile above Riddlesburg, on Six Mile run; the other on Long run (a branch of Sandy) by the Everett Coal and Iron Company.

The coal at Sweet and Brown's so far developed is only on the northwestern rim of the syncline, and consequently may not be so thick as near the center of the basin. It has a thickness of 3′ to 4′, without partings of shale.

A sample of this coal from Sweet and Brown's opening, taken as nearly across the bed as possible, gave the following result to McCreath on analysis:

Water,	.530
Volatile matter,	17.910
Fixed carbon,	75.239
Sulphur,	.656
Ash,	5.665


East Broad Top section (White)
30
Mahoning Lower
65
Shales and sandstone,
60
Shales and sandstone,
TWIN COAL
BARNET COAL
30
Sandstone and slate
COOK COAL
Conglomerate,
Robertsdale section.
(Sims)
Robertsdale section,
(Ashburner, Report F)
2.0" Coal and slate,
10
10
69
10
25
30
10.0"
Coal bed D.
8
11
3 10
Coal bed C.
Coal bed B.
Coal bed A
90
45
7.9
50
3.10"
18
4.8"
33
2.0"
100' : 1"
T3.

This shows a coal of great excellence, and one which would make a good coke.

The opening of the Everett Iron Company on Long run exhibits the coal with the following structure and relations to the other rocks:

Slate,			
Kelly coal,	coal good,	1′ 6″	4′ 6″
	coal and shale,	5″	
	coal good,	1′ 1″	
	coal slaty,	8″	
	slate,	1″	
	coal,	9″	
Sandy shales and concealed,			80′
Sandstone, gray, somewhat flaggy,			30′
Twin coal,			1′ to 6′
Shales,			8′
Barnett coal, bony at top for 6″,			3′ 3″

The Twin coal bed, No. 5, of this section is the same clean, dry, open burning bed that we find at this horizon in Huntingdon county, separated by from 2′ to 30′ of rock from the *Barnett coal* below.

Prof. Stevenson considers the *Kelly coal* as the representative of the *Upper Freeport* of the Allegheny river series, in which I concur.

The Freeport Sandstone group.

Below the *Kelly coal* there occurs a series of sandy shales and shaly sandstones, which often thicken up, especially in the lower part, into rather massive, gray sandstone, well exposed in the north bluff of Shoup's run, opposite Dudley, and also on the south bank of the same run half-way between Dudley and Powelton station, where it makes a cliff directly above the *Twin coal bed.*

In some localities, however, as near Powelton station, the series consists largely of sandy shales, gray, dark, and brown.

Opposite Moredale this rock makes a bluff near the summit of the hill, just north from the run.

A hole was sunk through the lower portion of the group for an air-shaft on the Rock Hill Coal Company's land, 1½ miles southeast from Broad Top city. The shaft was 45′

deep, and the rock was principally gray sandstone, until the *Twin and Barnett beds* were encountered.

At the Ocean mine, above Dudley, a shaft and also a tunnel were driven through the entire group. Here it was mostly hard sandstone in the lower half, and sandy shales and shaly sandstone in the upper half, the whole interval from the *Kelly bed* to the *Twin bed* being here about 100′, which agrees very closely with that found in Bedford county by Stevenson, and measured by myself, at the Everett Iron Company's coal openings. I have never seen any coal beds in this interval nor heard of any being found in it; so that if the *Kelly coal bed* be the *Freeport Upper* then the *Freeport Lower coal* would seem to be absent, which frequently occurs in the western part of the State.

The Twin coal bed.

A very persistent coal bed is found at the base of the *Freeport sandstone group*, or at 90′–110′ under the *Kelly coal*, and in Huntingdon as well as Bedford county usually goes under the name of the *Twin seam*, since it often occurs only a foot or two above the *Barnett bed* and is then mined as a part of the latter.

This *Twin coal bed* is remarkable 1. for the persistency of character which it maintains over the Broad Top region, and 2. for the great variation in its height above the *Barnett bed.*

The coal itself is always a hard, dry stratum, perfectly clean, and free from partings of slate or shale, seldom attaining a thickness of 2½′, and hence not workable by itself, but only in conjunction with the Barnett.

In the *Powelton basin* the interval separating this coal from the Barnett is often 30′, sometimes composed largely of massive sandstone. On the same property the interval is reduced to 8′.

This coal has been mined to only a limited extent on the Powelton property. An old opening in it may be seen a few rods from the R. R. station, where a few tons were once taken out.

As we trace the coal eastward from Powelton the interval separating it from the *Barnett* bed thins so that in the Dudley syncline it is only 6′ to 8′, as may be seen along Shoup's run, just opposite Dudley station, where the *Twin coal* is finely exposed in the cliffs, having a thickness of only 1′ to 1½′.

Just above Dudley, at the Ocean mine, the interval thins down still further, and we find the coal only 1½′ above the *Barnett bed* in some parts of the mine; but in other parts of the same mine the interval thickens to 7 or 8 feet.

In the Fisher colliery, above Moredale, this bed was generally mined with the *Barnett*, except where the interval rocks had a greater thickness than 3 feet, when it was sometimes taken out independently by cutting holes up from the *Barnett bed* and taking the coal from the "*Twin*" *bed* down through them. In some parts of the mine the beds were 6 or 7 feet apart.

At Robertsdale colliery this *Twin bed* is on top of the *Barnett*, and is taken out with it, the parting rocks sometimes thinning away to only 6″, but again thickening up to 7′ according to Mr. Findlay, the superintendent. The coal there varies in thickness from 2′ 4″ to 3′, and has the same physical characteristics as in the Broad Top field proper, viz: a clean, dry coal, with no slate partings.

Prof. Stevenson reports the *Twin coal bed* as persistent above the *Barnett* in Bedford county.

In my section on Long run at the Everett Iron Company's coal works, it appears, with its characteristic features, lying 8′ above the *Barnett bed.**

The Barnett coal bed.

The *Barnett bed* was early named after a gentleman of that name who had a mine on this coal seam in the vicinity of Barnettstown, just below Dudley.

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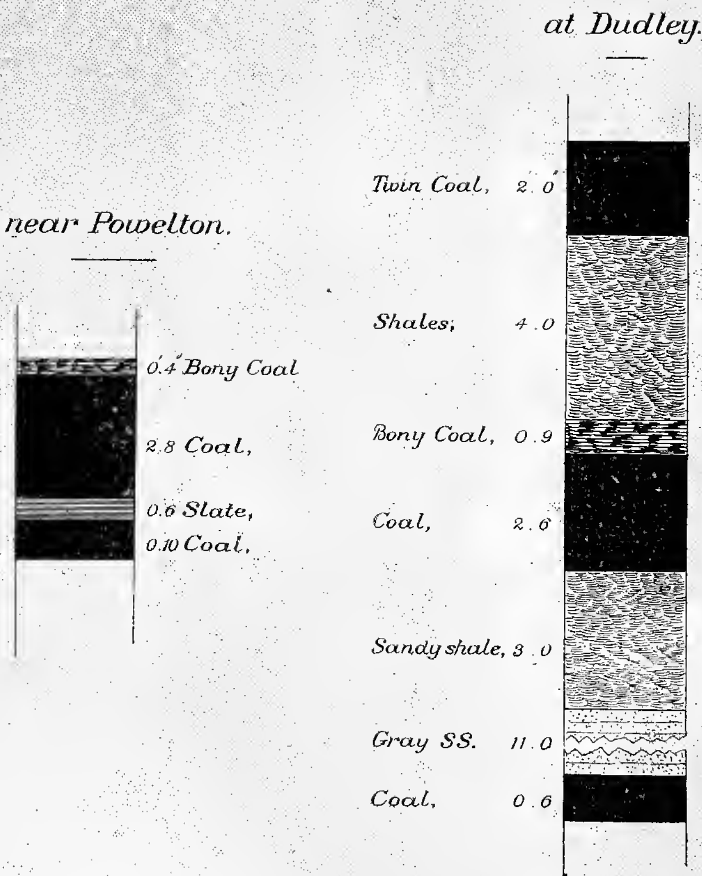
*Prof. Stevenson describes this bed in Report T², pages 61, 62, and 237, as *coal* 1′, *clay* 2′, *coal* from 6″ to 1′. But on Sandy below the mouth of Long run, it has been crushed into pockets, some of which contain as much as 10′ of coal. This crushing does not injure its quality, but makes handling difficult. It is mined and much liked at Hopewell. Its distance above the "Barnett" in Prof. Stevenson's general section is 30′. The interval is occupied by *clay* 2′, *sandstone* 28′.

Broad Top Coal measures.

Barnett bed,



Much more coal has been mined from this bed in Huntingdon county than from any other, especially in the *Powellton* and *Dudley basins*; while in East Broad Top it, in connection with the "*Twin*" above, is the only one mined now to any extent.

This bed has one unfailing mark by which it is distinguished from the other coal beds of Broad Top, viz: a top layer of *bony coal*, 4″ to 6″ thick, which is never absent, so far as I could determine, at any locality on Broad Top or East Broad Top, while none of the other beds possess this peculiarity. Prof. Stevenson also reports (in T²) the same feature as a constant accompaniment of the *Barnett coal* in Bedford county.

The rest of this bed is often divided into two portions by a layer of slate or shale, 2″ to 12″ thick, just above the center.

This coal was once extensively mined by R. H. Powel in what is known as the Old Scott mine near Powelton station, several hundred thousand tons of coal having been taken from it before the basin was exhausted.

This coal is now mined by the Reed Brothers a short distance above Powelton, in whose mines the coal exhibits the following structure in different parts of the colliery:

	a.		*b.*		*c.*	
Bony coal,	6″	6′ 9″	4″	4′ 4″	4″	4′ 4″
Coal,	44″		30″		32″	
Slate,	10″		8″		6″	
Coal,	21″		10″		10″	

Section *a* above was taken just south from a big "roll" which extends through the mine along the western margin, so that it hardly represents a fair average of the thickness which is more nearly given by Nos. *b* and *c*.

The coal from the Reed mine is shipped to the Powelton furnace near Saxton, where preparations are being made to coke it on an extensive scale

The only other mine operating the *Barnett bed* in the western Broad Top region of Huntingdon county is the Ocean mine, above Dudley, superintended by Mr. Sweet. There the following abnormal section of this coal and associated rocks was found in the tunnel:

Coal, "Twin,"				2′
Shales and rock,				4′
Barnett coal,	coal bony,		9″	17′ 9″
	coal,		2′ 6″	
	sandy shale, 3′	14′		
	gray sandstone, 11′			
	coal,		6″	

Here the lower bench of the *Barnett* has separated 14′ from the upper bench and a very hard gray sandstone has made its appearance in the separating portion. The lower 6″ of coal is known to be the lower bench of the *Barnett bed* from the fact that in another portion of the Ocean mine this lower bench *comes up close to the upper* and is then mined. Mr. Sweet informs me that in a certain part of the mine the interval separating the two benches of coal began thickening rapidly, the lower coal going down so far that it was abandoned and only the upper bench was mined. This section is a good illustration of the great irregularities which are found in every extensive coal mine on Broad Top, viz: the *local thinning and thickening of the shale partings* in every coal bed except the "*Twin.*"

The coal at the Ocean mine is highly valued as a locomotive fuel, the H. & B. T. R. R. having preferred it for that purpose for several years.

An analysis of the *Barnett coal* from the Ocean mine, by Mr. McCreath, gave the following results:

Water,	.480
Volatile matter,	17.745
Fixed carbon,	68.727
Sulphur,	4.038
Ash,	9.010
	100.000
Coke per cent.,	81.775
Color of ash,	Pink.

The Barnett coal bed with the "*Twin*" resting directly on top of it is now the only one mined to any extent; the *Cook seam*, which lies below, having been practically abandoned.

This is the "D" bed in Mr. Ashburner's section of the East Broad Top region, published in Report F, pages 185-6.

My identification of the upper (D) coal bed at Robertsdale with the *Barnett* and "*Twin*" *seams* is based on the general identity of the section there with that in the Dudley and Powelton regions, as given on a previous page, and also an identity in structure of the individual beds, including all the coals—"*Twin*," *Barnett*, and *Cook*—fortified by the separating intervals. So that, although the *Barnett* cannot be followed by surface outcrop from Shoup's run over to East Broad Top, yet there is no more reason for doubt that the Robertsdale "D" bed is identical with the *Barnett* than there is for doubting that the *Big coal* in the Cumberland basin is identical with the *Pittsburgh coal.*

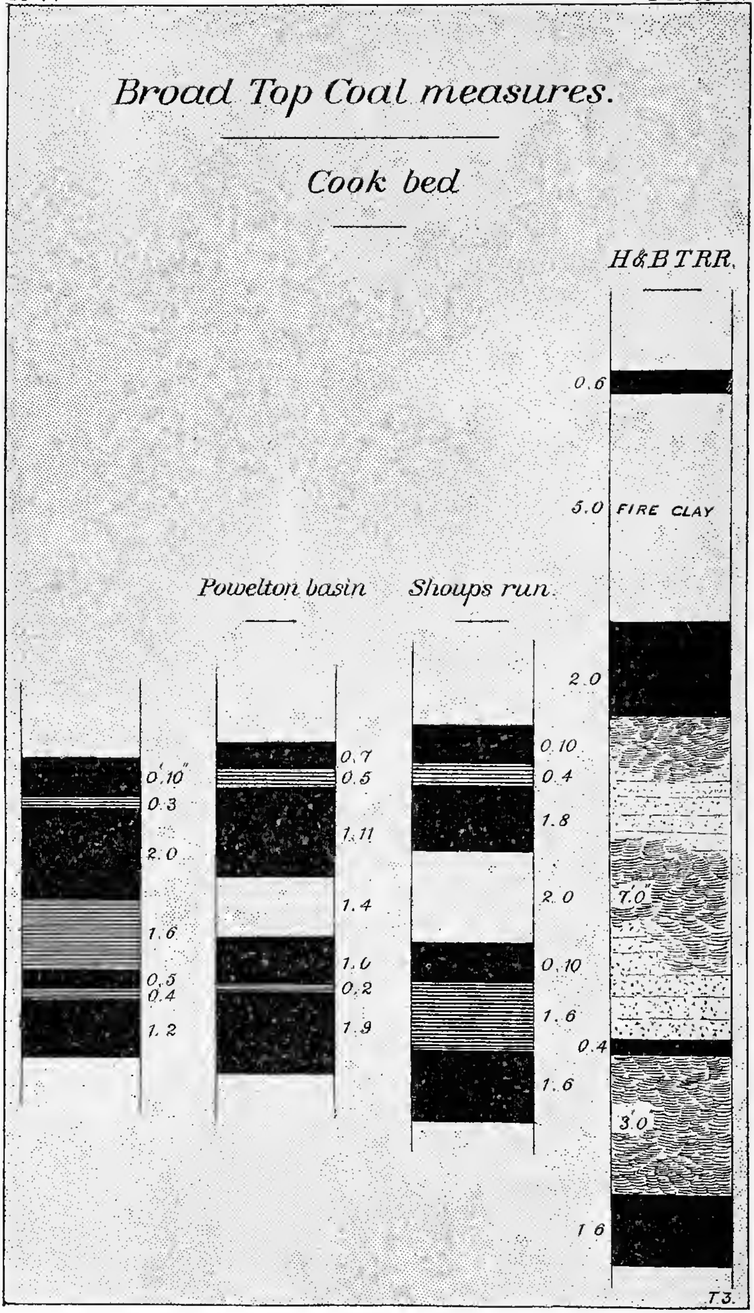
In passing east from Dudley the *Barnett bed* is carried into the air by the southeast rise of the strata, so that only the underlying *Cook bed* is now mined in that direction, though formerly the Fisher colliery, near Moredale, was operated on the *Barnet*, where a shallow syncline catches a considerable area of it on the south bank of Shoup's run.

At Broad Top city the *Barnett* is only a few feet below the surface, showing at the roadside just west from the town. East of this it is carried into the air by the *Broad Top anticlinal.*

Several mines in the vicinity of Dudley were once operated on the *Barnett bed*, but they have now all been worked out or abandoned.

The Barnett may be considered identical with the *Lower Kittanning bed* of western Pennsylvania.

The reasons on which this belief is founded are—1st, its place in the section, viz: as the lowest workable coal but one, of the Broad Top section, and this is often the case with the *Lower Kittanning.* 2nd, the structure of the coal itself. By reference to Mr. Franklin Platt's report on Blair county (T) it will be observed that the *Lower Kittanning coal*, at nearly every locality on the Allegheny mountains, contains a few inches of *cannel* or *bony coal* at top; and this peculiarity has been noted by the writer at the western edge of the State. The *Barnett* exhibits this feature, which no other bed in the Broad Top region does; so that miners who have worked in both the *Kittanning*


Broad Top Coal measures.
Cook bed
H&B T RR.
0.6
5.0 FIRE CLAY
Powelton basin
Shoups run.
2.0
0.10"
0.3
2.0
1.6
0.5
0.4
1.2
0.7
0.5
1.11
1.4
1.0
0.2
1.9
0.10
0.4
1.8
2.0
0.10
1.6
1.6
7.0"
0.4
3.0"
1 6
T3.

and *Barnett* beds asserted their belief in the identity simply from similarity in structure

The Powelton shales.

The rock interval which separates the *Barnett coal* bed from the one next below is usually about 50 feet in Huntingdon county, though in the East Broad Top basin, at Robertsdale, it is reduced to 35 feet, and in Bedford county to much less.

It is composed largely of shales, though occasionally *gray sandstone* takes the place of shale to a considerable extent, as at the New York Company's old openings south from *Coalmont*, where a rather massive sandstone separates the two coal beds. As a rule, however, the lower half is composed of *dark sandy shales*, while the sandstone is confined to the upper half.

The immediate roof shales of the *Cook bed* at the bottom of the *Powelton shales* are very *fossiliferous*, containing immense quantities of *fossil plants*, especially *ferns*. In fact the basal portion of this interval is about the only horizon in the Broad Top section at which *fossil plants* occur in abundance.

It is a peculiarity of the *flora* of the *Powelton shales* that it is often almost completely monopolized by the remains of a single plant, an *Alethopteris*, closely allied to, if not identical with *A. Pennsylvanica*, and this plant is seldom found at any other horizon. At Powelton the immense heaps of rubbish from the roof of the *Cook bed* are filled with this fossil plant, and scarcely anything else can be found in them, except some *Lepidodendron leaves* and *Lepidostrobus fragments*.*

At the Ocean mine tunnel these same *Alethopteris shales* were encountered just above the *Cook bed*, and here the plant in question is very abundant, while the shales contain many *nodules of iron ore*, as they do nearly everywhere in their lower half.

At Mears Bros' mine, one half mile below Broad Top

*See the remarkable abundance of *Alethopterid ferns* in Bed B of the Anthracite region.

city, and just opposite the old Jesse Cook opening, we find the roof shales brought out from the *Cook bed* crowded with the *Alethopteris* peculiar to this horizon.

In the East Broad Top coal field the basal portion of this interval is a *black shale* or *slate* in which no plant remains were observed.

At the Ocean mine, and at an old mine near Barnettstown, the basal portion of the Powelton shales have furnished the following list of fossil plants :

Alethopteris Pennsylvanica.
" *Serlii.*
Neuropteris hirsuta.
" *flexuosa.*
Pecopterus arborescens.
Pseudopecopteris Sillimani.
Lepidodendron obovatum.
Lepidostrobus Sp.
Cardiocarpus Sp?
Stigmaria ficoides.

No *molluscan* or other *animal remains* of any description were noticed by me anywhere.

At some localities an enormous thickness of fire-clay is found at the base of the *Powelton shales*, and this peculiarity is notably present at Mears Bros.' mine in the *Cook bed*, one half mile below Broad Top city, where 18 feet of impure clay was passed through in an air-shaft. Even this did not express the whole thickness of the deposit, since it extended above the mouth of the shaft. But the clay is too sandy for manufacturing into brick or any other economic use.

The Cook (Fulton) coal bed.

We come now to the lowest coal bed of the *Broad Top field* that has ever furnished any considerable quantity of workable coal, viz: the one called the *Cook bed* by the First Geological Survey. It was thus named from an old opening made in it for country use on the land of Mr. Jesse Cook, near the head of Shoup's run and one half mile northwest from Broad Top city.

This coal bed has been a fruitful source of error in the Broad Top coal field.

The geologists of the First Survey, owing to the few openings and the wilderness condition of the country at that time, failed to identify this coal in the Powelton basin, it having been there confused with the *Barnett bed*, as may be seen on page 452, Vol. II of Rogers' Report, where the section given for the *Barnett bed* is unquestionably that of the *Cook*.

Afterwards the bed opened by Mr. Cook below Broad Top city was considered to lie far (100′ or more) *above* the *Barnett*, instead of lying, as it actually does, 50′ *below* the *Barnett*.

After mining operations had demonstrated the fact that a workable bed existed *beneath* the *Barnett* in the *Powellton basin* and Dudley region, this was supposed to be an entirely new coal and was called the *Fulton* coal in honor of the eminent engineer, Mr. John Fulton of the Cambria Iron Company, who has done so much to develop the Broad Top coals.

This name is still used to designate the *Cook bed* west from Dudley.

The idea that the (*Jesse*) *Cook bed* near Broad Top city is *the Kelly bed* and far *above* the *Barnett* is still held by some of the old miners in Bedford county; but in Huntingdon county there are no coal operators, and scarcely any miners, who do not now identify the *Cook* with the *Fulton*.

The honor of demonstrating the identity of the *Cook* and *Fulton beds* belongs to Mr. W. H. Sweet, of Dudley, superintendent of the Ocean mines, who, from a study of the different coal openings between Broad Top city and Dudley, had already arrived at the conclusion that the *two coals* found above Dudley were the same as the *two* found below Dudley.

The demonstration of the correctness of this view was the result of a practical question arising in the working of the Howe mine above Dudley.

This mine was operated on a bed which lay 50′ or 60 above the *Cook*, and which Mr. Sweet claimed was identical with the *Barnett*. The *Barnett* had been mined from a slope at Dudley far up the southeast rise toward the Howe mine. Mr. Sweet, the "mine boss" at the Howe works, proposed to cut a "dip heading" down to the old Blair workings on the *Barnett*, to establish drainage, although the Howe coal was commonly supposed to lie at least 100′ above the *Barnett*. Mr. Sweet, however, was unmoved by predictions of failure, and putting a force of men to work on the "dip heading" was eventually rewarded by seeing them dig into the old Blair mine, on the acknowledged *Barnett*.

No one after this could claim that the original *Cook seam* was not identical with the *Fulton seam* below Dudley.

Previous to this event it was the general belief that *four* workable beds existed on Shoup's run, and that a shaft started below the *Jesse Cook coal*, near Broad Top city, would pass through the *Barnett* and *Fulton beds* at a depth of from 100 to 150 feet.

The structure of the *Cook coal* has everywhere on Shoup' run the same general appearance. The original *Jesse Cook bank* is now abandoned and fallen in, but in Rogers' volume II, page 454, the following section of it is given:

Coal,	10″	6′ 6″
Slate,	3″	
Coal,	24″	
Slate,	16″ to 20 ′	
Coal,	5″	
Slate,	4″	
Coal, slaty, sulphurous,	14″	

A new opening by Mears Bros. on the south side of Shoup's run, and one half mile below the old Cook opening, shows:

Coal with 2″-6″ of bone 10″ below the top, (Upper bench,)	34″	8′ 8′
Rock.	24″	
Coal, Middle bench,	10″	
Slate, gray,	18″	
Coal, Lower bench,	18″	

The *Cook bed* is sub-divided by rock partings into three benches: an *upper one* which contains the main body of coal; a *middle one*, which, though always pure, is never more than a foot thick, often only 4″ to 6″; and a *lower one*, which varies from 1½ to 2 feet in thickness, and is often so impure that it is not mined.

The partings which separate these several benches are subject to astonishing variations in thickness, sometimes thinning away to almost nothing, and then suddenly thickening up to many feet.

When these rock partings thicken up so greatly the miners term it a "*roll*" in the coal, and one of these, 600′ wide, was encountered in the Mears Bros.' upper mine near the old Cook bank.

As an example of the great variation in these partings the following section of the *Cook bed*, taken along the H. & B. T. R. R. in the "Y" below Mears Bros.' lower opening, may be given :

Coal,	0′ 6″	19′ 4″
Fire-clay,	5′ 0″	
Coal, Upper bench,	2′ 2″	
Shale and sandstone,	7′ 0″	
Coal, Middle bench,	0′ 4″	
Shale,	3′ 0″	
Coal, Lower bench,	1′ 6″	

It is my opinion that the 7′ parting between the *upper* and *middle benches* (No. 4 in the above section) represents the 18′ (sandstone, slate and shale) interval in Mr. Ashburner's Robertsdale section (page 48 of this report, and No. 246 on page 186 of his report F,) separating his *B bed* from the *C bed* over it.

If I am right in this opinion, then the two benches of his *B bed* will be identical with the *middle* and *lower benches* of the Cook bed as shown in the section given above.

I am strengthened in this opinion by being informed by Mr. James Findlay, the present superintendent of the East Broad Top mines at Robertsdale, that this parting has been known to vary from 4′ to 25′.

I am not aware that any *workable* coal bed is known to underlie the *Cook* (*Fulton*) bed. Mr. Ashburner's *A bed*, 35′ beneath his *B bed*, is only 2′ thick.

In the *Powelton basin* where the *Cook coal* is now mined extensively by R. H. Powel's Sons & Co., the general structure of the bed is represented by the following section, made in one of the headings:

Coal, Upper bench,	coal, 7″; bony coal, 5″; coal, 23″	35″		
Rock,		16″	7′ 2″	
Coal, Middle bench,		12″		
Slate,		2″		
Coal, Lower bench,		21″		

Of course, in other parts of the mine each of these subdivisions shows variations in thickness, No. 4 especially being generally thicker than here given, usually not less than 6″ to 10″.

The *rock parting* No. 2, is a very hard stratum, often so siliceous that it is quite as hard and difficult of removal as an equal amount of sandstone; in fact when this interval thickens excessively as at Robertsdale and in other localities, a considerable portion of the interval is then composed of gray, fine-grained sandstone.

It is the hardness of this parting which renders the mining of the *Cook bed* within the limits of Huntingdon county difficult and expensive.

For analyses of this coal the reader is referred to the detailed geology of Carbon township in this report.

The *upper* and *middle benches* of this coal are usually much purer than the lower one, the *middle bench* especially being always very clean and pure, however small it may be (it is often only 4″ or 6″). The *lower bench* is often so slaty and worthless that it is not taken out.

The Cook coal is successfully coked at Powelton, in Belgian ovens, and the product used at the Powelton furnace, near Saxton.

The Mears Bros., near Broad Top city, are the only other persons in Huntingdon county now engaged in mining the *Cook coal* for shipment, but the Reakirt, Fisher, and other collieries formerly sent a large quantity of it to market.

The extent of this lowest workable coal bed is of course much greater than that of any of the others in the *Broad Top field*, lying, as it does, nearly down on the *Pottsville conglomerate No. XII.*

It has recently been found in a small cap of several acres on the summit of the Shirley Knob, near Cassville, where formerly only the *Pottsville conglomerate* was supposed to exist. Mr. Sleeman sunk several shafts on Shirley's Knob, and found the *Cook coal* within 10′ or 15′ of the top of No. XII, but so broken and crushed that only a few hundred bushels have been mined. The bed was from 5′ to 7′ thick according to Mr. Sleeman.

In the Rocky Ridge coal basin this bed is supposed by the writer to be the one recently opened by Mr. Sleeman, near the northern end of that coal field, where it obtains a development unequaled at any other locality in Huntingdon county, with the following structure:

Black slate,	—	
Coal,	4½ to 5′	7′
Shale,	1′	
Coal,	1′ 6″	

If this be the *Cook bed* we may consider the *upper* and *middle benches* united in nearly 5′ of good, clean coal in a single bench.

It is possible that some small patches of this coal may exist in the shallow synclinal basins which extend into the long triangular point of Broad Top mountain in the southern part of Todd township, but if there be any such they must be too small to work.

The interval from the *Cook bed* down to the top of the *Pottsville conglomerate* is not fully exposed anywhere in the Broad Top region, but the topography shows it to be composed of soft rocks. The thickness of this interval is usually only 10′ or 15′, and sometimes less, but between Dudley and Broad Top city it increases to 30′, or even more.

[In December, 1884, Mr. H. N. Sims, assistant of the Survey of the Anthracite Coal fields, was requested to reëxamine the Robertsdale, East Broad Top section, and made the following report of it:

Robertsdale Section. (Sims.)

24.	*Coal* and slate,		2' 0	216' 2"
23.	Concealed,		10' 0	214' 2"
22.	Small pea conglomerate in a clay-slate matrix,		10' 0	204' 2"
21.	Massive, light gray, pebbly sandstone, becoming slightly argillaceous toward the top,		69' 0	194' 2"
20.	Concealed,		4' 6'	125' 2"
19.	Micaceous and argillaceous sandstone, (thickness doubtful,)		2' 0'	120' 8"
18.	Concealed,		10' 0'	118' 8"
17.	Concealed, (top of hoisting shaft,)		24' 10'	108' 8"
16.	Fine dark gray, massive, sandy slate, with *iron ore balls,*		30' 0	83' 10"
15.	Fine dark gray sandstone, with specks of mica,		5' 0'	53' 10"
14.	*Coal. Top Bench,*	2' 7"		
13.	Black slate with *small seams of coal,*	5"		
12.	*Coal. Middle Bench,*	3"	10' 0"	48' 10"
11.	Slaty sandstone parting,	2' 9"		
10.	*Coal. Bottom Bench,*	4' 0"		
9.	Concealed,		4' 6"	38' 10"
8.	Very fine blue clay shales,		3' 0"	34' 4"
7.	Concealed,		8' 0"	31' 4"
6.	Yellow shaly sandstone,		3' 6"	23' 4"
5.	Fine dark gray sandy slate in benches about 1' thick,		5' 0"	19' 10"
4.	Very fine black sandy slate, thinly bedded,		11 0"	14' 10"
3.	*Coal. Top Bench.* (No. 1 Mine,)	1' 6'		
2.	Hard grayish black slate parting, (variable,)	4"	3' 10"	3' 10"
1.	*Coal. Bottom Bench,*	2' 0"		

The above section was made with a Locke level, very carefully, with all the aid that was freely afforded on the ground. The description of Nos. 1, 2, 3 was taken from Report F, as No. 1 Mine was not in operation.—Nos. 4 to 8 are exposed at the adit.—The 4½' of No. 9 was got by subtracting from 35' (the interval between the two beds worked at Mine No. 1 and Mine No. 3, as shown by two ventilation holes, according to the authority of Superintendent, Mr. Sims, and Mine boss, Mr. D. B. Patrick,) the 30½' of Nos. 4 to 8.—Thicknesses of Nos. 10 to 16 were measured by D. B. Patrick and described by H. N. Sims.—The 24' 10" of No. 17 is the difference between the 45' of No. 10 to 16, and

69′ 10″ the depth of the shaft.—Thicknesses of 18 to 21 were measured from the top of the shaft.—Those of 22 to 24 by Mr. D. B. Patrick.]

The Pottsville conglomerate, No. XII.

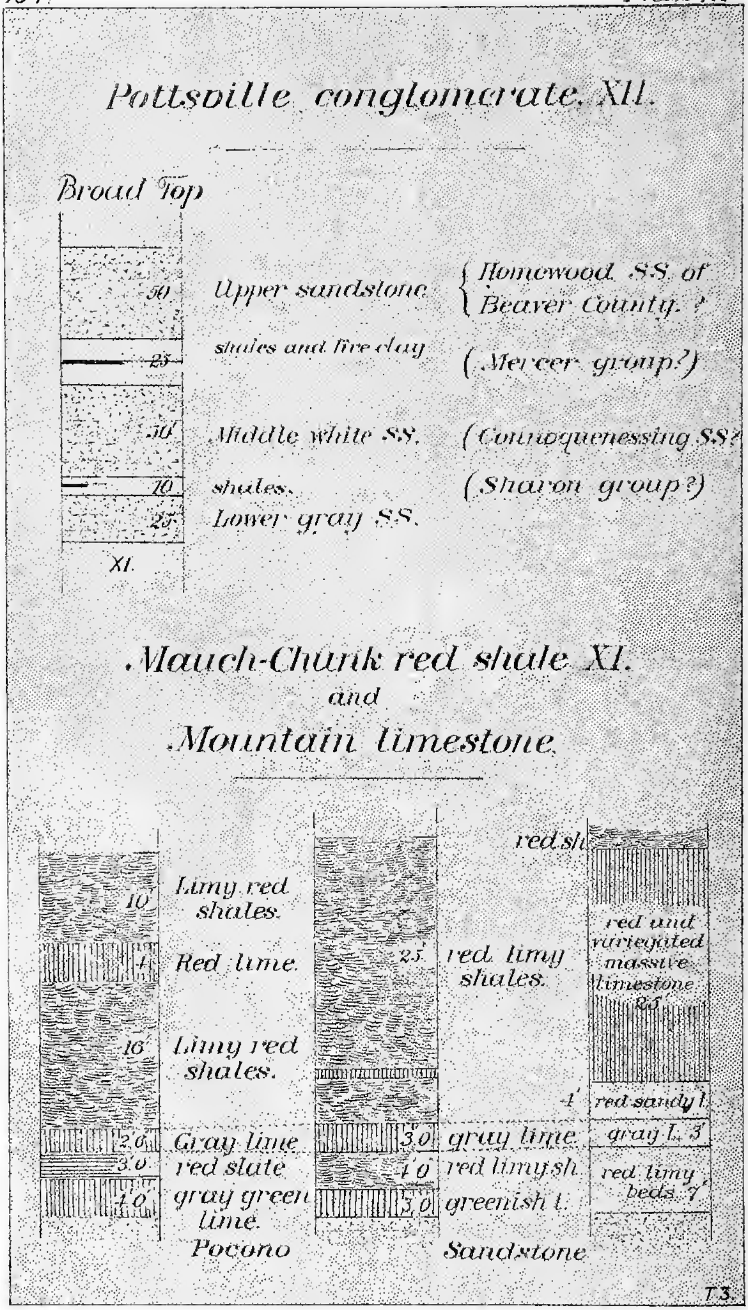
This formation, forming the rim of the Broad Top plateau all round, and the crests of the spurs which project from it northward into Trough valley :—Wray's hill, Rocky ridge, Shirley's knob, Round knob, Chilcoat's knob, Houck's knob, Boker's knob, and Crum's knob (encircled by Tatman's run), consists of three massive sand rocks separated by two intervals of shale; thus:—

XII	*Homewood* sandstone, slightly pebbly,	50′	160
	Mercer shales and coal bed,	20′ to 30′	
	Connoquenessing white pebbly sandstone,	50′	
	Sharon shales and coal bed,	5′ to 15′	
	Sharon pebbly sandstone,	25′	

The Homewood Sandstone, (*Johnson Run sandstone* of McKean county,) has a thickness of only 50′ at any locality where I could recognize it on Shoup's run; but Mr. Ashburner's survey of East Broad Top gives it 160′. (See Report F, p. 191.) Its layers, 1′ to 3′ thick, being generally free from pebbles, it is called locally the "building stone," and is readily split and dressed. It is well exposed where Miller's run enters Shoup's run; and on both dips of the anticlinal between Powelton and Dudley, it makes a 30′ cliff south of the run.

The Mercer Coal bed, (*Alton Coal bed* of McKean county,) can seldom be seen on account of the fallen blocks of the overlying sandstone. Its blossom appears on Miller's run, a little above Powell's coke works; overlying 10′ to 15′ of impure fire clay. In an old trial drift at the spring below Robertsdale it proved to be only 1′ to 2′ thick. Mr. Foster informed me that he has found it 3′ thick east from Broad Top city.

The Connoquenessing Sandstone (*Kinzua creek sandstone* of McKean county) is harder and more massive than the one above it; a matrix of grayish white sand, through


Pottsville conglomerate XII.
Broad Top
50 Upper sandstone
Homewood SS. of Beaver County?
25 shales and fire clay
(Mercer group?)
50 Middle white SS.
(Connoquenessing SS?
10 shales.
(Sharon group?)
25 Lower gray SS.
XI.
Mauch-Chunk red shale XI.
and
Mountain limestone.
10 Limy red shales.
4 Red lime.
16 Limy red shales.
2.0 Gray lime
3.0 red slate
4.0 gray green lime.
Pocono
25 red limy shales.
3.0 gray lime.
4.0 red limy sh.
3.0 greenish l.
Sandstone
red sh
red and variegated massive limestone 25
4 red sandy l.
gray L. 3
red limy beds 7
T3.

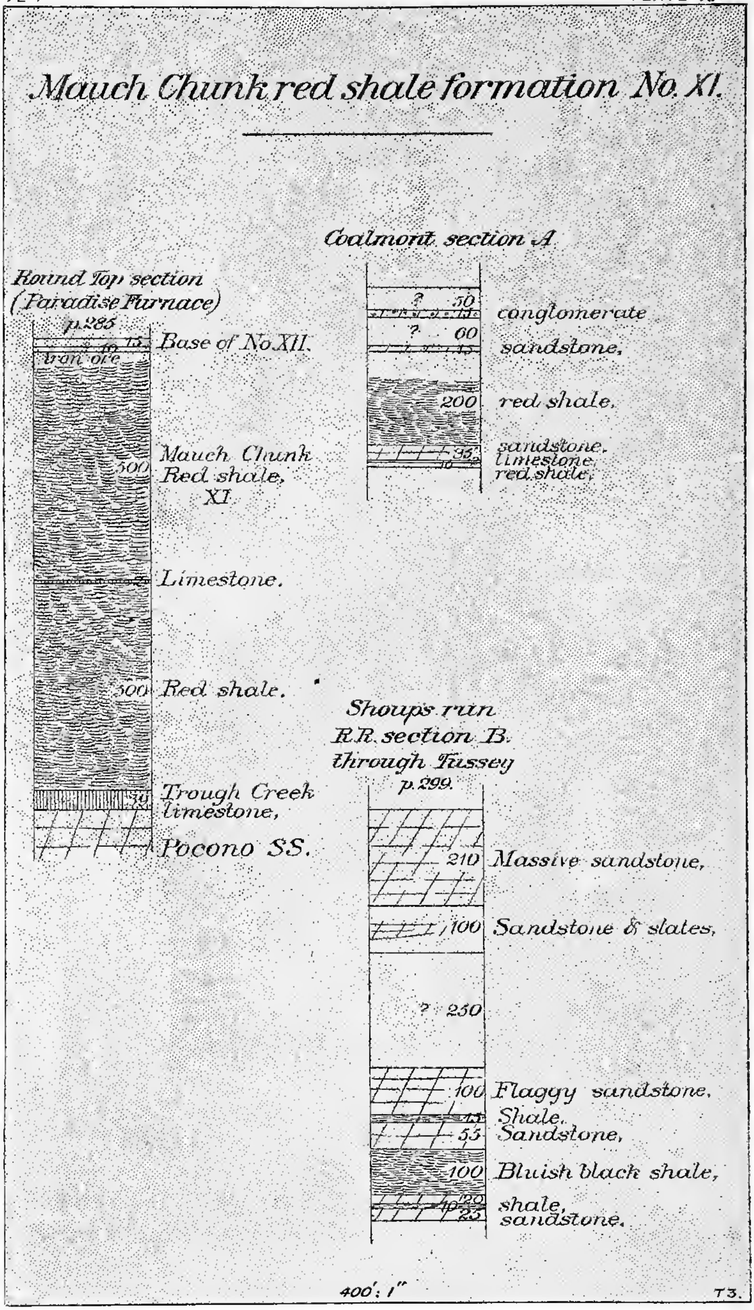
which white quartz pebbles are scattered, varying in size from a pea to a chestnut and never exceeding that of an egg. It is finely exposed between Dudley and Powell's station, arching over the anticlinal, in cliffs 45′ high, on both sides of Shoup's run. It makes cliffs back of Powell's coke works for a long distance up Miller's run.

The *Sharon Coal bed* (*Marshburg Coal bed* of McKean county report) with its fire-clay floor shows under the arch of conglomerate on the Dudley road above Powell's station 1½′ to 2′ thick, and 125′ to 140′ beneath the top of No. XII.

The *Sharon conglomerate* of Mercer county (the *Olean conglomerate* of McKean, &c.,) a hard grayish white sandstone, tending to brown, and not more than 20′ or 25′ feet thick, caps Round Top knob, near Paradise furnace in Todd township (1000′ above Trough creek) with cliffs 10′ or 15′ high over several acres of ground. It makes conspicuous cliffs on both sides of Shoup's run at Coalmont; and rising northward it makes a large part of the surface of the mountain until it breaks off at the cliffs overlooking Trough Creek valley in that direction.

[In Report F, at page 192, will be found Mr. Ashburner's measurement and description of the Conglomerate No. XII, in the long synclinal ridge of Wray's hill and Rocky ridge; thus:

Homewood sandstone: (*top member*, white and reddish white, and gray flaggy sandstone and conglomerate beds; *middle member*, predominance of conglomerate beds, with large pebbles, irregularly distributed, and strong current-bedding; *bottom member*, chiefly thin bedded, pebbly sandstones) in all	160′
Mercer group: (sandstone and shale 14′; *coal bed* 2′; fire clay, not measured; gray sandstone, current-bedded 17′; dark gray and black slate, and slaty sandstone 7) in all .	40′
Connoquenessing sandstone: hard massive gray strata, cleavage both right angled and oblique surface stained and coated with iron and manganese, with impressions of *calamites*, *lepidodendra* leaves, and *sigillaria*, . .	10′
Sharon conglomerate; *upper part*, hard massive gray and white sandstone beds and conglomerates with large pebbles abundant in the middle layers; *lower part*, less pebbly, sandstone bed becoming dark gray and flaggy, containing specks of mica; in all	70′


Mauch Chunk red shale formation No. XI.
Coalmont section A.
Round Top section (Paradise Furnace) p.285
Base of No XII.
iron ore
Mauch Chunk Red shale, XI.
500
Limestone.
500
Red shale.
Trough Creek limestone,
50
Pocono SS.
50
conglomerate
60
sandstone.
200
red shale.
35
sandstone.
limestone.
red shale.
Shoup's run R.R. section B. through Tussey p.299.
210
Massive sandstone,
100
Sandstone & slates,
? 250
100
Flaggy sandstone.
Shale.
55
Sandstone,
100
Bluish black shale,
shale,
sandstone.
25
400': 1"
T3.

Total thickness of No. XII (a little uncertain where measured at Wray's hill railroad tunnel, on account of varying dips; but verified by measurements west of Sideling hill tunnel, and on the road from Robertsdale to New Grenada,) in all, ... 280′]

The Mauch Chunk red shale, No. XI.

This formation, which Mr. Ashburner's topographical survey between Sideling hill and Wray's hill makes 1,100 feet thick, surrounds the Broad Top mountain, and occupies the whole of the wedge-shaped valley of Trough creek, rising on the inside slope of Terrace mountain.

It is fairly well exposed on the slopes of Round Top near Paradise furnace (where it is nearly horizontal) from the coping cliffs at the summit of the knob, down to the bed of Trough creek. Allowing 50′ to 75′ for dip in half a mile, its thickness will be 1,050 feet.

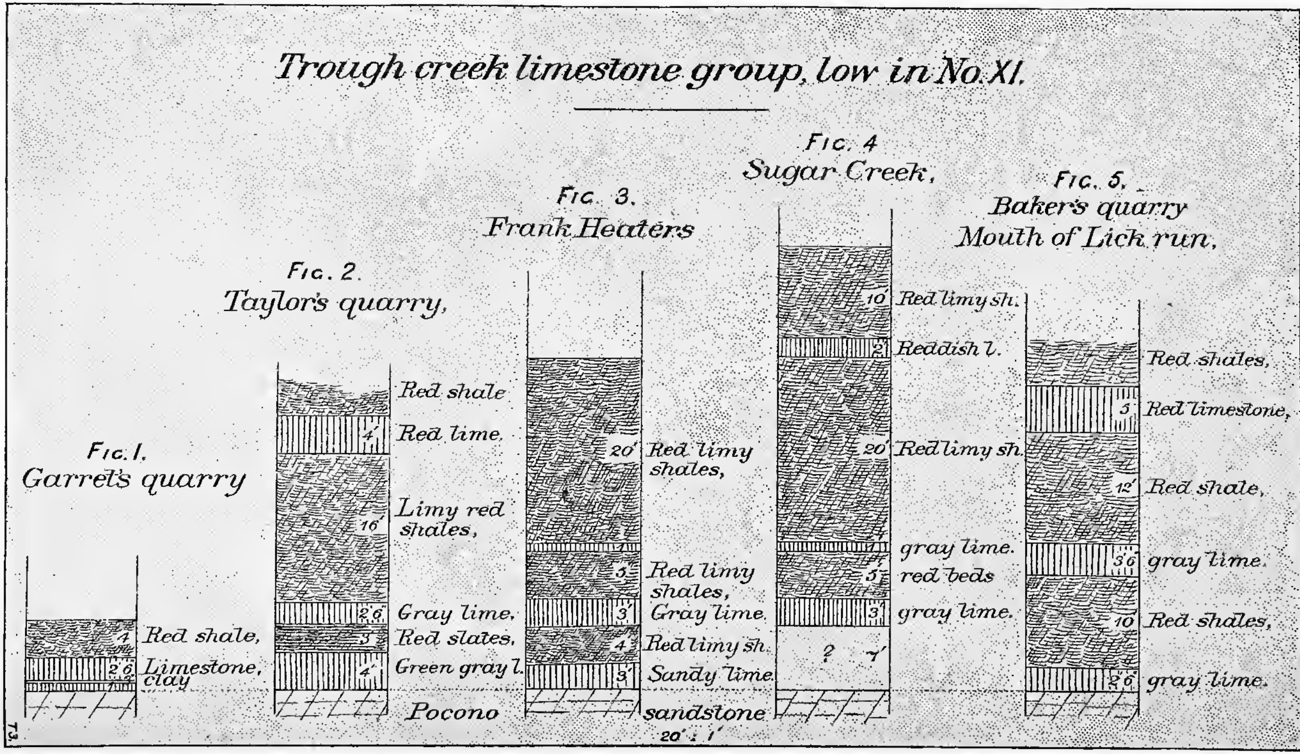
Some green sandstone beds occur in its upper portion, one of which (about 150′ beneath the summit) is rather massive.

Nodules of iron ore are scattered through a bed of shale 10′ or 15′ beneath the cliffs of XII at the top of the knob; and this is all that represents the *Ralston iron ore* of other parts of the State, especially in the northern and southwestern counties.

Brecciated limestone, 2′ thick, crops out on Shoup's run about 175′ beneath No. XII.

Another bed of *brecciated limestone* occurs in Round Top at about 500′ beneath No. XII, where its fragments lie scattered over the surface in considerable quantity, indicating a bed about 3′ thick; a reddish-gray, impure limestone. It crops out also on the road from Todd P. O. through Tatman's gap. This bed may be the representative of the limestone bed of Fayette county and W. Virginia, which there is only 50′ to 75′ above the mountain limestone at the top of X; whereas here it is about 500′ above it, the intervening lower red shales of XI thickening that much coming east.

The *Trough Creek limestone* group separates this forma-


Trough creek limestone group, low in No. XI.
Fig. 1. Garret's quarry
4 Red shale,
2 6 Limestone, clay
Fig. 2. Taylor's quarry,
Red shale
4' Red lime.
16' Limy red shales,
2 6 Gray lime,
3 Red slates,
4' Green gray l.
Pocono
Fig. 3. Frank Heaters
20' Red limy shales,
5 Red limy shales,
3' Gray lime.
4 Red limy sh.
3' Sandy lime.
sandstone
20' : 1'
Fig. 4 Sugar Creek,
10' Red limy sh.
2 Reddish l.
20' Red limy sh.
gray lime.
5' red beds
3' gray lime.
? 7'
Fig. 5. Baker's quarry Mouth of Lick run,
Red shales,
5 Red limestone,
12' Red shale,
3 6 gray lime.
10 Red shales,
2 6 gray lime.
T3.

tion XI from the underlying Pocono sandstone formation X. It is shown on the south bank of the creek, three fourths of a mile below Todd (Brick) mills, on Mr. Taylor's land, thus:

	Red limy shale,	10′	34½′
c.	*Red limestone,*	4′	
	Red limy shale,	16	
b.	*Gray limestone,*	2½′	
	Red slate,	3′	
a.	*Gray-green limestone,*	4′	

Pocono sandstone beds immediately underlie bed *a*, which has been considerably quarried in Trough Creek valley for the farmers' use, greatly increasing the fertility of the red-shale soil.

Another section just below Trough Creek church, on the south bank of the creek, reads as follows:

	Red limy shale,	25′	41′
c.	*Reddish-gray limestone,*	1′	
	Red limy shale,	5′	
b.	*Gray limestone,*	3′	
	Red limy shale,	4′	
a.	*Greenish sandy limestone,*	3′	
	Sandstone.		

There are many other exposures of these beds along the creek, between the mouth of Little Trough creek and the gap through Terrace mountain. The principal quarries on Little Trough creek are on Mrs. Swope's land near its head, and on the Borings' lands further down. The quarry bed at both places is a greenish-gray bench, 3′ or 4′ thick, over sandstone beds. Mrs. Garret has a large quarry nearly opposite the mouth of Little Trough creek. The Sideling hill outcrop of these beds is not used because too siliceous.

The whole thickness of this *Trough Creek limestone group* may be stated as 50 feet.

The sections given above may be considered typical; but there are not wanting evidences that the group changes its character in various localities. For example the following section appears 200 yards above Trough Creek bridge at Paradise furnace, on the Patterson lands; the upper or red limestone (*c*) making a cliff along the creek above the furnace:

	Red shale.		
c.	*Red variegated massive limestone,*	25′	39′
	Red shaly limestone,	4′	
b.	*Gray limestone,*	3′	
	Red limy shale,	7′	
a.	(*Wanting.*)		
	Sandstone		

Other sections will be found in the description of Todd township.

An analysis of the *red* limestone (c) showed it to be only 52 per cent carbonate of lime and 43 per cent. siliceous matter; whereas the *gray* limestone was 91 per cent carbonate of lime and only 6 per cent siliceous matter. The physical aspect of the gray and greenish gray siliceous limestone beds is exactly like that of the "Siliceous limestone" which appears at the bottom of No. XI, in the gaps of Chestnut Ridge and Laurel Hill in Westmoreland and Fayette counties. (See Reports, K^2, K^3.)

Fossils are seldom seen, except apparently ground up fragments of shells. But at G. W. Baker's quarry, a mile north of Todd P O., a species of *Straparollus* was seen, in a red brecciated limestone, 30′ above the base of the group.

Manganiferous iron ore deposits, derived apparently from the dissolution of the Trough Creek limestone group, occur at several places in the valley; one on the Patterson estate at the foot of Terrace mountain, just south of Trough creek, where nodules and nuggets of various sizes are scattered through a considerable mass of clay and *débris*. But the limestone beds are not seen at any place where the ore-clay is seen. It was once quite extensively mined for Paradise furnace, and stoves and other castings of good quality were made for farmhouse use. Mr. McCreath's analysis of a sample of 110 small pieces collected by John A. Patterson showed a percentage of 23.650 metallic iron, and 19.676 metallic manganese, in the ore; with 0.458 phosphorus. In all cases the ore deposit lies directly on the sandstones at the foot of the mountain.

[Mr. Ashburner's section of No. XI, in Report F, page 195, divides itself into three parts: 910′ of yellow, red and gray shales, and red and gray soft sandstones; 49′ of limestone and limy shale beds, and 141′ of underlying red and greenish gray sandstones and sandy shales, which Prof. White prefers to consider the upper beds of the Pocono formation No. X.

His Trough Creek limestone is divided into ten smaller groups, thus:

Red shaly limestone,	3′+	49
Red clay shale,	10′±	
Red clay shale, very soft,	5′	
Red siliceous limestone, massive, easily weathered, and containing *Terebratula ræmingeri, Grammysia, Strophodonta, Rhynchonella,*	2½′	
Red shale, very soft,	2′	
Red and gray mottled limy shale, (concretionary), containing *Centronella,*	3′	
Red limy shale and *limestone,*	9′	
Red and gray massive limestone,	1′	
Gray massive limestone,	3′	
Red shale,	6′	
Greenish gray clay-limestone,	4′	

This section, however, is composed from two localities, Todd P. O. and New Grenada, nine miles apart, and depends for its correctness upon the identification of the variegated limestone quarried at the two places, which is the only valuable part of the group.]

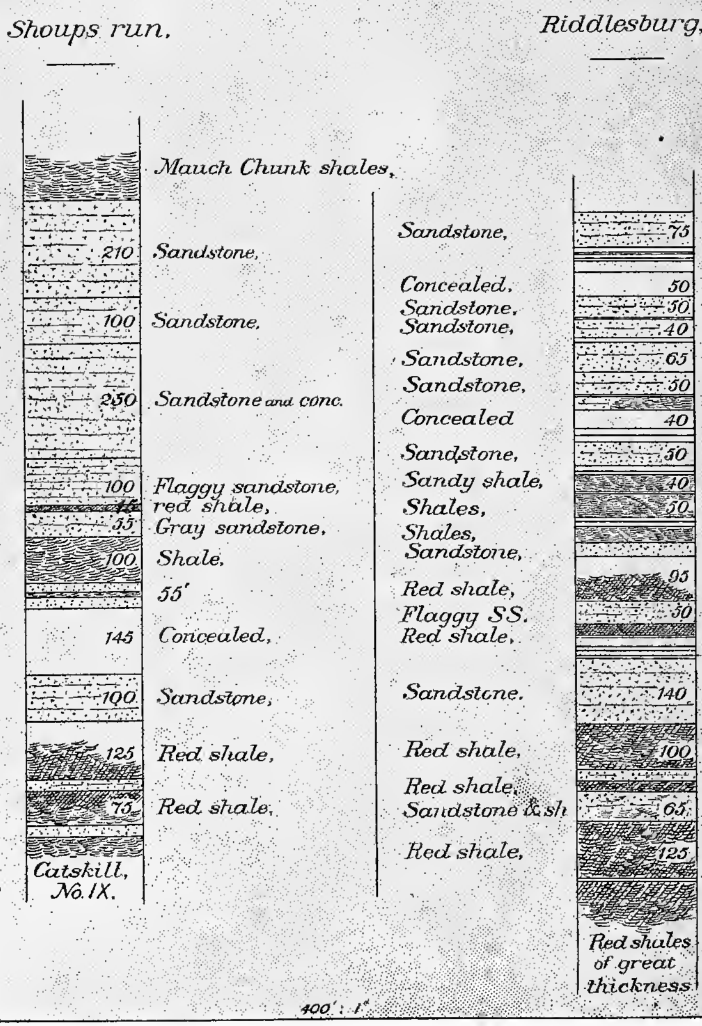
Pocono Sandstone formation, No. X.

This formation makes Terrace mountain west of Broad Top, and Sideling hill east of it.

It is composed of coarse, sometimes pebbly, greenish-gray, characteristically false bedded, more or less massive sand rocks, interstratified with thinner gray shales, like those of the Productive coal measures, but without *workable* coal beds.

Thin seams or streaks of coal, however, exist in the formation, two or three of which, varying from one to six inches in thickness, may be seen at the *Copperas Rocks* in Trough creek gap through Terrace mountain, half a mile below Paradise furnace, and about 200′ beneath the top of the formation.

Pocono Sandstone, No. X.



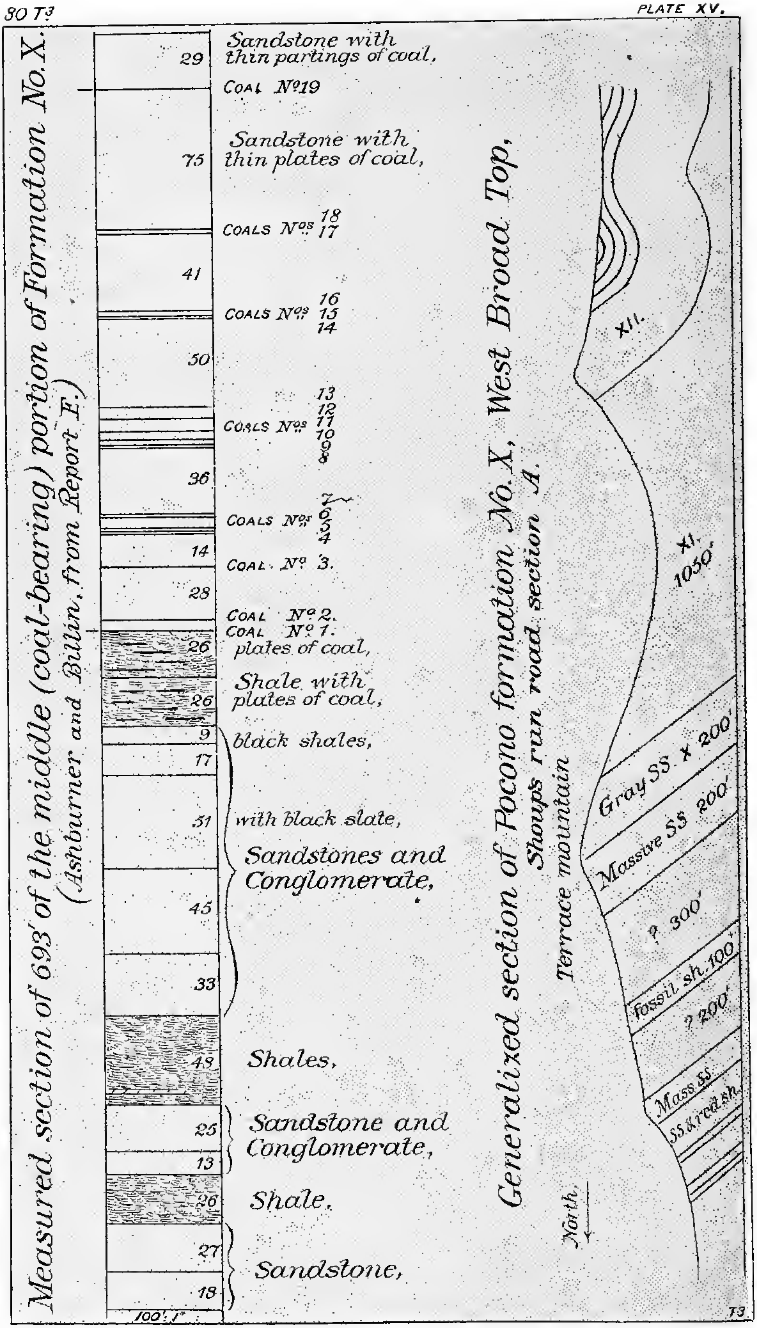
The following sections were measured in the gap which Shoup's run makes through Terrace mountain at Saxton, and in the gap which the Juniata makes through the same mountain at Riddlesburg. In both sections the topmost bed immediately underlies the lowest red shale of XI:

Shoup's run gap section (No. X.)

Gray sandstone, massive, coarse, somewhat pebbly (*underlying red shale XI,*)	210′	
Gray sandstone, dark, with thin dark shales,	100′	
Gray sandstone, massive, pebbly beds in a partly concealed interval of	250′	
Gray sandstone flags and shales,	100′	
Red shale,	15′	
Greenish gray sandstone,	55′	
Blue-black shale, with a few thin flags; (At the top, impressions of *Lepidodendron gaspianum;* In the bottom 25′ an abundance of fossil shells.)	100′	
Gray sandstone, massive,	20′	
Sandy shales,	10′	
Yellowish gray sandstone massive,	25′	
(Interval concealed,)	145′	
GRAY SANDSTONE, MASSIVE,	100′	
		1130′
Green sandstone and *red shale* in a partly concealed interval of	125′	
Greenish gray sandstone, massive,	25′	
Red shales visible in an interval of,	75′	
Greenish gray sandstone (making cliffs),	25′	
		250′
Red shale of IX in great force.		
Total thickness of rocks in the section,		1380′

Riddlesburg Gap Section. (No. X.)

Gray sandstone, massive, (*under XI*)	75′
Shale and sandstone,	13′
Shale, dark,	3′
Sandstone,	10′
Shale, dark, with broken *plants,*	3′
Gray sandstone,	25′
(Interval concealed,)	50′
Gray sandstone, massive,	50′
Black coal shale,	$\frac{1}{2}$′
Sandy shales,	$2\frac{1}{2}$′
ebbly sandstone, massive,	40′
Shales and shaly sandstone,	8′
Sandstone, massive, (lower half *pebbly*),	65

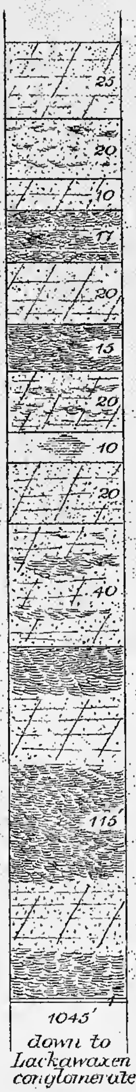

Measured section of 693' of the middle (coal-bearing) portion of Formation No. X.
(Ashburner and Billin, from Report E.)
29
Sandstone with thin partings of coal,
Coal No. 19
75
Sandstone with thin plates of coal,
Coals Nos. 18 17
41
Coals Nos. 16 15 14
50
Coals Nos. 13 12 11 10 9 8
36
Coals Nos. 7 6 5 4
14
Coal No. 3.
28
Coal No. 2.
Coal No. 1.
26
plates of coal,
26
Shale with plates of coal,
9
black shales,
17
51
with black slate,
Sandstones and Conglomerate,
45
33
48
Shales,
25
13
Sandstone and Conglomerate,
26
Shale,
27
18
Sandstone,
100' 1"
Generalized section of Pocono formation No. X, West Broad Top,
Shoups run road section A.
Terrace mountain
North.
XII.
XI. 1050'
Gray SS. X 200'
Massive SS 200'
? 300'
Fossil sh. 100'
? 200'
Mass. SS
SS & red sh.
T3

Gray sandstone, with shale partings, ...	50′	
Calcareous breccia, ...	1½′	
Sandstones and shales interstratified, ...	30′	
Red shale, showing at the bottom of a concealed interval of	40′	
Shales, { yellowish, sandy, 15′ / olive and yellow, 15′ }	30′	
Sandstone, massive, ...	50′	
Shales, olive-yellow, ...	15′	
Sandstone, gray, ...	5′	
Shales, yellowish, sandy, ...	40′	
Sandstone, gray, ...	2½′	
Shales, dark, very *fossiliferous;* (in the bottom 10′ *Spirifer, Rhinchonella,* &c.), ...	50′	
Sandstone, massive, ...	10′	
Shales, { sandy, . 10′ / red, yellow, &c., 35′ }	45′	
Sandstone, *very massive,*	30′	744′
Red shale, abundant in a partly-concealed interval of	95′	
Shales and flags, ...	50′	
Red and yellowish shales, ...	25′	
Sandstone, gray, ...	8′	
Red shale, ...	20′	
Sandstone, gray, ...	5′	
Red shale, ...	10′	
Red sandy beds, ...	5′	
GRAY SANDSTONE, MASSIVE; including one *calcareous breccia* (3′ to 4′) 40′ above the bottom; and several other smaller ones, ...	140′	358′
Red shale, ...	100′	
Sandstone, greenish gray, ...	25′	
Red shale, ...	20′	
Sandstones, green, with *red shale partings,*	65′	
Red shale, ...	125′	
Red sandstone, ...	5′	340′
Red shale of No. IX in great force.		
Total length of section, ...		1442′

The above sections are subdivided into groups, the uppermost of which consists of *Pocono rocks* with little or no red shale ; the middle one of *Pocono rocks*, with interstratified red shales, ending below in a massive gray sandstone of great thickness ; and the lowest one of *Catskill rocks.*

	Shoup's run.		*Riddlesburg.*	
Upper group, X, ...	730′	1130′	744′	1152′
Middle group, X, ...	400′		358′	
Lower group, IX, ...	250′		340′	
Length of section, ...	1380′		1442′	

Middle measures of Catskill No. IX.



Sandstone, greenish gray, massive,

Shaly sandstone,

Sandstone, massive, greenish,

Red shale and thin red sandstones,

Sandstone, grayish green,

Red shale,

Reddish gray sandstone and shale,

Concealed,

Sandstone, massive, reddish gray.

Red sandstone and shales,

Olive sandy shales and sandstones containing crinoidal fragments, Spirifers and fragments of other fossil forms,

Spirifer bed (S. disjuncta)

Scale 60' : 1"

The 100′ massive gray sandstone of the Shoup's run gap section is undoubtedly the 140′ massive gray sandstone (with calcareous breccia layers) of the Riddlesburg gap section; lying in both cases about 1000′ beneath the base of XI; and being in both cases the lowest well defined massive gray Pocono sandstone in Terrace mountain.*

Prof. Stevenson's measurement of No. X in the Riddlesburg gap of Terrace mountain agrees closely with mine, being 1365′.†

Messrs. Ashburner and Billin (in 1877) measured these rocks in Sideling hill, on the eastern side of the Broad Top synclinal, with the following result:

Upper X.	*d.* Sandstones massive and flaggy,	610′	1303′	
Middle X	*c.* Coal-bearing series,	313′		
	b. Conglomerates, sandstones, &c.,	380′		
Lower X.	*a.* Sandstones and shales,		830′	
	Total length of section in Sideling hill,		2133′	

Although the instrumental survey carried on by Messrs. Ashburner and Billin for mapping that part of Huntingdon county gave special accuracy to their measurements, yet the exposures in the gaps of Terrace mountain are so good that, by carefully pacing the horizontal distances, the calculation by dip cannot be in error more than 50′ or 100′ in the total length of either section.

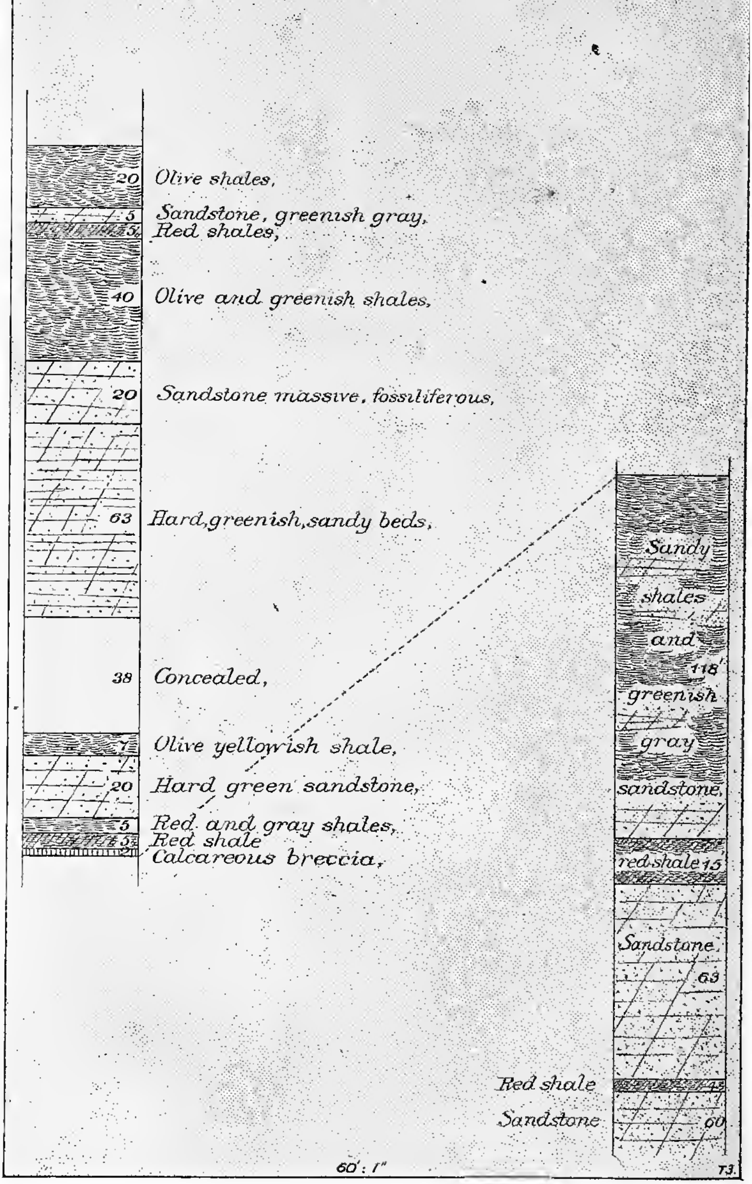
A comparison of the measurments in Sideling hill (Report F) with my measurements in Terrace mountain, shows that when both formations (X and IX) are taken together, they have the same total thickness, thus:—

X. *Pocono*,	In Terrace Mt. 1132′	In Sideling hill,	2133′
IX. *Catskill*,	" " 3600′	" "	2680′
	4732′		4813′

* In my reports G^5, G^6 and G^7 on the counties of north-eastern Pennsylvania I have made this rock the basal member of a *Pocono-Catskill group*, or *passage beds from X to IX*, containing both gray sandstones (X) and red shales (IX); but as Report F makes no such distinction it seems needless to insist upon it in this report. (See G^7, page 50.)

† See Report T^2, p. 234.

Red beds in Catskill formation No. IX.



The greater abundance of red shale intervals in the western (Terrace mountain) sections, and of gray shales in the eastern (Sideling hill) section, suffices to explain the different way in which this mass of nearly 5000′ has been classified ; and it must be kept in mind that the deposits of red shale are not a perfectly reliable guide, because they have the habit of passing into a peculiar type of greenish gray fine grained sandstone, in a distance of a few miles.

[If the Trough creek limestone group be assumed as the bottom of No. XI, there remains to be accounted for in the Terrace mountain sections 141′ of rocks placed by the Sideling hill survey at the bottom of No. XI, beneath the limestone. These beds (see Report F, p. 195) are not well exposed in Sideling hill, but consist of alternations of thick standstones and shales with gray flagstones, containing red and variegated shales, and were placed in No. XI on that account.]

Pocono rocks in Sideling hill.

[The Pocono formation No. X in Sideling hill was made to commence (at top) with the great mass of sandstone beds, coarse-grained, massive, gray and brownish gray, alternating with thinner flaggy layers and partings of shale, a few of which near the top (both sands and shales) are *red*, forming the western slope of the mountain ; the whole being . 580′

Under this mass (at the western mouth of the railroad tunnel through the mountain) is a massive gray sand rock coated with iron rust, ... 8′

Under this (in the tunnel) lie gray and greenish-gray sandstone beds, containing a foot of black slate . . . . . . 22′

Under this lie the shales and flags which hold *nineteen* small seams of coal,* (see the figure on Plate —, already referred to,) . . . . 313′

---

*Sometimes the partings of coal are between the sandstone beds, but sometimes they lie along the cross-bedding planes, showing that the coal did not grow on the spot, but was drifted in from a distance.

These coal seams vary from one inch to ten or twelve inches, and sometimes they are parted themselves by layers of sandstone, which enter them and leave them again on a knife edge. Fire-clay (underclay) is almost unknown to these coal seams, which goes further to prove their drifted character.

Under this lies a thick bed of soft black shale containing plates of coal and impressions of minute plants, alternating with thin layers of a fine-grained micaceous conglomerate, the shales much iron-stained, and the whole mass, . . 25′

Then, yellowish shale with plates of coal, and slickensided surfaces (showing this to be one of the planes of the shearing movement when the anticlinal and synclinal waves were produced,) . . . . 26′

Then the uppermost of the great sand rocks, 9′ thick, on an exceedingly thin (2″) seam of black coal slate, under which come the *massive conglomeratic sand rocks, extraordinarily current-bedded* (the middle layers (51′) making the central rib and *crest of the mountain;*) . . . . . 122′

Next below this, on the east slope of the mountain crops out a mass of shale (with a few sandstone layers) . . . 83′

Then massive sandstone beds, 35′; fine-grained conglomerate, with thin beds of black micaceous sandstone, 13′; shale and sandstone, 26′; massive, false-bedded sandstone, 17′; shale and sandstone, 6′; sandstone, 7′; shale, 5′; sandstone and shale, 15′; in all, ... 85′

Under these crop out further down the slope many alternate beds of more clayey and less massive sandstone, (coarse-grained and much stained with iron, and often specked with red and yellow,) and beds of both sandy and clayey shales, which are more numerous in proportion than those higher up; the prevailing colors of both sands and shales being gray, yellow, olive, and green, and nodules of carbonate of iron being frequent; in all, ... 830′

This 830′ of beds Mr. Ashburner grouped together under the name "*Lower (green sandstone) group of No. X.* If added to the *Upper (gray sandstone) group of No. X*, 610′, and the *Middle (coal-bearing and conglomerate, double) group of No. X*, 693′, then the whole of formation No. X in Sideling hill becomes . . . . 2133′

If however the *Lower (green sandstone) group of X* be considered as the upper part of the Catskill formation No. IX, then No. X remains only 1303′ thick, agreeing very well with the thickness assigned to it by Prof. White in Terrace mountain.

This Lower group (still in the tunnel) begins with:

Slaty sandstone, dark blue, with fine white shale,	22′
Shales, gray, green and yellow,	25′
Cypricardina and Orthis green shale bed,	5′
EAST MOUTH OF SIDELING HILL TUNNEL.	
Softer shales (outside the tunnel,)	25′
Sandstones, coarse, hard, reddish gray, / Shales alternating with the sandstones,	165′
Sandstone, coarse, yellow, iron stained, / Sandstone, grayish brown, (alternations,)	12′
Shaly sandstones, yellow, gray and green,	44′
Soft shales, gray flags and brown micaceous sands,	50′
Olive flags and green-gray sands with iron balls,	42′
Soft sandstones, green and olive, / Soft sandstones, yellow, flaggy, / Hard sandstones, massive, iron-specked, — alternations,	440′

The little coal beds between the sandstones of the upper half of the middle part of the formation are thus arranged.

Top sandstone mass,	29′ 5″
Coal seam, 2½ inches thick.	
Second sandstone mass,	76′ 3″
2 coal beds, in 12 inches.	
Third sandstone mass,	41′ 4″
2 coal beds, in 3′ 3″ of rocks.	
Fourth sandstone mass,	47′ 1″
6 coal beds, in 19′ 10′ of rocks.	
Fifth sandstone mass,	36′ 8″
4 coal beds, in 6′ 10″ of rocks.	
Sixth sandstone mass,	17′ 0″
1 coal bed, 2 inches thick.	
Seventh sandstone mass,	28′ 0″
2 coal beds, in 5′ 2″ of rocks.	
Total,	37′+276′=313′

The sandstone masses and shale masses of the lower half of the same middle division of the formation are arranged thus:

Top shale,	51′	
First sandstone mass,		122
Shale,	83′	
Second sandstone mass,		38′
Shale,	26′	
Third sandstone mass,		40′
Shale,	5′	
Fourth sandstone mass,		15′
Total,	165′+215′=380′	

Coal-plant fragments collected from the *débris* at the west end of Sideling hill tunnel were determined by Mr. Lesquereux to be mostly pieces of *Sphenopteris flaccida* and *Stigmaria minuta;* with a *Ulodendron* (*majus?*); a *Knorria avicularis;* a branch of *Stigmatocanna* (*Volkmanniana?*); a *Lepidodendron;* and many fragments of *Sphenopteris* (*Hymenophyllites*) *furcata.* (See Report F, p. 212.)]

Considering the extreme thinness of these coal beds in Sideling hill (none of them being more than 3 inches thick, and only two of them having a fire-clay floor) it is not surprising that they do not appear in the natural rock exposures in the gaps through Terrace mountain.

There does appear however in the Trough creek gap, in the Shroup's run gap, and in the gap at Riddlesburg, the outcrop of a notably thick group of dark, nearly *black, sandy fossiliferous shales*, which may represent on the west side of the trough the coal-bed series of the eastern side.

In a cutting made by the Huntingdon & Broad Top railroad, just south of the county line, appear the black shales, 100′ thick, mentioned in the Shoup's run section, 730′ beneath the bottom of the No. XI red shale, holding impressions of *Lepidodendron* trunks in the upper layers, and shells in the lower layers.

In the Riddlesburg gap section, 609′ beneath the top of the section (bottom of XI), are seen 50′ of *very fossiliferous dark shales* with *Spirifers*, *Rhynchonellas*, and other shells in the lower layers. In some of the layers the shells are abundant enough to turn the shale into a kind of poor limestone bed.

The Catskill formation, No. IX.

This makes the foot slope of Terrace mountain and the valley of the Raystown branch of the Juniata river; and the foot slope of Sideling hill and Smith's valley.

At some of its great bends the river cuts into the underlying Chemung rocks of VIII, and then crosses the east-dipping Catskill rocks nearly to the top layers at the foot of the mountain, giving fine exposures of the whole formation.

Red shale predominates in the upper two thirds of No. IX; but in some of the sections green sandstone beds are extensively interstratified with the red shale, greatly reducing its amount; notwithstanding which the whole belt of outcrop is a beautiful farming country, the sandstones weathering readily, and making with the red shale a mixed soil, exceedingly fertile, especially when properly limed. This interstratification is well shown in the great bend opposite the mouth of Coffee run, the top of the section being on the foot slope of the mountain. See Fig. 3, sheet No. 2; and page Plate XVI.

Coffee run section, No. IX.

POCONO SANDSTONE.		
Interval concealed,	700′	
Red shales predominating in	1270′	
Sandstone, greenish gray, massive,	10′	
Interval,	15′	
Sandstone, reddish, massive,	10′	
Red shale with some thin green sands,	115′	
Sandstone, greenish gray, massive,	25′	
Sandstone, shaly,	20′	
Sandstone, greenish gray, massive,	10′	
Red shale and thin *red sandstone beds,*	17′	
Sandstone, grayish green,	20′	
Red Shale,	15′	
Sandstone, reddish gray and *red shale,*	20′	3478′
Interval,	10′	
Sandstone, reddish gray, massive,	20′	
Sandstone red and *red shale,*	40′	
Fossiliferous olive sandy shales and sandstones, containing *Crinoidal* fragments, *Spirifers* (of the *S. disjuncta* type), and other forms too much broken up for even generic determination,	115′	
Spirifer disjuncta bed,	1′	
Shales, olive and greenish, (with *red shales* at the bottom) in a partially concealed interval of	300′	
Sandstones and shales, greenish, in a partially concealed interval of	220′	
Sandstones (green), shales (olive), and *red beds,*	525′	
UPPER CHEMUNG CONGLOMERATE of Stevenson (in Bedford county) very hard, dark gray, filled with *flat quartz pebbles* (*Lackawaxen Conglomerate* of N. E. Pennsylvania,)	10′	
Sandstone, greenish gray, rather massive,	15′	110′
Red shales, in an interval of	85′	

This section was constructed by pacing the horizontal distances, and calculating the geological thicknesses, the dips increasing from 15° at the top to 35° at the bottom of the section (which is assumed as the bottom of the Catskill formation No. XI.)—*Total calculated thickness*, . . 3588′

Another section made along Trough creek and James creek (see the description of Todd township) but largely measured by reference to points on the township map, foots up . . . . 3942′

A third set of measurements, made a mile further east (see the description of Penn township) foots up . . 3650′

A fourth section, made along the south bank of the Juniata river in Juniata township, gave a total of . . . 3420′

A fifth, on the north bank (see the description of Henderson township) gave . . . . 3620′

An average of all five sections of No. IX, from say 1100′ beneath the bottom red beds of IX, down to the bottom of the lowest red shales (say 100′ beneath the UPPER CHEMUNG CONGLOMERATE of Prof. Stevenson,) would be . . 3625′

This conglomerate seems to be very certainly identifiable with the great *fish conglomerate* of Montour and Columbia counties (see Report G[7]) and the *Lackawaxen conglomerate* of Pike county (see Report G[6]) where it lies more than 1000′ above the base of the Catskill formation No. IX as there limited ; for the bones, teeth and scales of *Holoptychius* found in it, and in beds at least 100′ beneath it, are considered characteristic of the Catskill formation.

Chemung shells, however, occur in Huntingdon county 1000′ above it ; and in Montour and Columbia counties 700′ above it ; but in Monroe and Pike counties not a shell of any description was found in any of the rocks above it, nor any of the rocks for 2000′ beneath it.*

* The absence of the *molluscan fossils* together with the presence of *red beds* and the characteristic, greenish-gray sandstones would in Pike county and in the *Catskill mountain* region be conclusive evidence of *Catskill age*, hence when a particular stratum, like the *Lackawaxen conglomerate*, has been traced continuously from the region where its *Catskill age* would be unquestioned, and *Chemung fossils* are found coming up not only to it, but passing even a thousand feet above the same I cannot see that the latter fact can have any weight in determining the question as to whether or not it shall be placed in the *Catskill;* for, where stratigraphy can be employed its author-

No. IX in Huntingdon county may then be subdivided into—(1.) 2500′ of *red shales*, with gray sandstones;—(2.) 1000′ of *greenish gray sandy shales and flags*, with a few thin red beds, holding from top to bottom fossil shells of Chemung type;—(3.) 20′ of *flat quartz pebble* conglomerate

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ity is absolute, however the fossils may arrange themselves; hence when I have shown conclusively, as I am able to do, that the *Lackawaxen conglomerate* of Pike county, which has no *fossil mollusca above* it, and none *under* it for an interval of 2000′, is identical with the *upper conglomerate* of Huntingdon, Bedford and Fulton counties *above* which *fossil mollusca* extend for 1000′, then it must still be called *Catskill* in the latter localities, or else be thrown out of the *Catskill beds* at the east and relegated to the *Chemung*, along with about 2000′ of beds which were certainly intended to be included in the *Catskill group* by the author of the term.

It is possible that the name *Chemung*, in the New York system, has really been made to include rocks in southern central New York, which at the east, overlooking the Hudson, have been placed in the *Catskill*, and if so it would furnish a simple explanation of the fact that *Chemung fossils* are found in Pennsylvania passing high up into beds that are certainly of the same age as those which make up the lower half of the Catskill mountains.

It is true that in the central Pennsylvania series, *red beds* occur down as far as 700′-800′ under the *Lackawaxen conglomerate* even in Huntingdon county; 1100′ in Montour, and 1300′ in Pike, while *no red beds* have ever been reported from the *Chemung* of southern New York. Still the absence of *red beds* there is readily explained from the fact that the whole *Catskill series* thins away very rapidly *northward*, and as I have shown in G^5 and G^6, this thinning is largely due to the northward disappearance of the *red beds* from IX. Hence it may well be that this *fossiliferous Catskill series* of greenish-gray sandstones and red shales in central Pennsylvania, when followed north into New York may have lost every trace of the *red beds*, and be represented by the greenish-gray sandy rocks above, just as every trace of the *red shale* in the 3000′ of *Mauch Chunk red shale beds* on the Lehigh river disappear completely when we follow it northward to the northern end of the *Lackawanna coal basin;* but this would not change the age of the greenish-gray rocks which, deprived of the interbearing *red beds*, still represent the *Mauch Chunk* on the Lackawanna river.

Hence if it should prove true that the *Chemung beds* of southern central New York have the relation to the rocks of the *Catskill mountain* region suggested above, there would be no reason (except possibly priority of name) why the beds in question should be included in the *Chemung*, seeing that they have been included in the *Catskill* at the east; so that until this question is decided by stratigraphy (for the *mollusean remains* can be no better guide in New York than in Pennsylvania) viz: whether or not the *Chemung* of southern central New York includes rocks which in eastern New York have been referred to the *Catskill*, and *vice versa;* until this has been done, it seems preferable to the writer to retain these beds in the *Catskill* to which group as at present understood in the region where it was named, the stratigraphy shows they unquestionably belong. The general argument of this will be given in connection with the *Chemung beds*.

(some of the pebbles being apparently of *red jasper*) with occasional fragments of *fish*, and broken up *shells*;—(4.) 100′ of olive, green, red and variegated shales and red sandstone beds, holding Chemung fossil shells.

The base of No. IX, however, is here assumed merely to harmonize the Huntingdon county section with that of the northeastern counties (described in Reports G⁶, G⁷,) in which Holoptychius (fish) remains were found 100′ beneath the Lackawaxen Conglomerate (3); for there is really nothing in group (4) to distinguish it sharply from the 400′ or 500′ of beds underlying it which are assigned to the Chemung formation ; as will be made apparent further on in this report. Prof. Stevenson, in Report T² on Bedford and Fulton counties prefers to include this Upper Conglomerate in the Chemung formation.

(1.) These 2500′ of beds are very barren of fossil remains ; although a few undeterminable macerated fragments may be seen in them ; and occasional rare specimens of fish scales and broken bones. *Calcareous breccia* (cornstone) beds are sometimes seen, seldom more than one or two feet thick. Ripple-marked surfaces are very abundant, especially in the red shale layers.

A very remarkable layer of pure *specular iron ore, one or two inches thick*, (therefore worthless) is found on Messrs. Shonefelt's land, near Haun's bridge, about 1400′ above the LACKAWAXEN CONGLOMERATE. The pieces first found were supposed to be meteoric ; but the regular bed was afterwards discovered. Prof. Claypole reports a similar occurrence, at about the same horizon in the series, in Perry county.

(2.) *The Haun's Bridge group* has been so named from the superb exposure of the 1000′ of fossiliferous beds overlying the LACKAWAXEN CONGLOMERATE, at that locality in Juniata township. Here some of the common Upper Chemung types of *brachiopod* and *lamellibranch* shells are very abundant ; large collections may be made along the north bank of the river, just below the bridge. The group is here between 1000′ and 1100′ thick.

EXAMPLE OF SURFACE CREEP A

on the East Broad Top Raili

AS EXHIBITED IN SMITH'S VALLEY,
road in Huntingdon Co. Pa.

(3.) The UPPER (or LACKAWAXEN) CONGLOMERATE contains fragments of fish, and also shells, so completely ground up that not even the genus to which they belong can be determined; although one single specimen of a *Rhynchonella* was recognized with tolerable certainty. Its red jasper (?) pebbles would recall to a geologist of the Oil Regions the red pebbles which are peculiar to the Venango Oil-Sands. Other considerations pointing to this rock as the 1st Venango Oil-Sand, will be discussed when we come to describe the *Lower* (*Chemung*) *Conglomerate*. (See also Report G^5.) Its pebbles are generally *flat*, and some of them are 3″ long, 2″ wide, and 1′ thick. One of its best exposures is where the Cove Station road southeast to Puttstown crosses the river. Here the outcrop of the conglomerate makes a fall of more than one foot in the river bed, diagonally across it. A few hundred yards down stream the river bends and is again crossed by the rock (20′ thick), which then ascends the bank (at 38°) in a cliff.

(4.) The underlying beds are also here exposed; thus:

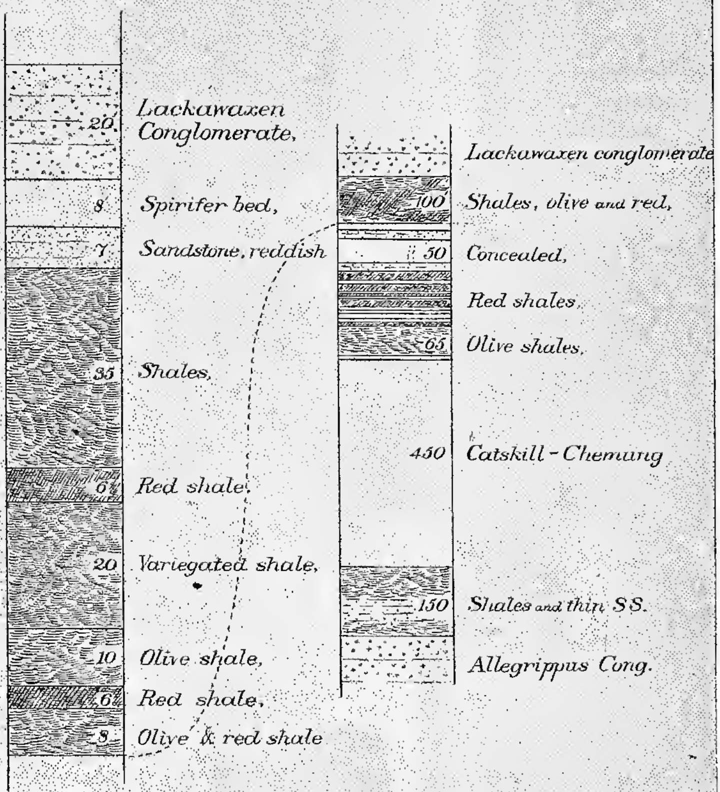
Shales, olive, sandy, with *Spirifer disjuncta ?*	8′	100′
Sandstone, *reddish*,	7′	
Shales, olive and greenish,	35′	
Red shales and *red sandstones*,	6′	
Red and olive shales,	20′	
Shales, olive, sandy,	10′	
Red shale,	6′	
Red and olive shales,	8′	

Catskill rocks in Sideling hill.

[*The Catskill formation No. IX* outcropping along the eastern foot of Sideling hill in Smith's valley was carefully measured by Messrs. Ashburner & Billin in 1874-5, and is thus described in Report F, p. 216.

The top of the section, however, commences at the base of the 440′ of olive shales and sandstones (777′ geologically beneath the *Cypricardia Orthis shale bed* at the east mouth of the railway tunnel, mentioned on page 87 above. Proceeding down the slope and across Smith's valley, we find:

Lackawaxen Conglomerate.



Sideling hill section of IX.

Red shales and red sandstones, with Gray and white sandstones; not well seen,	175′	2680′
Greenish gray slaty sandstones, with *Red shales*, soft and bright, alternations,	100′	
Reddish gray, coarse, massive sandstones, with Red shales and red sandstone alternations,	125′	
Bed of iron ore, very siliceous brown hematite,	—	
Red flags and red shales, alternating with Shaly sandstones, massive, yellow, gray, white,	1520′	
Red shales, both sandy and clayey, Lower part, ripple marked, with *fucoids*,	270′	
Red sandstone, massive and *red shale*, Brown sandstones, towards the base,	140′	
Red shale, alternating with *gray shale* and Sandstones, gray, massive; containing *Coal seams, very small*,	290′	
Shales, light sandy, yellow, alternating with *Shales red*, friable; *pitch stained*; Sandstones, brownish-gray, mica specks at bottom,	60	

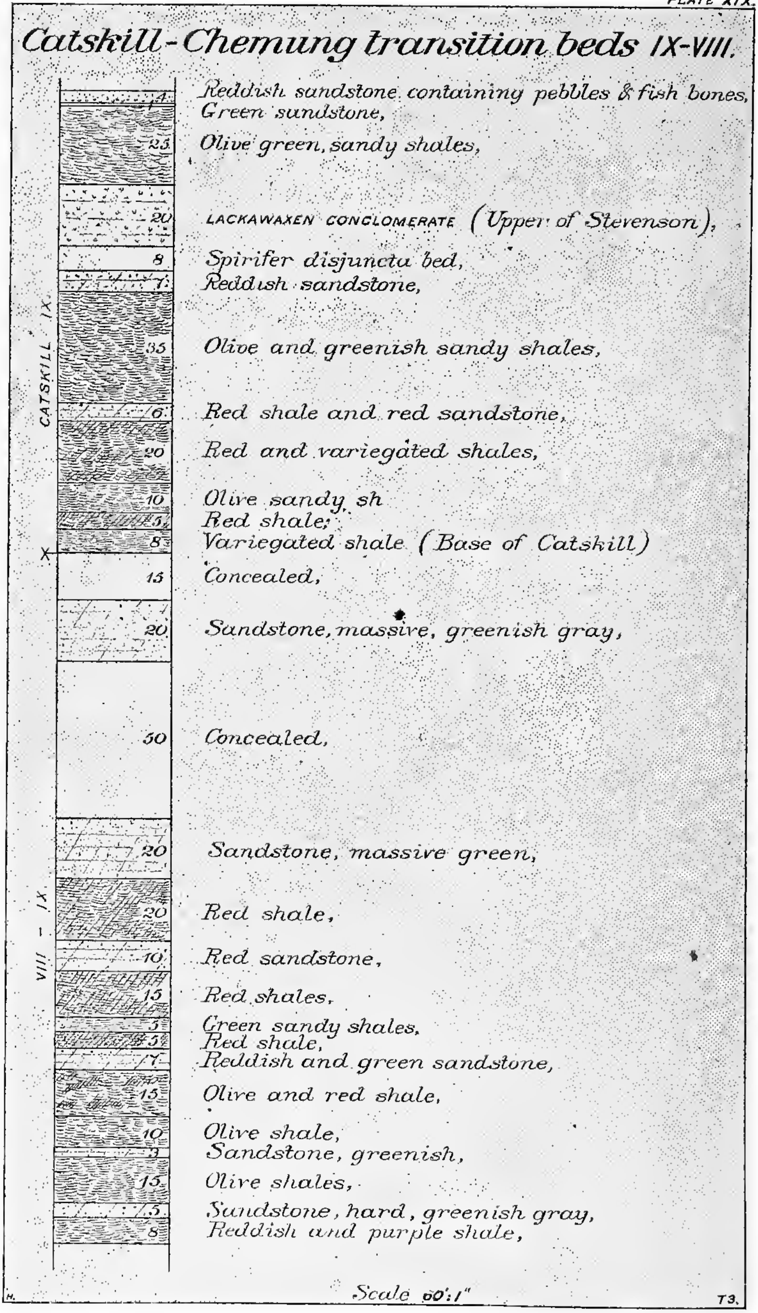
A few *fish-bone and scale fragments* were found in the lowest (60′) beds; and they may suffice to explain the slight *bituminous coating* which some of the surfaces exhibit.

The impure brown hematite iron-ore outcrop, which runs along the west side of Smith's valley, is evidently of no practical value; but it may have some connection with the pure red hematite ore-bed in the Haun's bridge section in Juniata township (mentioned on page 92 above); and in that case it could be used as a base of measurement, in the comparison of sections on the two sides of the great Broad Top synclinal.

The crest of Clear ridge in Smith's valley is made by the Lackawaxen conglomerate; and where the railroads cut through the end of Clear ridge at the foot of the mountain the dip is exceedingly steep, 78° < N. 73° W.

The transition beds of IX-VIII.

In northeastern Pennsylvania there lie beneath the lowest exposures of *fossil fish fragments*, a considerable thickness of alternate *red shales* which should be assigned to the overlying Catskill formation No. IX, and *olive shales* and *greenish-gray sandstones* which resemble the underlying


Catskill-Chemung transition beds IX-VIII.
CATSKILL IX.
VIII – IX
4 Reddish sandstone containing pebbles & fish bones,
Green sandstone,
25 Olive green, sandy shales,
20 LACKAWAXEN CONGLOMERATE (Upper of Stevenson),
8 Spirifer disjuncta bed,
7 Reddish sandstone,
35 Olive and greenish sandy shales,
6 Red shale and red sandstone,
20 Red and variegated shales,
10 Olive sandy sh
5 Red shale;
8 Variegated shale (Base of Catskill)
15 Concealed,
20 Sandstone, massive, greenish gray,
50 Concealed,
20 Sandstone, massive green,
20 Red shale,
10 Red sandstone,
15 Red shales,
3 Green sandy shales,
5 Red shale,
7 Reddish and green sandstone,
15 Olive and red shale,
10 Olive shale,
3 Sandstone, greenish,
15 Olive shales,
5 Sandstone, hard, greenish gray,
8 Reddish and purple shale,
Scale 60':1"
H.
T3.

Chemung strata No. VIII, and which contain characteristic Chemung shells. (See Report G^7.)

Along the North Branch Susquehanna in Montour county, the lowest fish bed lies 100′ beneath the UPPER (LACKAWAXEN) CONGLOMERATE. Then 1000′ of transition measures reach down to within 100′ of the top of the LOWER (ALLEGRIPPUS) CONGLOMERATE. The two conglomerates are therefore 1200′ apart.

In Huntingdon county one set of measurements put the two conglomerates about 1000′ apart; the lowest fish bed 100′ *beneath the Upper;* the lowest red shale bed 150′ *above the Lower;* consequently, the transition group 750′ thick.

Cove and Puttstown road section.

LACKAWAXEN CONGLOMERATE,		——
Lowest *Catskill* beds, as given on page 93,		100′
Concealed interval,	15′	
Sandstone, massive, greenish-gray,	20′	
Concealed interval,	50′	
Sandstone, massive, greenish,	20′	
Red shale,	20′	
Red sandstone,	10′	
Red shale,	15′	
Shales, green, sandy,	5′	
Red shale,	5′	
Sandstone, reddish and green,	7′	
Shales, olive and *red,*	15′	
Shales, olive,	10′	
Sandstone, greenish,	3′	
Shales, olive,	15′	
Sandstone, hard greenish-gray,	5′	
Purple shales,	8′	
Shales olive, and sandy bed,	65′	
Sandstone, massive, greenish-gray,	10′	298′
Uncertain measurement of concealed interval,*		450′
Chemung olive shales and thin sands,		150′
ALLEGRIPPUS CONGLOMERATE,		——

Other sections give the following measurements:

Along the Pennsylvania railroad,	700′
Along the south bank of the Juniata,	675′
At Hann's bridge in Juniata township,	730′
Along James creek in Penn township,	655′
Along Coffee run in Lincoln township,	725′

* This mostly concealed interval (450′,) estimated by calculating between points on the township map and allowing for dip, may be exaggerated, the total thus obtained being 748′.

Along Shy Beaver creek in Hopewell township, ...	662′
Along the Cove-Buttstown road (as above,)	748′

These measurements in all cases exclude the 100′ of red rocks beneath the *upper* conglomerate, and the 150′ of olive shales and sands above the *lower* conglomerate. They represent the group of *alternations* between the lowest fish bed horizon and the lowest red bed anywhere seen.

The upper portion of this group is often fossiliferous. At Haun's bridge the upper 300′ contain great numbers of shells which have been identified by Prof. Claypole:

Ambocœlia umbonata, found at 175′ and at 200′ beneath the Lackawaxen conglomerate.

Atrypa reticularis, at 175′ ditto.

Spirifera mesocostalis, at 175′, 200′, 350′, and 375′.

Orthis impressa, at 200′.

Atrypa aspera, at 200′.

Productella hirsuta?, at 200′, 350′.

Spirifera disjuncta, at 350′, 375′ to 400′.

Prof. J. J. Stevenson in his report T², on Bedford and Fulton counties, pages 75–103, includes this transition group in the Chemung formation, the upper limit of which (in Fulton county) he prefers to place *800′ above the* CLEAR RIDGE (LACKAWAXEN) CONGLOMERATE, which is there 10′ thick; the distance between the two conglomerates he finds to be in Fulton county 950′; the ALLEGRIPPUS CONGLOMERATE 10′ thick; and the rest of the Chemung shales, underneath it 450′, down to top of the Portage flags. And Prof. James Hall would make the same arrangement of the series in the eastern counties. But as the 1800′ of strata charged with Chemung shells in Huntingdon county are the same as those on the Delaware river in Pike and Wayne counties, where they are totally destitute of Chemung (and all other) shells, and where they are evidently part of the Catskill formation in New York State, it is not necessary to change their name in Huntingdon county from Catskill to Chemung, but merely to recognize the fact that the animal life characteristic of the Chemung age became extinct at the beginning of the Catskill age in the northeast, but continued to exist in that age in the southwest;

and longer and longer the further southwest; so that in Fayette and Westmoreland counties Prof. Stevenson reports Chemung shells abundant at the very top of the Catskill (IX), or base of the Pocono (X); and in the State of Ohio even the Pocono formation itself exhibits forms so closely related to Chemung forms that Prof. Hall has proposed to call the Waverly (Pocono) sandstone Chemung.*

The Chemung formation (*VIII f.*)

The Portage formation (*VIII e.*)

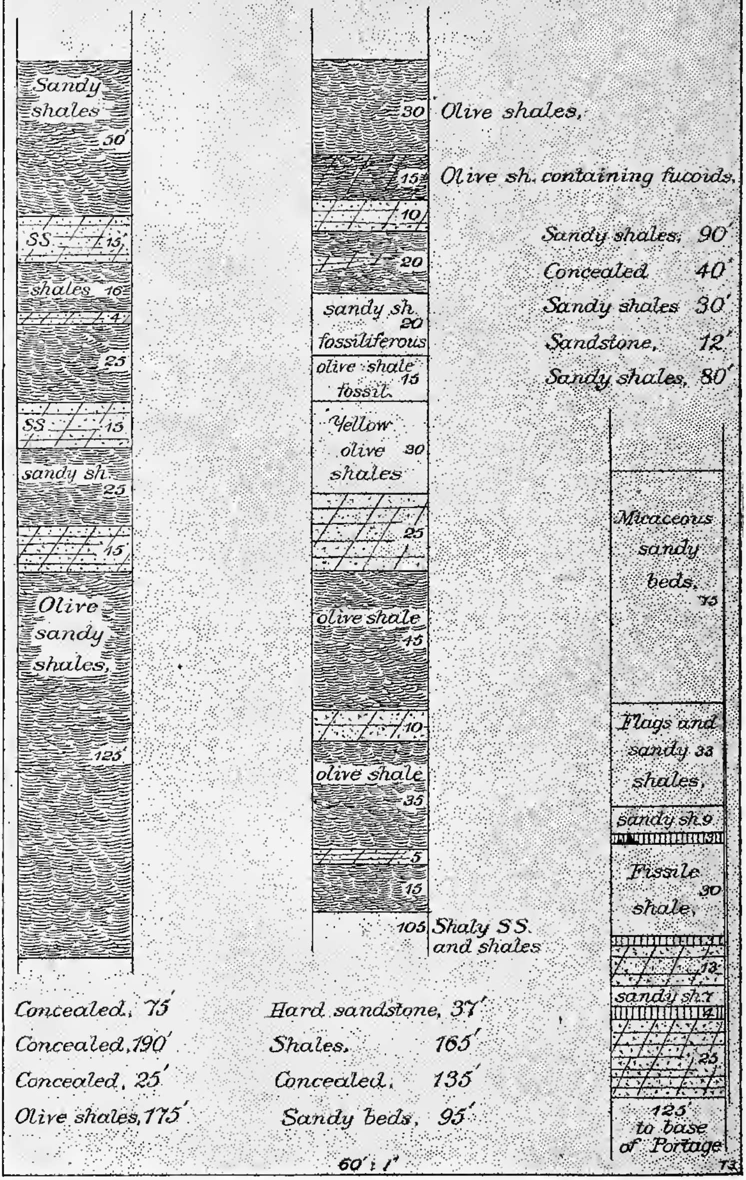
The whole thickness of 2650′ may be roughly divided into an upper more massive gray sandstone, (*Chemung*) division 1500′ to 1600′ thick; and a lower, yellowish, sandy shale, and shaly sandstone (*Portage*) division 1000′ to 1100′ thick; the former making the high ridges, and the latter making wide and nearly level slopes of farm land (where the dip is gentle) with a yellowish poor soil. The lowest Portage rocks however being rather harder than the rest, the surface falls off suddenly into a valley of softer underlying (Genessee and Hamilton) strata.

This is finely shown along the north bank of the Juniata below Huntingdon; the town being built on a Hamilton plain, vertical bluffs of lower Portage sandstone rising along the edge of Standing Stone and Muddy creeks, and higher ridges of Chemung overlooking all. The river makes a gap through the line of Portage bluffs, those running on south being called *Piney ridge:* those running on north (along Stone creek) *Stone ridge.* The higher Chemung outcrops south of the river make *Allegrippus ridge;* and the crest of this ridge is made by the outcrop of the *lower conglomerate*, lying 1000′ beneath the upper conglomerate, and 150′ beneath the lowest *red bed* seen.

The ALLEGRIPPUS CONGLOMERATE is largely composed of white quartz pebbles in a matrix of grayish white sand; is

* It is possible, also, that the eastern red beds of the Catskill thin away west, leaving the gray beds to make the upper part of what is called Chemung in Western New York.

Chemung and Portage beds, VIII f, e.



rarely more than *five feet thick;* and yet makes a bolder mark than the LACKAWAXEN CONGLOMERATE (twice, thrice or four times as thick) does, at least along the much-eroded belt of the Raystown river bends. The Allegrippus conglomerate outcrop is noticeable on every road crossing the ridge, if not as a solid rock, at least by surprising quantities of fragments, which have been piled along the line by the slow erosion of the shales above and below it.

Not a single *red bed* was detected in the whole 2500′ of Chemung and Portage series under this conglomerate; and Prof. Stevenson could find none in Bedford and Fulton counties, through which this conglomerate is everywhere traceable.* In fact the deposit of genuine red mud and red sand in this region of the old Appalachian sea seems to have virtually ceased at the close of the *Salina* (*Onondaga*) age (V,) and not to have commenced again until the beginning of the *Catskill* age (IX.) In other words *red rocks* are unknown for 150′ above and 5350′ beneath the ALLEGRIPPUS CONGLOMERATE, throughout the Chemung, Portage, Genessee, Hamilton, Marcellus, Oriskany and Lower Helderberg formations.

The thickness of Chemung and Portage rocks (as limited) was measured (in various ways, some more and others less accurate) on eight different section lines, as follows:

Along the river in Henderson township, ...	2516′
Along the river in Juniata township, ...	2850′
At Hann's bridge in Juniata township, ...	2730′
Across the northern part of Penn township, ...	2580′
Along James creek in Penn township, ...	2850′
Along Coffee run in Lincoln township, ...	2850′
At Rough and Ready in Hopewell township, ...	2689′
South from Cove in Hopewell township, ...	2588′

the average of all being 2700′, and those considered most reliable falling below 2650′, which is therefore assumed as nearly correct. Prof. Stevenson's estimate of 3620′ in Fulton county (Report T², page 75) includes 1870′ of rocks higher than my upper limit, leaving 1750′ to be compared with the measures given above, showing a decided thinning of the measures south-westward. Mr. Ashburner's estimate

*In two or three places I thought I saw red beds 200′ or 300′ below it, but on being broken they proved to be only reddened on their exposed surfaces.

of 3400′ in the Aughwick creek valley also includes higher rocks, which must be deducted in the comparison. The total thickness of all the strata from the base of XI down to the top of the Genessee *west of Terrace mountain, and east of Sideling hill*, seems to suffer but little change, however much the sub-divisions may vary, and whatever may be the limits independently assigned to them by the two surveys, thus:

	White.		*Ashburner.*	
4775′	1150′	Pocono, X,	2133	4813′
		Pocono-Catskill, X-IX,		
	3625′	Catskill, IX,	2680′	
3350′	700	Catskill-Chemung, IX-VIII,	90′	3400′
	1550′	Chemung (VIII f,)	1860′	
	1100′	Portage (VIII e,).	1450′	
8025′				8213′

The Catskill-Chemung series (and even the lower measures of the *Catskill* proper) are more fossiliferous than any part of the Chemung series, although the fossils are poorly preserved and in a very broken-up condition. The uppermost 400′ or 500′ of *Chemung* rocks contain numerous quite fossiliferous beds, but the rest of the series is scantily provided. The *Portage* rocks are practically non-fossiliferous; except that they show seaweed markings (resembling *Fucoides graphica*), and occasionally completely ground-up shells; also, a few exposures were seen holding *Cardiola speciosa.*

[On the eastern side of the great trough when the same rocks come up in Smith's valley and in Clear ridge, Mr. Ashburner describes them (in Report F, p. 221) thus:

Transition beds, IX-VIII.

Shale, with *lepidodendra* and *calamites*,	8′
Red sandstone and shale (some green), ripple marked,	18′
Sandstone and shale, olive green and green,	10′
Sandstone and shale, greenish gray; upper ten feet with quartz crystals; lower part *fossiliferous*,	15′
Red sandstone and shale, alternating,	25′
Shale, green, fissile,	1′
Iron ore bed, with *Spirifera disjuncta* and *Rhynchonella*, from 4 inches to	1′
Shale, green, fissile, with two-inch layers of sandstone; the upper sides of which are rippled; the under sides marked with *fucoids*,	3′

Sandstone, brownish gray, with *Spirifera disjuncta*, ... 1′
Shale, whitish, with *plant impressions*, ... $\frac{1}{4}$′
Sandstone, yellowish *red*, ... 5′
Red shale, &c., ... 3′

Chemung beds, VIII f.

Sandstone and shale, olive and brown (with some *red shale*), weathering to clay and concealing part of this interval of . . 245′
SANDSTONE, MASSIVE, dark gray iron-specked; alternating with flags, reddish gray, ... 15′

NOTE.—This is 3050′-3065′ above the top of the Genessee; while Prof. White's LACKAWAXEN CONGLOMERATE is 3450′; and his ALLEGRIPPUS CONGLOMERATE is 2500′.

Sandstone, greenish gray, (upper beds,). . . . }
Shales, sandy soft, alternately red and light green. . . } . . 100′
Sandstone, MASSIVE, brown iron stained, surfaces coated with minute quartz crystals; parting beds of light *red shale* with *fucoids*, ... 70′
Sandstone, *red*, brown, gray; lower beds principally sandy shale, *red* and olive, with mica specks; olive shale surfaces iron stained, ... 140′
Sandstone, HARD, MASSIVE, gray and brown, mica specked, with shale alternations, make up most of this interval of . 500′

NOTE.—This lies from 2240′ to 2740′ above the Genessee, and contains the ALLEGRIPPUS CONGLOMERATE (2500′, White). It constitutes the backbone of the Clear ridge, the crest of which is made by Prof. Stevenson's Lower Conglomerate.

Sandstone, MASSIVE, gray and brown, specked with yellow and red spots; alternating with softer beds of sandstone and shale, so thick as to make sharp narrow ravines descending with the strike, ... 490′
Sandstone, MASSIVE, brown, green and gray; and flags; much iron stained, ... 80′
Red and olive shales, and sandstones (more shales than sandstones), ... 100′
Sandstone, reddish-brown, massive, micaceous, ... 10′
Sandstone, reddish-brown, massive beds alternating with shale, and brown sandstones holding fragments of *crinoid stems*, ... 110′
Total, ... — 1860′

Portage beds, (VIII e.)

Sandstone, hard, massive, brown and gray, with olive and gray shale alternations 10′ to 30′ thick, weathering into small ravines along the strike, ... 500′
Sandstone, massive, brown, iron specked, with shale partings, ... 40′

Shale, clayey, fawn-colored (with greenish-yellow flags,) surface studded with minute crystals, ...	70′
Shale, yellow, green, olive (with beds of brown and gray sandstone) mostly occupy this interval of .	140′
Shale, clayey, fawn, yellow, green (with soft olive, brown and green flags, specked yellow and red and iron stained,)	100′
Shale, light olive, stained red and yellow, (lower beds very fissile,)	80′
Shale, yellow, (with a few flags,)	80′
Shale, clayey, dark olive and yellow, ...	120′
Shale, light olive (with alternations of one and two inch laminated sandstones,)	100
Shales, light olive, (with a predominance of the same kind of sandstones,)	60′
Shales, dark olive (with beds of shaly sandstone, iron stained a bright red,)	50′
Shales, olive, red and yellow, ...	10′
Sandstone, gray (with a few olive shales,)	35′
Sandstone, fine grained, greenish-gray, in beds 4″ to 6″ alternating with fine grained olive fissile shales, ...	65′
Total, ... —	1450′
Grand total, ...	3310′

Note.—The 100′ of sandstones thus underlying 810′ of almost continuous shales represent the harder lower Portage beds in the escarpment which Prof. White describes above (page 99) as facing the valley through which the Huntingdon and Broad Top railroad runs. But underneath them lie another 100′ of sandstone beds of so similar a character that they might be included in the Portage, instead of making them the top of the Genessee, as Mr. Ashburner has done. In that case his Portage will be increased to 1550′; and his Genessee diminished (from 325′) to 225′, which is about the thickness ascribed to the Genessee by Prof. White, as will appear in the following pages.]

The Hamilton series, (*VIII d, c, b.*)

The valley west of Allegrippus ridge, along which runs the Huntingdon and Broad Top railroad, from Rough and Ready, past Marklesburgh and McConnellstown to Huntingdon, and so on northward up Standing Stone creek to its fork in Barree township, and then returns as the valley of Mill creek, to Mill Creek station on the river, and runs on southward as Hare's valley to Clay township—is excavated along the outcrops of the soft Genessee, Hamilton and Marcellus rocks, making up together the Hamilton formation, about 1500′ thick.

Fine exposures of the harder beds are made by the small streams which cross from Warrior ridge to the Raystown branch, and also by the cuts of the railroad.

A section near Cove station will suffice to describe the series—descending from the base of the PORTAGE BEDS :—

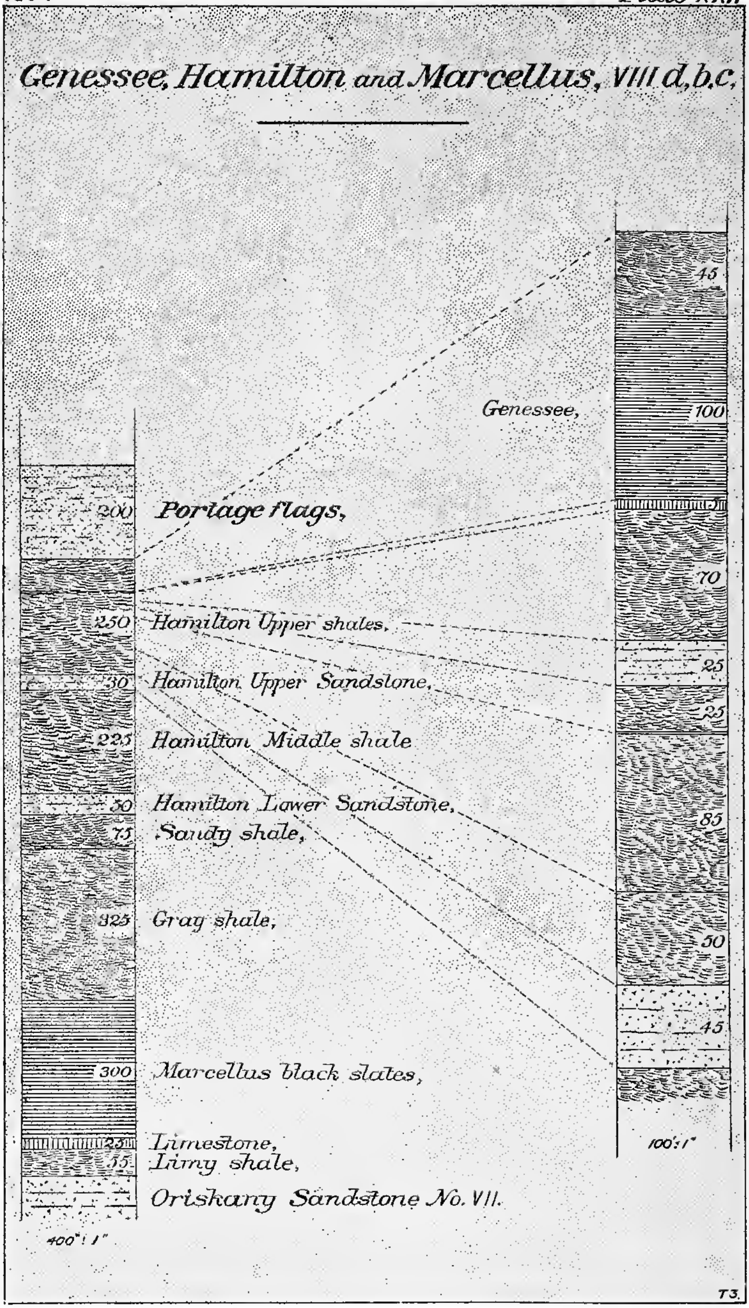
GENESSEE slates, dark,		200′
HAMILTON	*upper shales* in an interval of	250′
"	*upper sandstone,*	30′
"	*middle shales,* soft, gray, (lowest beds fossiliferous,)	225′
"	*lower sandstone,* hard,	50′
"	*lower shales* and *shaly sandstones,*	75′
MARCELLUS	*gray shales* (with hard sandstone layers 8 to 12 inches thick at intervals of 10′ to 15′ throughout,)	325′
"	*black slates,*	300′
"	*limestone,* gray, shaly, (with partings of dark shales,) holding *Phacopsrana* and other (undetermined) fossils,	25′
"	*limy shales,* dark, with a few thin greenish-gray *limestones* lying on top of ORISKANY SANDSTONE of Warrior's ridge,	55′
Total interval between Portage and Oriskany,		1535′

A third Hamilton sandstone sometimes occurs in the Hamilton upper shale, but is too uncertain to affect the classification given above.

A limestone is sometimes seen at the bottom of the Genessee slate, representing the New York *Tully* limestone.

Numerous sections given in the body of this report exhibit a striking uniformity of thickness; eight of them were made on the gently east dipping outcrop on the west side of the great trough; the ninth on the steeply west dipping outcrop at Mapleton, at the entrance to Jack's Narrows, on the east side of the trough.

1. At Mapleton, in Union township.
2. At Huntingdon, in Oneida township.
3. At McConnellstown, in Walker township.
4. Through the Patterson estate, Penn township.
5. Along James creek, in Penn township.
6. Along Coffee run, in Lincoln township.


Genessee, Hamilton and Marcellus, VIII d, b, c,
Genessee,
45
100
70
25
25
85
50
45
100':1"
Portage flags,
200
250 Hamilton Upper shales,
30 Hamilton Upper Sandstone,
225 Hamilton Middle shale
50 Hamilton Lower Sandstone,
75 Sandy shale,
325 Gray shale,
300 Marcellus black slates,
25 Limestone,
55 Limy shale,
Oriskany Sandstone No. VII.
400':1"
T3.

7. One mile east of Cove, in Hopewell township.
8. At Rough and Ready, in Hopewell township.
9. At Cove, in Hopewell township.

	Genessee.	*Tully.*	*Hamilton.*	*Marcellus.*	*Total.*
1 . .	145′	5	600′	700′	1450′
2 . . .	200′	—	600′	700′	1500′
3 . . .	250′	5′	550′	650′	1455′
4 . .	250′	5′	585′	725′	1565
5 . . .	200′	—	613′	700′	1513′
6 . . .	200′	—	643	625′	1468′
7 . . .	200′	—	605′	675′	1480′
8 . . .	200′	—	665′	600′	1465′
9 . . .	200′	—	630′	705′	1535′

A section made in Bradley township gave only 1260′; but there was a large concealed interval with an unknown dip.

The Genessee slate (*VIII d.*)

The *débris* which falls from the Portage sandstones outcropping in the steep bluff side of the valley commonly hides the Genessee beds, and often also the underlying Hamilton upper shales. But there is a good exposure of them on the south side of the river at the railroad bridge a mile above Mapleton, where we have, from the exposed base of the Portage sandstones, descending:

GENESSEE SHALES, *bluish black*, with *thin sandy limestones*, holding large numbers of *Goniatites* and the other fossil shells, ...	45′
Shales, *black*, fissile, ...	100′
TULLY ? LIMESTONE, impure, gray, holding *Ambococlia umbonata* and other (unrecognizable) fossil shells,. .	5′
HAMILTON UPPER SHALES, sandy, holding *Homalonotus dekayi*, *Heliophyllum halli*, *Spirifera*, and *Stictopora*,. .	70′
Flags, sandy, with *crinoidal* remains, ...	25′
Shales, sandy, gray, ...	25′
Coral bed a mass of *Heliophyllum* and *Cystophyllum*, from 4 inches to 6 inches thick.	
Shales, dark brown and blackish, quite fossiliferous near the bottom, ...	85′
Shales, dark gray, sparingly fossiliferous, ...	50′
HAMILTON UPPER SANDSTONE, flaggy at top and rather massive below, ...	45′

Here the striking contrast between the Portage sandstones above and the Hamilton sandstones below cause the intervening Genessee black and the Hamilton gray shales to appear in bold relief in the river bluff.

Lunulicardium fragile, *Cardiola doris*, *Goniatites petersoni*, and *Orthoceras aciculum* have been identified by Prof. Claypole from beds only from 10′ to 30′ beneath the base of the Portage sandstone, at this locality ; and

Lunulicardium fragile, *Cardiola doris*, *Cardiola speciosa*, *Goniatites complanatus*, *Orthoceras subulatum* and *Styliola fissurella* which I obtained from the same horizon (near the top of the Genessee) on the road from McConnellstown, which ascends Piney ridge.

Wherever I have seen the top of the Genessee I have found this group of fossil forms : *Lunulicardium*, *Cardiola* and *Goniatites* are always present.

Cardiola speciosa has also been seen in the Portage beds one or two hundred feet above the top of the Genessee.

The Genessee slates are not generally *black from top to bottom*, as they are in the Mapleton section, some of the beds being a dark gray ; but in every section some of the beds will be black, if only 20 or 30 feet in all.

[Mr. Ashburner's section of the Genessee in Clay township has concealed intervals which may contain black beds ; but the upper 100′ seems more properly to belong to the overlying Portage sandstone series :

Sandstone, olive, slaty and shaly, alternating with flags, brownish gray, and a few beds of olive shale ; (concealed,)	100′
Shale and slate, clayey, light olive and greenish-gray, . . .	75′
Probably the same (partly concealed), ...	100′
Slate, *dark olive*, fissile, with occasional brown sandstone layers only from 2 to 4 inches thick, ...	50′

The shale and slate are slightly *bituminous*, and iron stained.]

The Tully limestone.

The limy beds of Montour and Columbia counties, 50′ thick (see Report G⁷),are exposed in Huntingdon county only 5′ thick, under the southern end of the Mapleton railroad bridge (see section on page 107,) holding triturated fossil shells, only one of which can be recognized, *Ambocoelia umbonata ;* and this is the most abundant species in Montour and Columbia counties also.

The Hamilton upper shales.

These yellow, greenish and gray beds, 200′ to 250′ thick, everywhere rest on a sandstone which makes a continuous ridge; but the upper part of the group next the Genessee slate is almost always concealed by the fallen fragments of Portage sandstone, so that the division plane between Genessee and Hamilton is seldom got, from which to measure the two groups.

These upper shales are the specially fossiliferous subdivision of the Hamilton formation.

Under the Mapleton railway bridge the uppermost 50′ are so crowded with fossil shells that Prof. Claypole and myself collected in one hour specimens of *Dalmanites colliteles*, *Loxonema delphicola*, *Loxonema terebra*, *Modiomorpha concentrica*, *Lunulicardium fragile*, *Eodon bellistriatus*, *Palæoneilo constricta*, *Actinoptera decussata*, *Tropidoleptus carinatus*, *Athyris spiriferoides*, *Spirifera mucronata*, *Ambocoelia umbonata* and *Strophodonta perplana.*

From the upper half of these shales at Huntingdon (near where the road leads into the cemetery) the following forms were obtained and identified by Prof. Claypole: *Dalmanites colliteles*, *Palæoneilo constricta*, *Tropidoleptus carinatus*, *Athyris spiriferoides*, and *Spirifera mucronata* (five of the species found at Mapleton); also *Orthonata undulata*, *Leiopteris bigsbyi*, *Leiopteris rafinesqui*, *Nuculites elongatus*, *Nuculites triquetra*, *Cardiomorpha bellatula*, *Cardiomorpha zonata*, *Cardiomorpha concentrica*, *Cardiomorpha cordata*, *Spirifera fimbriata*, *Chonetes setigerus*. *Pleurotomaria capillaria*, *Nautilus buccinum*, *Bellerophon leda*, *Homalonotus dekayi*, *Phacops rana*, and *Beyrichia punctulifera.*

At about 50′ beneath the top of these shales, again, near Grafton, Penn township, I obtained the following species, identified by Prof. Claypole: *Dalmanites colliteles*, *Spirifera mucronata* (both found at the other two localities;) *Chonetes setigerus*, *Nuculites triquetra*, *Homalonotus dekayi* (all three found also at the Huntingdon locality;) *Modiomorpha complanata*, and *Tentaculites attenuatus.*

The sandy flags (25′) in the Mapleton section are sometimes sufficiently hard to make a low ridge on the surface.

The *coral bed* (4″ to 6″ thick) in the middle of this shale series suggests a comparison with the great *coral reef* near the top of the Hamilton proper described in Report G[6] on Pike and Monroe counties.

The Hamilton upper sandstone.

These sandy beds (30′ to 40′ thick) make a low ridge in the valley; are of bluish gray or drab, occasionally buff or dark yellowish-gray; sometimes contain 10 or 15 per cent of lime; and are always crowded with impressions of the long corrugated fronds of a cock-tail seaweed, *Taonurus* (*Spirophyton*) closely allied to if not identical with that which gives name to the *cauda-galli* grit (many hundred feet further down in the series,) or intermediate between it and *Taonurus crassus*. The plant is sparingly exhibited in the higher and lower portions of the Hamilton formation, but covers almost all the surfaces of the layers of this upper sandstone.

Spirifera ziczac and *crinoidal* fragments are also abundant in them everywhere; and *Homalonotus dekayi*, *Phacops rana*, and *Orthonota undulata* have also been found in them.

These sandstone beds are visible on all the roads which run east from the Huntingdon and Broad Top railroad; and are conspicuous at Rough and Ready station, where they make a ridge along the middle of the valley 50′ to 75′ high. They make also the island-like bluff of rock where the county road passes underneath the railroad opposite Huntingdon; and where they have been extensively quarried for rip-rap and road-fills; although some of them are cut away by Muddy creek.

[Mr. Ashburner's section in the Aughwick valley around the end of Jack's mountain (Report F, p. 223) gives:

Gray sandstone, flags and shales, with fossils less abundant, in a partly concealed interval of 250′.

Sandstone group;—upper part hard massive greenish-gray and flaggy-olive layers;—lower part light olive slaty layers ;—surfaces much iron-stained; *Spirophyton cauda-galli* abundant; also *Aviculopecten princeps*, *Chonetes mucronatus*, *Chonetes coronatus*, *Spirifer granulifera*, *Spirifer mucronatus*, *Grammysia*, and *Tentaculites*, 85′

Sandstone, massive gray and flaggy layers alternating with thinly laminated fissile shale, *fossiliferous*, 250′.

Calcareous thin gray flags and greenish-gray fragile sandstones, alternating with gray and dark olive shales, resting on the Marcellus formation, 100′.

Ripple marks are finely exhibited on the lower strata along Aughwick creek near Potts' gap.]

The Hamilton middle shales.

These soft beds usually make a deep little vale between the upper and lower sandstones. They are 200′ to 225′ thick; dull gray; decomposing into small chips, called "slate-gravel," the best material for roads in the State. The first H. & B. T. R. R. cut, half a mile south of the Huntingdon bridge, has furnished a mass of the slates for the "long fill" across the river valley.

Univalve shells are characteristic of these Hamilton Middle shales, from which most of the Hamilton species have come; they are sparingly scattered through the whole mass of shales, but become numerous near the bottom layers; through which the railroad is cut for a long distance between Rough and Ready and Cove stations, approaching the Bedford county line. Here I obtained many fossils, weathered out of the shale, from 1 to 10 feet above the underlying sandstone; which were identified by Prof. Claypole as—

Spirifera granulifera, *Spirifera medialis*, *Spirifera mucronata*, *Rhynchonella prolifica*, *Lingula tigea?* *Chonetes logani*, var. *aurora*, *Tropidoleptus carinatus*, *Pleurotomaria sulcomarginata*, *Pleurotomaria capillaria*, *Loxonema terebra*, *Loxonema delphicola*, *Cyclonema hamiltoniæ*, *Bellerophon leda*, *Palæoneilo emarginata*, *Palæoneilo perplana*, *Nucula corbuliformis*, *Cardiomorpha concentrica*, *Cardiomorpha bellatula?* *Pterinea flabellum*, *Leiopteris rafinesqui*, and *Actinodesma subrectum;* which last occurs only at the very base of the shale, almost in contact with the sandstone.

The Hamilton lower sandstone.

The ridge which these hard beds (50′ thick) make along the valley can be particularly well studied between Cove station and Coffee run, as the railroad in following it runs sometimes on one side and sometimes on the other side of it; but from McConnellstown station to Huntingdon the ridge is left to the west. North of the river the ridge reappears and separates the Genessee subvalley of Stone creek from the Marcellus subvalley of Muddy run. The hill behind Huntingdon is largely made of the lower sandstone; but the part covered by most of the Cemetery grounds of the upper sandstone; the two here make different portions of one ridge.

The layers (6 inches to 2′ thick) of dark-gray or yellowish-brown stone seldom aggregate less than 50′; the upper ones being often quite fossiliferous in streaks; *Rhynchonella* and *Spirifera* specially abundant; as at Cove station.

This group may represent the *Selinsgrove upper sandstone* (200′ thick) making ridges 500′ to 700′ high in Northumberland county; and the *lower sandstones* of the 800′ group which makes the rocky ranges of Perry county. (See Reports G^7 and F^2.)

The Hamilton lower shales.

These more or less sandy beds (75′ to 100′ thick) are well exposed at Huntingdon on the graded road which turns up Muddy run; again at Coffee Run station, where it has been quarried for the "long fill" across Coffee Run valley; and again almost completely exposed from Cove station along the road to Powell's iron and limestone mines.

They are everywhere sparingly fossiliferous, and the species badly preserved. At Coffee run were collected *Ambocœlia umbonata*, *Rhynchonella horsfordi*, *Pteronites lævis*, *Leiorhynchus limitare*, *Goniatites sp.*? *Orthis vanuxemi*, *Orthoceras subulatum*. A small *bryozoon* in delicate rounded patches occurs frequently.

Limy layers in the group are well exhibited on the road from McConnellstown to the station.

Two or three calcario siliceous layers, 6 inches to 1′ thick each, separated by from 2′ to 5′ of shales, may be followed for several miles from the river at Huntingdon, northward and southward. They show just below the 203d railroad mile post west of the town. And, only five or ten feet beneath them, appear shales with *Marcellus fossils.* Were it not for these fossils one might place the base of the Hamilton two or three hundred feet still lower; and this may have been done in other districts of the State.

The Marcellus formation. (*VIII b.*)

Its three subdivisions of Gray shale, Black slate, and Limestone, outcrop along a continuous subvalley, at the foot of Warrior's ridge, from Cove station near the Bedford line, northward, past Marklesburg and McConnellstown, down Crooked creek to Huntingdon, and so on up Standing Stone creek (above the bend) to the forks and so south again down Mill creek. The brick clay worked back of Huntingdon, and along Broad Top railroad, comes from the decomposition of these outcrops.

The Marcellus gray shales measure about 300′ along the H. and B. railroad. They are seen at some exposures to contain, at every 15′, 20′ or 25′, layers of hard sandstone a foot thick, more or less. The shales themselves weather to an ashen-gray or dirty white color. At the top (as has been already remarked) near the 203d railroad mile post near Huntingdon, they contain the following fossil shells (named by Prof. Claypole:)

Leiorhynchus limitare, *Ambocoelia umbonata*, *Pteronites lævis*, *Goniatites discoidens* and *Chonetes setigerus.* The first three species occur, in vast numbers and in the same relative position, on the road between McConnellstown and its station.

The Marcellus black slates also measure about 300′. Some of the beds contain so much carbon as to present the aspect of *anthracite coal;* as, notably, at the "Slate-gravel quarry" in West Huntingdon, where about 18 inches of black slate has been mistaken for a coal bed ; and where moreover that peculiar wrinkled, gneiss-like structure of these slates can be seen, which Prof. Stevenson describes as characteristic of them in Bedford and Fulton counties. The whole formation can nowhere be seen at any one place, because more or less of its outcrop is covered by stuff from the Oriskany sandstone outcrops of Warrior's ridge, the steep slope of which runs close along beside it on the west; but considerable sections are seen on the cross-roads, and especially in the railroad cuts between McConnellstown and Rough and Ready.

Styliola fissurella, and a *Tentaculite* are the only fossil forms seen, but these occur in countless numbers in a cut through the top beds of this black slate group a short distance south of Grafton.

The *Marcellus limestone and lower shales* make a low but distinct terrace all along the bottom slope of Warrior's ridge. Thin beds of greenish-gray or bluish-green limestone, with but few fossil shells as a rule, are enclosed in beds of black slate and dark shale, without any of those chert nodules which occur at this horizon in New York State and along the Delaware river in Monroe and Pike counties.

Moreover, what fossils there are belong to Hamilton rather than to Corniferous types. It is better, therefore, to regard these beds as the lowest group of the Marcellus sub-division of the Hamilton formation, resting immediately upon the Oriskany.

They are well exposed on the gentle slope of Warrior's ridge just north of the Car Works in West Huntingdon, and fairly well in the bluff opposite Huntingdon (just south of the middle Penitentiary building) along the public road, thus :

Bottom beds of Marcellus black slate,	——
Bluish-gray impure limestones and limy shales,	12'
Black slates,	40'
Bluish-gray and greenish-gray limestones,	10'
Dark shales (and concealed beds,)	20'
ORISKANY SANDSTONE,	——

The interval is here 82′, but may be said to average 75′, and the limestone layers at other exposures occur at various places in the interval.*

Back of the Car Works the following fossils were collected:*

Ambocoelia umbonata, *Lingula spatulata?* *Discina media*, *Leiorhynchus limitare*, *Chonetes setigerus*, *Lunulicardium fragile*, *Beyrichia punctulifera*, *Orthoceras subulatum*, and *Spirifera raricosta*, the only one of them ever found in rocks of Corniferous age.

At Cove station, on the Bedford line, I obtained *Ambocœlia umbonata*, *Discina minuta*, and *Phacops rana*.†

In the blue and bluish-gray shales, back of the Car Works, occur thin layers of a lean carbonate of iron.‡

At the northern end of the new building they have weathered down into a thick bed of bluish-white clay

Marcellus formation in Aughwick valley.

[On the eastern side of the great trough, around the south end of Jack's mountain, the Marcellus beds (as measured by Messrs. Ashburner and Billin (Report F, p. 223,) are divisible into three:—*Upper* 591′; *middle* 284′; *lower* 60′; total, ... 935′.

Shale, gray and brown, with *slightly calcareous* flags, (partly concealed,)	200′
Shale, gray, olive, brown, much iron stained and black with carbon, ...	200′
Shale, black, brown and gray, with occasional sandstone beds, (partly concealed,)	171′
Limestone beds, gray, shaly, clayey, alternating with limy shales, greenish-gray, ...	20′
Black fissile slate and shale, much iron stained, and coated with bitumen, ...	100′
Black slate and shale, iron stained, bituminous, very clayey bottom layers, ...	180′

* I recognize in the above section the *Selinsgrove lower limestone*, and underlying *Selinsgrove shales* 75′ to 100′ thick in Northumberland county (see Report G^7.)

†Identified by Prof. Claypole.

‡The Marcellus ore of the Aughwick valley townships seems wanting west of the great trough in Huntingdon county, but appears in Bedford county.

Iron ore bed of varying thickness, say.	4′
Limestone, dark blue, seams of calcite,	4′
Lime shale, clayey, dark brownish-gray,	2′
Limestone dark blue, clayey,	2′
Lime shale, dark bluish-gray, and olive,.	7′
Lime shale, dark greenish-gray,	1′
Concealed,	7′
Lime shale, dark olive, easily weathering,.	22′
Limestone, massive, gray clayey.	5′
Limestone, fragile, dark and yellow,	10′
Clay and shale top of the ORISKANY SANDSTONE.	

In Report F, the lowest 60′ of the section is set apart as the representative of the Corniferous formation. The arguments against this classification have been already stated. The *Scoharie grit* and *cauda-galli grit* seemed also to be absent. All three are also wanting in Perry county; where the whole Marcellus formation is only 200′ thick. (See Report F[2].)

The 20′ limestone group in the section given above may not be its exact place in the series, because it could be studied only at Orbisonia, where the dips are uncertain and distant from the main line of section; the beds are moreover merely shales surcharged with lime.—The 4′ iron ore (280′ lower down) is a shale surcharged with carbonate of iron, which at its outcrop is weathered into brown hematite iron ore and mined a little at McCarthy's ore bank on Mountain Branch creek; whence its crop can be traced continuously through Hare's valley northward towards Mapleton; and southward and eastward in a great curve round the end of Jack's mountain, by R. Hudson's lime kiln, Black & Co.'s lime kilns, W. Jones' house, to the Hudson's extensive ore banks on the flank of Cave hill; thence northeast to Three Springs (where in the railroad cut it is an iron conglomerate); and so on to R. L. Greene's house, where a fault throws it 1400′ square to the east. Beyond this it was once mined on the Fleck farm and is reported to be there 12′ thick. Thence it runs on through Hill valley to Mt. Union. Other parallel outcrops run in front of Black Log mountain and are mined at several places (See Report F).]

The Oriskany formation, No. VII.

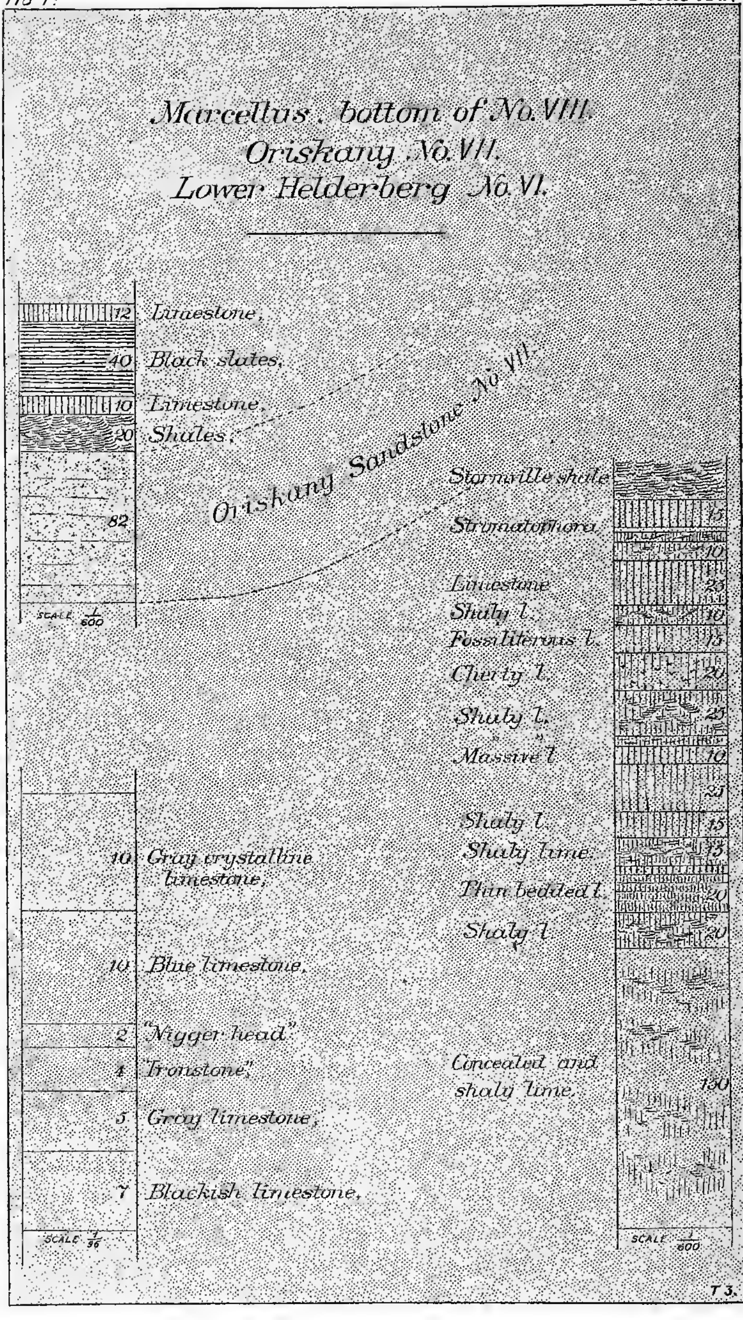
Warrior's ridge varies in height from 100′ to 400′ above the Marcellus black slate valley at its eastern, and the Onondaga and Clinton red shale valley at its western foot, being highest where the eastern dip is low and the eastern slope long, as is the case for five miles south and seven or eight miles north of the Juniata river, which cuts through it where it is four miles wide, making a wide gorge between vertical bluffs of limestone (No. VI) along the top of which runs a cornice of sandstone (No. VII,) worn by the weather into lines and groups of "Pulpit rocks," the tallest of which project their tops above the woods which cover the ridge. The sandstone is everywhere easily broken down into sand, and swept down the slopes far out over the Marcellus outcrops in the valley.

It is usually a rather coarse sand varying in color from gray-white to brown; is more or less pebbly, and has limy streaks in it owing to the great number of fossil shells.

It is never less than 50′, and is sometimes more than 100′ thick.

Its steep (west 65° to 75° dipping) eastern outcrop at the Juniata river near Mapleton has been extensively quarried, the rock being crushed and washed for the Pittsburgh glass works. This outcrop, disengaged from the foot of Stone mountain, runs on northward as Sand Ridge, furnishing good glass sand. But the Warrior's ridge outcrop (dipping from 10° to 40° eastward) does not seem to be suitable for the purpose. This may be explained by the leaching out of the lime from the steep Sand Ridge rocks; and also of the iron, which is a large ingredient in the Warrior's ridge rock. This is in a measure caused on Warrior's ridge by the drainage finding an easier passage along the vertical cleavage planes than through the rock itself along its planes of stratification.

The leaching process in Sand Ridge is illustrated by the honeycombed condition of the sandstone beds, from which innumerable shells have been dissolved, leaving only their hollow casts, such as (at Mapleton:)


Marcellus, bottom of No. VIII.
Oriskany No. VII.
Lower Helderberg No. VI.
12 Limestone,
40 Black slates,
10 Limestone,
20 Shales,
82
SCALE 1/600
Oriskany Sandstone No. VII.
Stormville shale
Stromatophora
15
10
Limestone 25
Shaly l. 10
Fossiliferous l. 15
Cherty l. 20
Shaly l. 25
Massive l. 10
25
Shaly l. 15
Shaly lime 15
Thin bedded l. 20
Shaly l. 20
Concealed and shaly lime. 130
SCALE 1/600
10 Gray crystalline limestone,
10 Blue limestone,
2 "Nigger head"
4 "Ironstone"
5 Gray limestone,
7 Blackish limestone,
SCALE 1/96
T 3.

Rensselæria ovoides, *Spirifera arrecta*, *Eatonia peculiaris?* *Platyceras tortuosum*, *Platyceras conicum*, var. *inornatum* and var. *inflectum*, *Platyceras platystoma*, *Platystoma ventricosum*.*

Spirifera arenosa, and a species of *Grammysia*, were seen by me at other localities; the first abundant in the top layers. The Mapleton species were all collected from below the middle of the formation.

[*Rensselæria ovoides*, *Rensselæria ovalis*, *Rensselæria marylandica*, *Spirifera arenosa*, *Spirifera arrecta*, *Eatonia peculiaris*, *Orthis hipparionya*, *Pterinea textilis*, *Megambonia lamellosa*, *Platyceras ventricosum*, *Cyrtoceras expansus*, and *Dalmania micrurus*, were collected in the East Broad Top railway cutting at Three Springs; and at the end of Royer's ridge and Sandy ridge near Orbisonia, by Mr. Ashburner, (see Report F, p. 239.)

The Oriskany is at Three Springs only 58′ thick; at Orbisonia 150′ thick; and this is a specimen of the great irregularity of this formation throughout Pennsylvania. No average thickness can be assigned to it; and the whole is sometimes wanting; as for example along the Blue mountain for some miles in Perry and Dauphin counties; and in Lycoming and Centre counties for miles along the foot of Bald Eagle mountain.

At Three Springs, at the south end of Jack's mountain, it appears thus:—

Ocherous clay, overlying coarse-grained, limy and irony sandstone, ... 12′

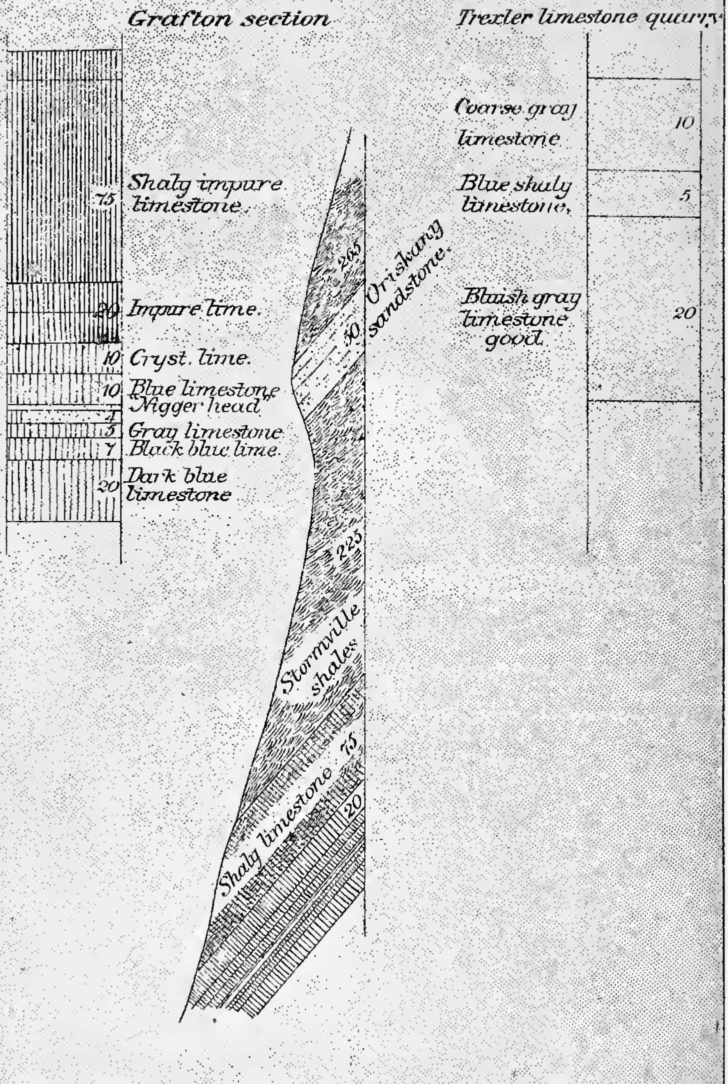
Friable sandstone, containing pebbles the size of a pea, 15′

Coarse sandstone, very fragile, breaking irregularly; iron-stained throughout, and the surfaces coated with *red hematite iron-ore;* in some places the amount of ore is sufficient to work. (For account of mines see F.) List of fossils in this lower part, given above, ... 31′

The outcrop runs from Three Springs, up Hare's valley, as a low, well-defined ridge, between Jack's mountain and Sideling hill. Cave hill, southwest of Three Springs, is

*Identified by E. W. Claypole, who proposes the varieties of *P. conicum*.

Lower Helderberg limestone quarries, Penn township.



made by it. Another outcrop runs along the eastern foot of Jack's mountain. Royer ridge and Sandy ridge are its outcrops in front of Black Log mountain and Blue ridge.]

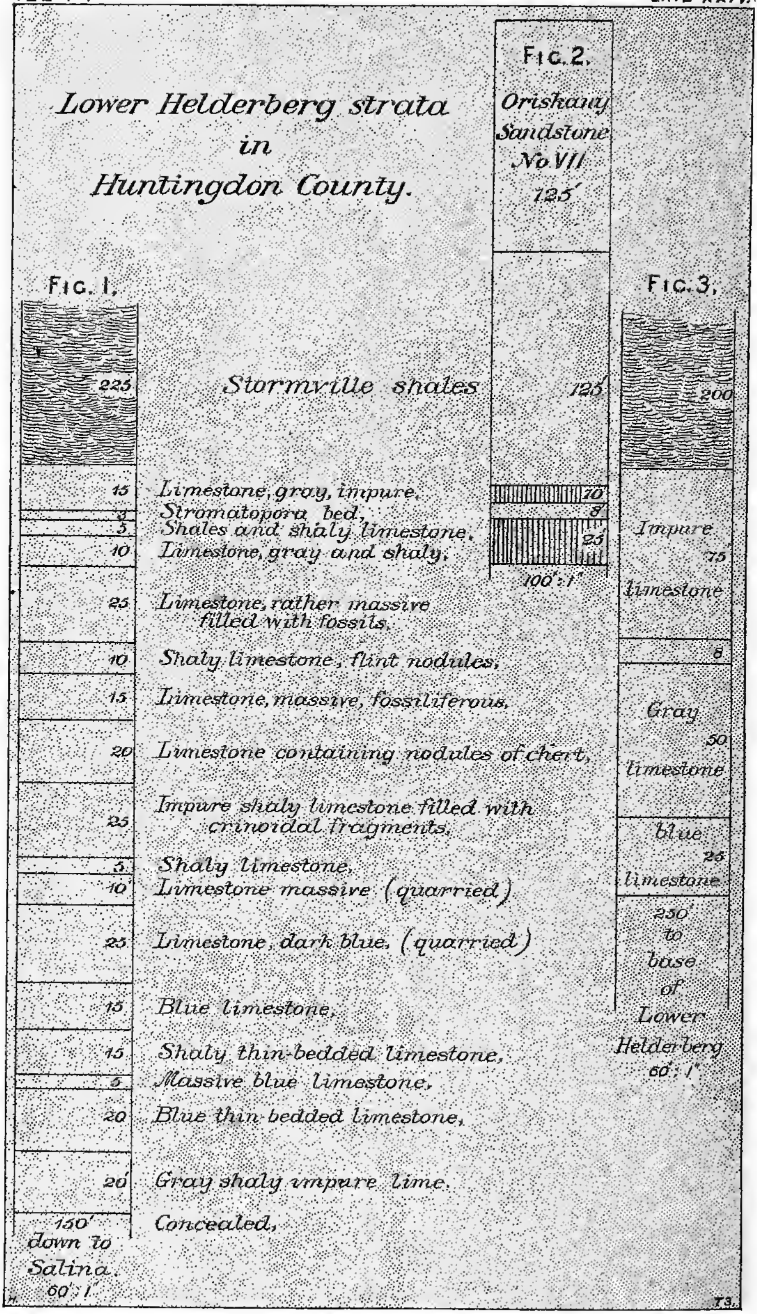
The Stormville (Oriskany) shales.

Dark-gray and black limy shales, more than 200′ thick (at one place measuring 250′,) underlie the Oriskany sandstone and form the steep west slope of Warrior's ridge. They have been named *Oriskany shales;* but the few fossil shells which have been found in them would rather make them the top division beds of the *Lower Heidelberg formation, No. VI.* (See descriptions of them in Report G[6] on Pike and Monroe counties, and Report G[7] on Columbia, Montour and Northumberland counties.) They were named in G[6] from a good exposure at Stormville, 6 miles west of the Delaware Water Gap. But they are so intimately connected with the lower divisions of the Oriskany, that they may be called a transition series. (See this subject discussed on pages 130, 131, G[6].)

They become in some places sandy; but in most places what sand is in them is exceedingly fine; so that they invariably moulder down along the outcrop into clay left by the waters which have removed the lime and iron. Very large clay deposits occur along Warrior's ridge, one of which is mined for iron furnaces, by Hatfield & Phillips, on the road from Huntingdon to Alexandria; and here at the bottom of the pit the stratified shales can be seen passing gradually into clay.

Where protected from this leaching process, they are black or blackish throughout; so that in the Gage tunnel below Grafton they were supposed to be the Marcellus black slate; and at Cove station some iron ore at the bottom of the group was supposed to be the Marcellus ore bed.

Brown hematite iron ore is nearly everywhere along the outcrop to be seen in scattered pieces on the ground; and in Porter township (see the detailed description of its geology) the accumulation of ore at the base of the group is considerable; but it has all been leached out of the shales and overlying sandstone.


Lower Helderberg strata
in
Huntingdon County.
Fig. 1.
225
Stormville shales
15 Limestone, gray, impure.
3 Stromatopora bed,
5 Shales and shaly limestone.
10 Limestone, gray and shaly.
25 Limestone, rather massive filled with fossils.
10 Shaly limestone, flint nodules,
15 Limestone, massive, fossiliferous.
20 Limestone containing nodules of chert,
25 Impure shaly limestone filled with crinoidal fragments,
5 Shaly limestone,
10 Limestone massive (quarried)
25 Limestone, dark blue, (quarried)
15 Blue limestone,
15 Shaly thin-bedded limestone,
5 Massive blue limestone,
20 Blue thin-bedded limestone,
20 Gray shaly impure lime.
150' down to Salina. Concealed,
60':1"
Fig. 2.
Oriskany Sandstone No VII 125'
125'
70
8
25
100':1"
Fig. 3.
200
Impure 75 limestone
8
Gray 50 limestone
blue 25 limestone
250' to base of Lower Helderberg
60':1"
T3.

The Lewistown limestone beds, No. VI.

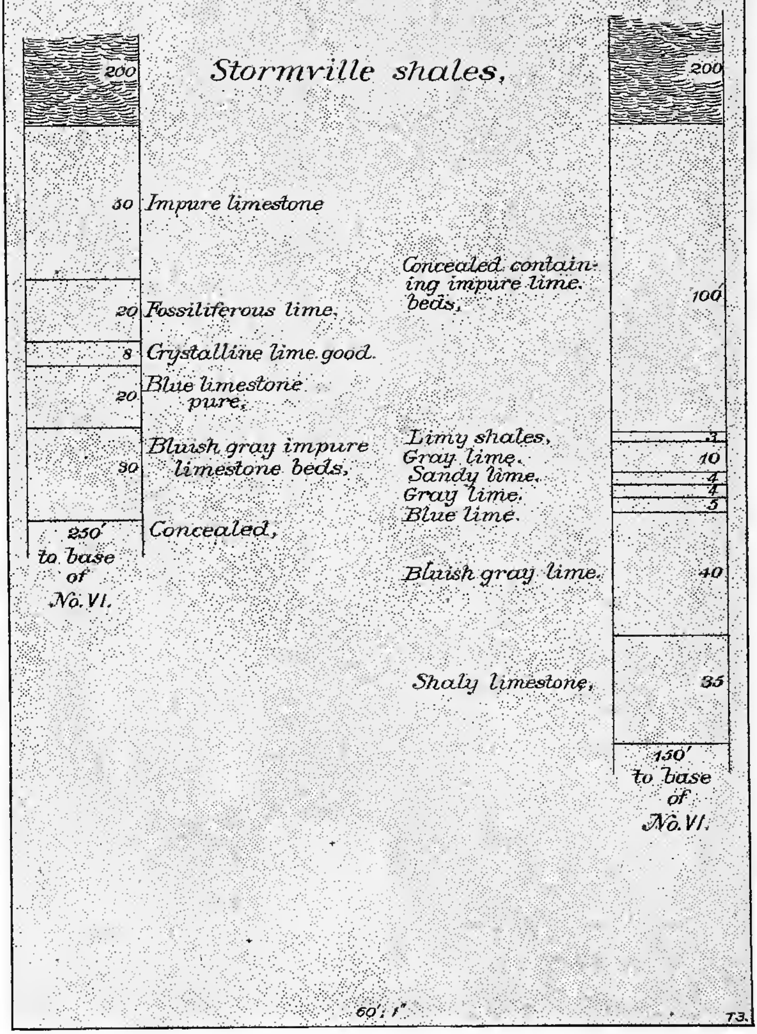
At Powell's quarries, near Cove station, at the Bedford county line, the succession of these strata can be easily studied.

UPPER DIVISION,		133′
Limestone, impure, gray,	15′	
Stromatopora bed,	3′	
Limy shale and shaly limestone,	5′	
Limestone, shaly, gray,	10′	
Limestone, bluish-gray, rather massive, filled with fossil corals: *Stromatopora; Zaphrentis; Favosites; Atrypa reticularis,* an *Orthis,* and many other shells,	25′	
Limestone, shaly, with *flint* stones,	10′	
Limestone, massive, blue, (*fossils.*)	15′	
Limestone, with many specimens of *Atrypa reticularis,* and flint nodules,	20′	
Limestone, impure, shaly, filled with *Crinoidal fragments, Atrypa reticularlis,* and *Chætetes,*	25′	
Limestone, shaly,	5′	
MIDDLE DIVISION,		90′
(*f*) Limestone, very pure, light-gray, massive, coarsely crystalline, containing many *Crinoidal fragments.* (*Quarried,*)	10′	
(*e*) Limestone, dark-blue, rather pure. (*Quarried,*)	25′	
(*d*) Limestone, dark-blue, not so pure,	15′	
(*c*) Shales interbedded thinly with bluish-gray limestone layers,	15′	
(*b*) Limestone, blue, massive,	5′	
(*a*) Limestone, blue, thin layers. (*Once quarried,*)	20′	
LOWER DIVISION,		170′
Shaly, impure, gray limestones,	20′	
The same seen in the remaining distance down to the assumed top of the Salina (Onondago) formation,	150′	
Total at Powell's quarries,		393′
Total as measured along Coffee run,		378′
Total of one section in Penn township,		340′
Total of another section in Penn township,		350′
Total as measured near McConnellstown,		351′

The *Stromatopora bed,* first studied in Pike and Monroe counties, and then in Columbia, Montour and Northumberland, appears in nearly all the exposures in Huntingdon county and in precisely the same geological position.

The limitation of *good* limestone beds to the *Middle division* is of great importance to those who design to open

Lewistown (Lower Helderberg) limestone,



quarries. Where Warrior's ridge is unbroken these beds can only be reached by tunneling through the poor beds of the *Lower division.* The considerable excavations of the Everett Iron Company, in Bedford county, which have not yet resulted in uncovering good limestone beds, should be regarded as a warning. The dip is about 45° (into the ridge) and a tunnel must be 300′ or 400′ long to strike the bottom layer of the *good limestone* series. But in the gaps through the ridge these good beds can always be easily opened.

Seldom more than 30′ or 40′ feet of good limestone exists, all told, and in many places not so much.

The principal quarries are at Grafton and at McConnellstown; and on the (*d*), (*e*) and (*f*) beds of the Cove section.

The Grafton (Powell Iron Company's) *quarry-series* is subdivided into—

(1) Top layers of gray crystalline,	10′
(2) Blue,	10′
(3) Cherty, (nigger-head limestone,)	2′
(4) Ironstone,	4′
(5) Gray,	5′
(6) Blackish,	7′

Specimens of which were analyzed by the chemist of the Survey, at Harrisburg, Mr. Andrew S. McCreath.

	Upper part of (1)	*Lower part of (1)*	*From (4)*	*From (5)*	*From (6)*
Carb. lime,	95.536	98.035	94.642	95.446	93.035
Carb. magnesia,	1.589	.908	2.800	1.135	1.816
Ox. iron and alum.,	.490	.410	.370	.520	.730
Phosphorus,	.011	.011	.006	.006	.006
Siliceous mat.,	1.851	.420	1.730	2.350	3.480
Totals,	99.476	99.779	99.548	99.457	99.067

Layer (1) is a coarse, grayish crystalline rock, almost entirely made up of the broken stems of stone-lilies (*Crinoids*), like bed (*f*) of the Cove quarries; in fact, the top bed of the quarry-series is always of this character, and is preferred to all others by furnace men. Layer (2) however makes the whitest lime. They are all largely quarried for ballast by the Pennsylvania railroad, near where the Oneida and West township line comes to the river above Huntingdon. Their belt of outcrop is the richest farming land, and the rock when burnt is a mine of wealth to the farmer.

The upper half of this formation is quite rich in fossils, but no systematic collection of them was made.

No. VI in Aughwick valley.

[In the Aughwick valley, Mr. Ashburner's section in Report F, p. 241, of rocks beneath the Oriskany, shows the following descending sequence, to the bottom of the *Bloomsburg red shale*, amounting in all to . . . . . 1302′

LEWISTOWN LIMESTONE,		162′
Limestone, { shaly beds, crystalline beds, }	30′	
Limestone, massive, dark blue, crystalline,	42′	
Limestone, bluish-gray, partly conchoidal,	20′	
Limestone, blue, and brownish-gray crystalline alternating with gray shaly limestone,	20′	
Limestone, gray crystalline, and dark-blue clayey, with occasional layers of light-gray shaly, and lime shales, containing *Acervularia, Alveolites minima, Astylospongia inornata, Merista arcuata, Merista levis, Orthis oblata, Pentamerus galeatus, Rhynchonella formosa, Atrypa reticularis, Aulopora, Conophyllum, Stromatopora, Trematospira formosa, Zaphrentis,*	50′	
WATER-LIME CEMENT BEDS,		580′
Limestones, thinly laminated, blue and gray (partly concealed),	150′	
L. thinly laminated, more massive, bluish-gray, clayey, (conchoidal fracture,)	110′	
L. massive, dark-gray and bluish-gray; surfaces carbonized, slickensided; cleavage marked; calcite; fucoids; bivalves,	30′	
L. ditto, with lime shales,	90′	
L. massive, blue-gray, alternating with L. slaty, clayey, and green and yellow lime shales,	50′	
Lime shales, clayey, yellow, gray (partly concealed),	60′	
L. slaty, clayey, gray and blue-gray; and shale,	20′	
L. thinly laminated, clayey, blue and yellow, Lime shales, gray, alternations,	20′	
L. slaty, brownish-gray; seams of calcite,	30′	
L. slaty, bluish; and lime shales,	20′	
Total,		742′

The uppermost (30′+42′+20′=92′) of these belong with Prof. White's *Stormville shales;* the next 20′ corresponds to the first 14′ of his *Lewistown limestone* series; the next 50′ full of *Stromatopora* and other fossils, to his *Stromato-*

pora bed 3′, and the 5′, 10′ and 25′ (= 43′) beneath it.—His *middle* (*quarry*) *division* begins 115′ beneath his *Stromatopora bed;* consequently in the middle of Mr. Ashburner's top 150′ of Water-lime series.—His *lower* (*poor limestone*) *division* begins 205′ and ends 375′ beneath his *Stromatopora bed;* consequently corresponds to Mr. Ashburner's 110′ (say 75′+110′+30′+90′+50′=say 355′).—All below this in Mr. Ashburner's section above, viz: 60′+20′+20′+30′+20′(=150′) of shales and lime shales are transferred by Prof. White to his *Onondaga* (*Salina*) formation.*—Continuing the Aughwick valley section (in F, pp. 241, 242 and 248) before taking up the *Onondaga* (*Salina*) *series* along Warrior's ridge we have:

Lime shales, clayey, yellow, brown, gray, green, ...	20′
Lime shales, olive and gray (partly concealed), ...	50′
Limestone, shaly, gray, with olive lime shales, ...	100′
Lime shales, yellow, green gray and olive; *alternating with red shales*, ...	270′

Bloomsburg red shale group.

Red shale, sandy, containing irregular layers of green shale; the red shale more sandy and massive towards the top, with rhomb fracture, ...	120′
Red shale, clayey; also green and gray lime shales (partly concealed), ...	100′
Red shaly sandstone, becoming clayey downwards; seams of calcite, ...	50′

These 440′ of lime shales and 270′ of red shales with the 150′ of the higher shales before-mentioned (in all 860′) in the Aughwick valley, must be taken as representing the *Onondaga* (*Salina*) formation, 1180′ thick, along Warrior's ridge, as formulated by Prof. White, who removes the *Bloomsburg red shale group* from the *Clinton formation* (*Va*), where it is placed in most of the Reports, to the base of the *Onondaga* (*Salina*) formation (*Vb*), where it properly belongs.]

*The sections at Mt. Union, McVeytown, and Lewistown show such variations of thickness and character of beds that a discussion of the classification becomes difficult and must be reserved.

The Onondaga (Salina) formation, No. Vb.

Upper; buff-colored, magnesian limestone, ... 375′ to 450′
Middle; green shale and shaly limestone, ... 400′ to 500′
Lower; (Bloomsburg) red shales, ... 200′

These 1050′ to 1150′ of beds like the 330′+410′+440′=1180′ of similar beds in Columbia county, represent the three divisions of the formation in middle New York State, but without *gypsum* and *salt*; as shown in Report G[7]. The belt in the valley between Warrior's ridge and Tussey mountain is poorly exposed; but sufficiently seen to show that the UPPER BEDS are sharply distinguished from the overlying lower division of the *Lewistown limestone series*, by their *buff color*, and by their *magnesian character;* as they are from the underlying *green shales;* they make the foot slope of Warrior's ridge and part of the valley. The MIDDLE (green) beds have hard layers which make a low ridge, fading out northward, but continuously conspicuous southward, through Bedford county into Maryland, as Mulberry ridge. The LOWER (red) shales have also massive hard layers which at length form the Redstone ridge of Bedford county. These two ridges are sometimes mere swells in the flow of the valley, 50′ high; in other places a continuous hill 200′ high; the effect being produced by an increase of the hard limy sandstone beds interstratified with the magnesian green shales; but the course of the Mulberry ridge along Woodcock and Hartslog valleys is variable in such a way as to show that it is not always made by the sandstone beds, but sometimes by the limestone beds of the middle group. The middle and upper groups make the best farming soil of Woodcock valley (except of course the still better soil along the narrow outcrop of the overlying Lewistown limestone beds) and Hartslog valley; its continuation from the Juniata river northward is exceedingly fertile, because occupied by the broadly outspread gently-dipping upper and middle *Onondaga (Salina) shales.* Some of their limestone layers would make good lime; but most of them are too impure; and lime-burning has been done at only one or two places.

A bed of *black shale* was noticed lying about 700′ down in the series.

The hard red beds (1½′ to 2′ thick) in the middle of the red shale division, which make Redstone ridge, and are almost sandy enough to be called sandstones, measure about 25′, sometimes in two groups separated by 5′ or 6′ of green calcareous shale. Irregularly segregated seams of quartz traverse the sandstone beds.

Red shales, interstratified with green lime shales, *overlie* the sandstone group for 75′ or 100′; but at one or two places a red shale bed was noticed as much as 250′ or 300′ above it.

Dark red shales underlie the sandstone group for 75′ or 100′ down to the top layers of olive shales of the Clinton formation.

Slaty cleavage is often well developed in both the upper red shales and the sandstone group.

Redstone ridge for several miles south of McConnellsburg is kept a mile away from Tussey mountain by the gentle east dip, and several rolls. These give place to one steep dip from opposite Brumbaugh's crossing southward, drawing the ridge to the foot of the mountain and making it actually a part of the mountain slope, from Marklesburg into Bedford county. But just north of Marklesburg a set of short sharp wrinkles repeat the outcrops; so that on Mr. Franks' lands, for example, there are seven or eight Red Stone ridges.—North of the Juniata, along the valley of Shaver's creek, the red stone group is thinner, and therefore makes only a low, but still perceptible ridge.

Fossils are very rare; no recognizable species was seen; but shells, too much broken to be named, occur in the purer limestones of the upper and middle divisions.

Lead ore (*galena*) in small pieces is often found near the contact of the *Lewistown limestone* with the underlying *Onondaga* (*Salina*) shales. A mile north-east of McConnellstown, shafts were sunk and tunnels driven into the lowest hard limestones in Warrior's ridge. Lumps of *galena* were found enclosed in the veins of *calcite* which ramify through the lime rock; but not a ton of lead ore was got from all the diggings. It is quite safe to say that neither lead ore nor zinc ore will ever be profitably mined from the *Lewistown limestone* formation of this county. The same experience has been got in the counties east of the Susquehanna river (see Report G[7]), and in other parts of the State.

Brown hematite iron ore deposits are made along the outcrop of the *middle division* of the *Onondaga* (*Salina*) formation by the decomposition of such of its limestone beds as contain more iron than the rest; and a very large deposit of this kind at Everett in Bedford county is described in Report T[2]. Lumps of ore from the size of one's fist to that of a barrel lie scattered along the outcrop in Woodcock valley, and also in Shavers' creek valley.

A large number of such cover Mr. Franks' fields a mile from Marklesburg. Specimens taken from two of them were analyzed by Mr. McCreath in the laboratory of the Survey at Harrisburg. One sample (of 4 pieces) showed 44.550 per cent. of iron; 18.780 of siliceous matter; and 0.065 of phosphorus. Another sample (of 2 pieces) showed 58.175 iron; 7.910 silica, &c.; 0.216 phosphorus.

Several tons have been dug from B. Groove's field, just east of the Bedford and Huntington turnpike, and there may be a considerable deposit beneath the surface. The ore is good, one piece analyzed by Mr. Patterson yielding 59 per cent. of iron.

These two points at Franks' and Grooves' are the only ones along the outcrop where the surface-show seemed to indicate paying deposits underground. And it must be remembered that a comparatively small quantity of such insoluble ore, if scattered through shales which are continually being carried away by the rainfall, will in the course of ages accumulate on the constantly lowering surface of the ground; and therefore they do not necessarily indicate a mass of ore underground.

Bloomsburg red shale at Saltillo.

[Mr. Ashburner's Report F includes the *Bloomsburg red shale* in the Clinton formation (as has been already said on page 127 above); and, in the absence of fossils (as remarked by Prof. White, page 129 above) the presence of a *fossil* *ore bed* in it at Saltillo in Clay township might possibly justify such a classification, but it is safe to predict that no classification of our formations *in detail* will ever be made in a perfectly satisfactory manner.

The red shale group is here 270′ thick, (at Orbisonia 233′,) sub-divided into : an *upper* set of red shales and sandstone ; a *middle* set of occasional red shale beds in a preponderance of gray, green and yellow shales ; and a *lower* set of red shales and sandstones (50′ thick,) immediately on top of which lies a *fossil ore*, thus :

Saltillo, . .	Soft fossil ore, ...	0′ 8″	2′ 4″
	Yellow lime shale, ...	1′ 0″	
	Harder fossil ore, ...	0′ 8″	

and this fossil ore bed lies about 210′ above the fossil ore beds mined at Orbisonia. It is opened at a height of a hundred feet above the railroad station, and also along the railroad on the south bank of the creek 600′ further north and 80′ lower, where the upper ore bench is merely a ferruginous limestone 2′ thick (in layers of 1″ to 3″), the intermediate shale is 1′ 3″, and the lower ore bench also is merely a ferruginous limestone, 10″ thick. This illustrates the nature of these fossil ore beds very plainly.]

The Clinton formation, No. V a.

A generalized section of these strata along the slope of Tussey mountain may be stated thus :

Shales, bluish-gray and olive ; *containing sometimes a thin fossil ore bed.*	75′
Shales, red, ...	50′
Shales, olive, ...	60′
Shales, and *limy beds* (which in places amount to 125′ or even 150′ of well marked BARREE LIMESTONE BEDS,)	175′
Barree shales, bluish, greenish, olive, ...	60′
ORE SANDSTONE, ...	10′
FOSSIL ORE, ...	1′ to 2′
Slates olive, reddish shales, and hard sandy beds, ...	600′
IRON SANDSTONE, (including its BLOCK ORE, "*Levant ore,*")	25′
Sandy beds, olive and reddish, ...	400′

Resumé.

Clinton upper shales,	420′	1457′
ORE SANDSTONE and FOSSIL ORE,	12′	
Clinton middle shales,	600′	
IRON SANDSTONE and BLOCK ORE,	25′	
Clinton lower shales,	400′	

the total thus given approaching rather the least than the greatest thickness of the formation, although larger than the total given for this formation in other reports.

The Clinton upper shales.

These olive shales, 75′ to 100′ thick, contain a bed of *fossil ore* in the middle, which has been mistaken for the regular bed much below it. In Mr. Robb's tunnel, on Given run, it was 10″ to 1′ thick, oolitic and fossiliferous, but rather lean. On Mr. Given's land several tons of it were dug and sold. Its outcrop is confined to a few farms, and when followed into the hill always turned to hard rock. It is evidently, like the Saltillo ore mentioned on page 130 above, one of the limestones highly charged with iron at this or that locality. An impure limestone bed, 25′ or 30′ under the ore, is seen on Given's run, on the road between Robb's and Given's.

The 50′ red shale is persistent through this part of the county, and may represent the 50′ red shale of Mr. Ashburner's Saltillo-Orbisonia section (see page 127 above.) If this *lower* red shale (sometimes 75′) were transferred (with the overlying 75′ to 100′ olive shales) to the *Bloomsburg red shale* group, then the thickness of the Clinton formation would not be 1427′, but about 1250′ thick.

The Barree limestones (Niagara ?)

There are some pure limestone layers in the 175′ of shales of the section, especially near the bottom, everywhere in the county; but in some localities they thicken up greatly. Where the outcrop belt crosses the Little Juniata at Barree forge the limestone group is 150′ thick.

It consists of thin beds of light gray, bluish-gray limestone, streaked with calcite, slightly fossiliferous, (with some greenish-gray shale partings,) quarried for flux for

Barree furnace, although not of the best quality, as shown by three analyses: A, specimen from the upper part of the 10′ quarry bed; B, from the lower part; C, average specimen.

	*A.**	*B.**	*C.*†
Carbonate of lime, ...	96.000	91.000	89.911
Carbonate of magnesia,	——	——	2.028
Oxide of iron and alumina, .	——	——	1.790
Siliceous matter, ...	——	——	5.660
Phosphorus, ...	a strong trace.	a trace.	0.014
Sulphur, ...	0.750	0.190	——

If the *Niagara limestone* have any representative in this part of Pennsylvania, this may be it, for, a *favosites* occurs in it, much resembling *Favosites niagarensis*, in the cut below Barree station.

The Barree shales.

In the green shales (60′ to 75′ thick) under the limestone group, occur thin, limy, fossiliferous layers, beautifully exposed in the railroad cut, and along the river below the furnace. The shales sometimes weather olive-green.

The *Barree limestone beds*, cut by the tunnels driven into the foot of Tussey mountain to reach the underlying fossil ore, are nearly always decomposed into a mushy clay, some of it nearly black, which invades the tunnel from all sides, like a quick sand, and can only be kept out by "four-poling" the tunnel.

The ore sandstone.

This somewhat ferruginous lime-sand rock weathers at its outcrop (by the loss of its lime) into a coarse, porous, dark gray, excessively hard and sandy stone, often streaked with thin quartz veins. It seldom makes a rocky outcrop, but covers the surface with blocks of various sizes (up to 4 feet) as a distinct ridge, which is repeated as often as the little anticlinals repeat the outcrop. Its last outcrop on the mountain slope makes a distinct terrace.

The fossil iron ore bed.

Under the sandstone this bed of ore sometimes exists, and sometimes is wanting; varying greatly in thickness

* By D. J. Morley, communicated by Mr. Muniper.

† By A. S. McCreath, laboratory at Harrisburg.

from nothing up to 3 feet; but averaging over any considerable area 1′ to 1½′.

Underground, deep enough to be beyond the reach of the drainage waters, the bed is a hard, somewhat siliceous limestone, holding 20 or 30 per cent of iron; 40 to 60 per cent of it being carbonate of lime; enough to flux itself in the furnace: called *hard block ore.*

From the surface down as far as the drainage waters can act upon the bed before issuing at the lowest springs in the neighborhood, the lime is leached out of the bed, leaving it a cellular or very porous siliceous stratum, called *soft block ore.*

Where the bed contains more alumina and less silica and its dissolution has proceeded to the uttermost, there remains a bed of *soft fossil,* or *keel ore.*

In many places there are two layers of ore, separated by a slate parting of variable thickness (up to 5′) the upper layer being called "the big bed" and the lower one "the little bed;" the latter being nearly always "keel ore."

The following analyses were made by Mr. McCreath in the laboratory of the Survey at Harrisburg:

From the Patterson estate in Penn township: A, one piece; B, 12 pieces; C, 8 pieces.

From Isaac Kurtz's mines in Walker township: D, E, F, G.

From B. Groves' estate, Penn township: H, three pieces.

From Mr. Franks' land near Marklesburg: I, two pieces.

From Powell & Cos.' Stolertown mine in Bedford county: J, three pieces.

	A.	B.	C.
Iron,	54.950	52.400	53.900
Sulphur,	.012	.009	.011
Phosphorus,	.469	.129	.138
Lime,	1.130	.070	.070
Silica, &c.,	9.690	14.860	12.510

	D.	E.	F.	G.
Iron,	52.100	54.975	49.775	53.275
Manganese,	.173	.223	.360	.129
Sulphur,	.002	.008	.005	.009
Phosphorus,	.142	.581	.207	.585
Lime,	.300	1.960	.380	1.660
Silica, &c.,	14.040	8.400	14.710	10.840

	H.	I.	J.
Iron,	50 925	55.550	54.750
Sulphur,	.016	——	——
Phosphorus,	.515	.586	.804
Lime,	1.430	——	——
Silica, &c.,	13.690	7.910	3.850

These analyses represent the ore when dried in the laboratory. As sent to the furnace the best ore yields only about 40, most of it not much above 35 per cent of iron.

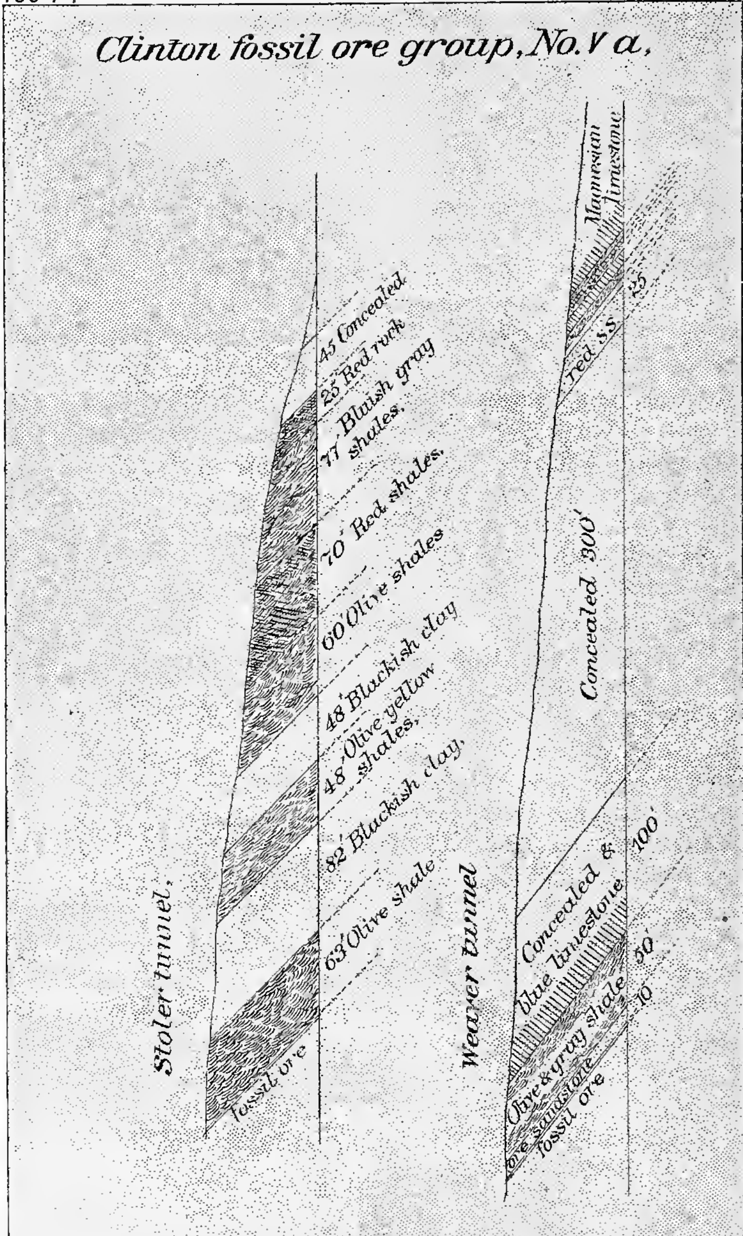
The slope and foot of Tussey mountain have been extensively explored and mined between the Little Juniata river and the Bedford county line, say 25 miles by the outcrop line, and the practical result is *that the fossil ore bed is not a continuous deposit*, as once imagined, but that it only offers valuable mining ground in three or four localities (others of more limited extent may be hereafter found) viz: One north of the river in West township, the Barree forge district; none in Porter; one in Walker, the Kuntz-Grubb district about a mile long; one in Penn, the Patterson-Grove district, not more than 2½ miles long; one in Lincoln, the Kittie Houp district, not more than half a mile long, and none in Hopewell.

The large number of *abandoned tunnels* driven at great cost into the mountain between the Juniata river and the Maryland line prove how little the *practical miners* who located them could tell the character of the ore underground from the "lay of the land," as they call it, on the surface. The "lay of the land," that is the shape of the ground, undoubtedly guides to the *place* of the bed (for the overlying sandstone must make some sort of a ridge or terrace) but gives no clue to its *character and condition.*

The iron has evidently been *filtered into the bed*, as the lime has been *filtered out of the bed*, otherwise the percentage of iron in the bed would not diminish below drainage level.*

Wherever the ore is valuable the enclosing rocks are very much weathered; the lime rocks are changed into clay, and

* We do not know, but it is probable, that the bed at great depths contains merely the small percentage of iron common to all fossiliferous limestone strata.


Clinton fossil ore group, No. V a.
45 Concealed
25 Red rock
77 Bluish gray shales.
70 Red shales.
60 Olive shales
48 Blackish clay
48 Olive yellow shales.
82 Blackish clay.
63 Olive shale
fossil ore
Stoler tunnel.
Magnesian limestone
25
red s.s.
Concealed 300
100
Concealed & blue limestone
50
Olive & gray shale
10
ore sandstone
fossil ore
Weaver tunnel
T.3.

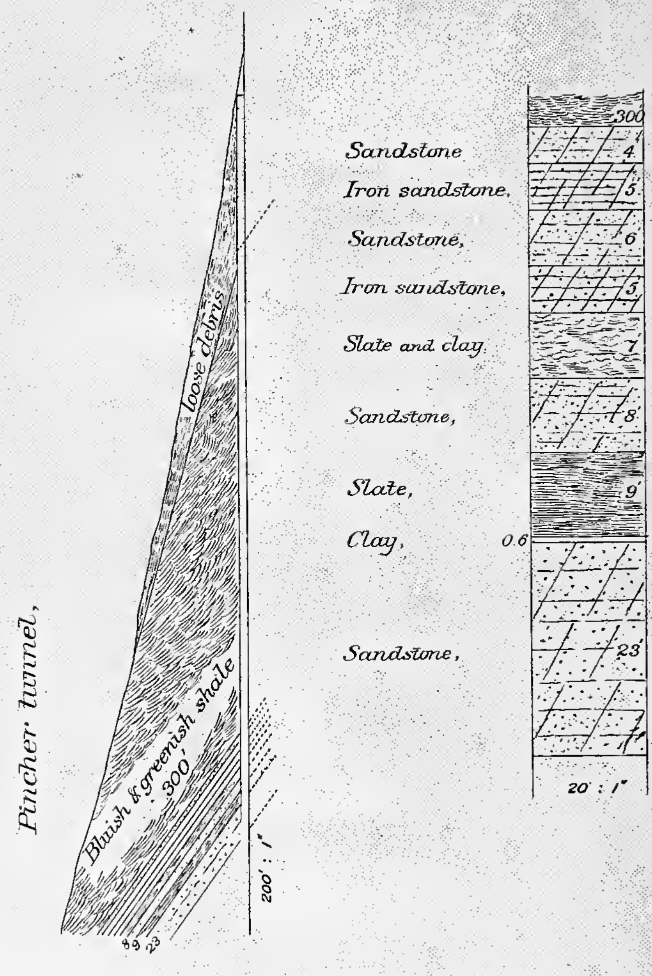
the shales overlying and underlying the ore are bleached almost white; their iron having been presumably transferred to the ore bed. And this is a reasonable way of explaining the fact that the ore bed does not always keep the same place in the series, for *any bed* can become an ore bed, provided it is so situated as to be a water-bearer and recipient of the iron-leachings.

In the stretch of fossil ore along Tussey mountain in Huntingdon county, it looks as if some of the iron, at least, has been leached into the bed from the overlying sand rock, under which lie shales which do not allow the waters to pass through them, consequently the ore bed represents the water-bearer. But then, along the same range in Bedford county *the principal ore bed is not underneath the sand rock, but on top of it;* and the same is true along the Black Log mountain range of fossil ore, in Huntingdon county, at Orbisonia, &c., (see the section from Report F on page 160 above) and there is no ore bed underneath the sand rock. The Saltillo ore bed shows that any limestone stratum in ferruginous shales may become an ore bed, *locally*, under favorable drainage conditions.

But from a careful study of the localities where the ore has been found good enough to mine, and localities where mining has been begnn and abandoned, I conclude that something can be learned from the lay of the land. Where the rainfall descends the slope unobstructed to the outcrop of the ore bed, where the porous and limy rocks permit it to sink into the earth, the ore will probably be good. But where the rainfall cannot so descend the slope, but is turned off sideways, before it reaches the ore bed, the ore bed is either absent or lean and limy. Such is the case where the *Clinton middle shales* (under the ore bed) have been eroded into a vale much below the outcrop of the ore sandstone, which then forms a ridge. I have nowhere seen a good ore bed under such conditions; the bed has been always merely a ferruginous limestone.

Descriptions of the bed at the various mines will be found under the head of each township in which they are.

Clinton fossil ore group No. V a.



[The zigzags of the ore outcrop across Barree and Jackson townships are shown upon Mr. Billen's map, and described, with the mines of Greenwood furnace, in a separate report by him in this volume.

[The variations in the fossil ore bed over the sand rock as mined at Rockhill gap (Orbisonia) in Cromwell township, is well shown in the mines driven north and south from the gap. There are three levels; the adit at water level, a middle gang-way and a higher gang-way. South of the gap the bed is thickest in the adit level and thins upward; north of the gap the bed is thinnest in the adit level and thickens upward.

Two small fossil ore beds underlie the sand rock; the first one just under it (50′ beneath the bed that is mined over the sand rock), 4″ to 6″ thick; a second 4′ lower is 10″ thick. They have not been worked, but have been found by the cross-cut tunnels driven around the downthrow faults, which shiver the mountain.

The ore sandstone is very siliceous at Rockhill gap; and quite calcareous at Saltillo. The ore bed on top of it has been traced along the west side of Jack's mountain to Mapleton; and along the east side of Jack's mountain to Mt. Union. It undoubtedly continues from Mapleton along the west side of Stone mountain to Greenwood furnace, at the north end of the county.]

The Clinton middle shales.

Below the ore bed we find everywhere a series of fine-grained yellowish or bluish "bottom slates," (the outcrop belt of which is marked by poor soil, and a different vegetation), passing down into reddish shales and gray sandy beds, becoming quite sandy at the bottom. The series is so covered by the slide from the mountain that it is only known as cut in three or four tunnels; and it seems to be about 600′ thick, or perhaps more; see the township descriptions.

The iron sandstone and ore.

Blocks of this rock lie along the surface slope of the mountain, from one third to one half way up to the summit, at the "Second bench" or terrace. The "keel," "block," "red," or "Levant" ore was once extensively mined near Marklesburg by the Cambria Iron company, but it was found to hold too much silicon and phophorus; as shown by the following analysis: A, from the Cambria Company's mine; B, from Short mountain south of Barree forge; and C, from Hatfield & Phillips' tunnel in the Loop, back of Alexandria:

	A.*	B.*	C.†
Iron,	44.25	41.10	33.475
Manganese,	——	——	0.147
Silica,	27.91	25.95	36.200
Alumina,	2.66	3.93	——
Lime,	0.52	0.29	1.880
Magnesia,	0.26	0.23	——
Phosphorus,	0.68	0.50	0.609
Sulphur,	——	——	0.025

the ore being an oolitic hematite, mining in thin slab-like blocks. The bed is often very thick; and the quantity of ore, such as it is, very great along the mountain; but it presents no natural exposure, and nothing is known of the bed except where it has been cut. (See descriptions of townships.)

Clinton lower slates.

These olive, gray and reddish sandy layers are everywhere so effectually concealed that the Iron sandstone ore has been supposed to lie directly on the Medina sandstones. But in a wide railway cutting above Barree, 400′ of these slates are exposed to view; and their outcrop must make the middle third of the mountain slope.

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*Analyzed by T. T. Morrell, and communicated by Mr. Mumper.

†Collec.ed on the dump; analyzed by Mr. McCreath at Harrisburg.

Fossil ore at Orbisonia.

[At Orbisonia Mr. Ashburner's section is as follows:

Clinton upper olive shale (at Orbisonia,)		163′
Lime shales, gray, olive, yellow, with Limestone layers, blue, fossiliferous, ...	30′	
Shales, olive and brownish, clayey and limy, with Limestone layers, blue fossiliferous,	80′	
Shales, olive and brownish, clayey and limy, with Limestone layers more numerous, . .	40′	
Shales, dark olive, alternating with Limestones, clayey, blue and gray, Fossils numerous; see note.*	12′	
Clinton fossil ore group (at Orbisonia), ...		53
Fossil ore,† upper bench, 0 10″; red sandstone and white shale, 1′; lower bench, 1′ 2″	3′	
Ore sandstone, ...	50′	
Upper part, massive, yellow sandstone at Orbisonia very limy at Saltillo.		
Middle part, yellow and green sandstone (with crinoidal stems) alternating with shale.		
Lower part, more massive.		
Fossil ore, upper bench, 0′ 6″; parting; hard bench, 0′ 10″		
Clinton lower olive shales (at Orbisonia),.		660′
Shales, yellow, gray, weathering olive and claret-colored; surfaces near the bottom stained with iron and bitumen, ...	600′	
Shales, as above, with soft *olive* shales (showing crinoidal impressions) in the lower part at Three Springs, and *red* shales at Orbisonia, ...	60′	
Total of Clinton formation at Orbisonia, ...		875′

The Clinton formation was carefully measured at Orbisonia, Mt. Union, McVeytown and Lewistown in 1874:

*The lower part of this 12′ light yellow clayey lime shales making the roof of the *fossil ore bed.* The fossils of the whole 133′ (more plentiful in the lower part) are *Atrypa reticularis*, *Beyrichia lata*, *Buthotrephis gracilis*, *Dalmania limulurus*, *Homalonotus delphinocephalus*, *Orthis elegantula*, *Platystoma niagarense*, *Pterinea emacerata*, *Rhynchonella neglecta*, *Strophomena rhomboidalis.*

†Said to be safe average of thickness, by Mr. Tarr, Superintendent of Rock Hill I. & C. Co. For full descriptions of the mines see Report F.

		Orb.	*Mt. Union.*	*McVey.*	*Lew.*
VII.	Oriskany sandstone,		95′	140′	110′
	" shale,	195′	282′	65′	205′
VI.	Lewistown shale,		18′	130′	140′
	" limestone,	125′	35′	215′	185′
	Waterlime shale,	600′	541′	520′	470′
	Variegated shale,	145′	473′		358′
	—— limestone,		3′		4′
	—— shale,	230′	232′		70′
V.	Bloomsburg red shale,				430′
	" *upper lime shale,*	233′	285′		305′
	" red shale,			2200′	260′
	" lower lime shale,				
	Clinton upper shale,	163′	141′		250′
	Fossil ore beds and ore SS,	54′	42′		120′
	Clinton middle shale,		359′		128′
	Iron sandstone,	660′	2′		7′
	Clinton lower shale,		307′		571′
Total of VII, VI, V, . . .		2405′	2815′	3270′	3613′
Total of Clinton, (V a,) . .		877′	851′		1076′

The increase of the whole mass of sediments from the top of the Oriskany to the bottom of the Clinton, northward, is constant, amounting:

In 10 miles from Orbisonia to Mt. Union, to	410′
In 10 miles from Mt. Union to McVeytown, to	455′
In 15 miles from McVeytown to Lewistown, to	343′
Mean increase in 35 miles (from 2405′ to 3613′), ...	34½′

The estimates of the whole mass made by Prof. White along Warrior's ridge (3032′ to 3357′=mean of 3200′) show that the increase is at the same rate from Orbisonia northwestward.

But the Clinton formation taken by itself increases from 877′ at Orbisonia to 1075′ at Lewistown; and from 877′ at Orbisonia to 1457′ between Huntingdon and Barree forge; but with no regularity; for at Mt. Union it seems to be only 851′.

This is only another illustration of the fact that while the Palæozoic deposits *as a whole* obey a pretty regular law of increase in certain directions, the individual formations are, each one, variable in thickness in all directions; which evidently militates against the theory of their being deep sea deposits.

But if they were not deep sea deposits then they must be delta deposits, issuing either from the mouth of one great river, or from the mouths of several rivers, and adjusted more or less by tidal currents. The ripple marks and triturated shells so frequently described in the preceding pages point to the same conclusion. The thinness of these formations in Virginia suggests a northeastern or eastern mainland from which the deposits came; and the total absence of some of them in Perry county (see Report F[2]) is an argument for local irregularities in the coast line of the main land, or in the bed of the sea in front of it.]

Medina and Oneida formation (No. IV.)

The following section, along the Pennsylvania railroad, begins half a mile above Barree and extends to Spruce Creek tunnel:

Medina upper (white) sandstone, with a few pebbles, and many impressions of *Arthrophycus harlani*, (dip 20° S. E.,)	1000′
Medina middle (red) sandstones and shales, ...	700′
Interval in the tunnel, concealed, ...	200′
Oneida conglomerate, coarse, pebbly, massive, ...	100′
Total of Medina and Oneida visible, ...	2000′

The blocks of the *white Medina* cover the eastern slope of Tussey mountain, the upper third of which is the belt of outcrop. They make also the great stone slides in Jack's Narrows below Mapleton. As railroad ballast material they have no superior. In the Waterstreet gap the beds (from 1′ to 8′ thick) are well exposed, their surfaces quite covered with the large branching forms of the *Arthrophycus harlani*, the only fossil seen in No. IV.

[The steep upper western slope and its ravines mark the outcrop of the *red Medina thin red sandstones* alternating with *red shales* from which the eastern end of Spruce Creek tunnel issues, and the curious gorge north of the tunnel is excavated in these rocks.

The hog-back through which the tunnel is driven is made by the massive, greenish-gray layers of the *Oneida conglomerate*, the outcrop of which turns the river north from the west mouth of the tunnel, the bend measuring two miles, whereas the tunnel is only 1250 feet long. This hog-back rises south of the tunnel to become a bold terrace on the west slope of Short mountain, as that part of Tussey mountain is called between the two gaps. North of the Little Juniata the terrace is the prominent feature of the mountain all the way into Centre county. South of the Waterstreet gap the Oneida is cut off from the mountain by the Juniata, and runs along the west bank as a long high hog-back; but further south in Blair county the terrace is resumed.

Spruce Creek gap is not a good place to measure the lower strata of No. IV, on account of a fault of considerable magnitude which brings the Hudson river slates and (further north) the great limestones up against the Medina. In the Tyrone gap through Bald Eagle mountain, also, measurements are rendered uncertain by a crush fault.

Mr. Sanders' section, made upon the basis of the instrumental survey of Blair county, and published in Report T, page 17, is as follows:

Sandstone, white, (more or less,)	100′	1068′
Sandstone, *red*,	255′	
(Concealed interval,)	540′	
Sandstone, *red*, massive,	84′	
Sandstone, green, slaty,	2′	
Sandstone, *red*, with a few red shales,	87′	
Sandstone red 10′; shale red 5′, green 5′; sandstone *red* 5′, gray 20′; slate *red* 1′; sandstone gray 10′; shale *red* 6″; sandstone red 10′, grayish *red* 15′; slate *red* 1′; green 1½′; sandstone gray 15′; slate gray 1′; sandstone brown 20′; slate gray 1′; sandstone brown 8; slate *red* 6″; sandstone reddish-brown 75′; slate *red* 1′; sandstone *red* and gray 200′, *red* 9′; shale *red* 4′; sandstone *red* 2′; slate *red* 3′, green 1′, *red* 4′; green 2′; sandstone *red* 6′, and some gray 15′, *red* 10′; slate gray 2′; sandstone *red* 18′; slate gray 6″; sandstone grayish-brown 12′; shale *red* 3″; sandstone brown 20′; shale green 2″; sandstone brown 4′; shale *red* 1′; sandstone brown and gray and concealed spaces 150′;—in all 634′ of sandstone, red and brown chiefly, and only 34′ of shale, red, green, &c.,		668′
Sandstone gray and concealed,	400′	1160′
Sandstone, gray	320′	
Sandstone, gray and slaty sandstone,	440′	
Total of Medina and Oneida,		2896′

At Rockhill gap, of Black Log mountain, Mr. Ashburner's section, (given in Report F, p. 256,) reads as follows:

Sandstone hard, massive, white, light-gray, fine-grained, (with alternations of red and green shale near the top; and impressions of *Arthrophycus*,)		400′
Sandstone, soft, clayey, brown and red and red shale; the middle sandstone beds softer and iron-specked, . .		930′
Conglomerate beds, red and reddish gray siliceous,	158′	. . 568′
Sandstone, hard, massive, greenish; and conglomerate beds gray, ...	410′	
Total of Medina and Oneida, ...		1898′

At Logan gap, near Lewistown, in Mifflin county, careful measurements (given in Report F, page 47,) read as follows:

Sandstone, light gray, rather fine, very hard and massive; surfaces of lower strata iron-specked, ...	820′
Sandstone, red, fragile, clayey, marly, thinly laminated,	1280′
Sandstone, red, massive; large pebbles,	309′
Sandstone, greenish gray, very hard, fine grained, parts ferruginous, ...	313′
Total of Medina and Oneida, ...	2722′

In the Seven mountains of Centre county Mr. Billin's topographical survey resulted in an estimated thickness of the *Medina and* Oneida of . . . . 2440′

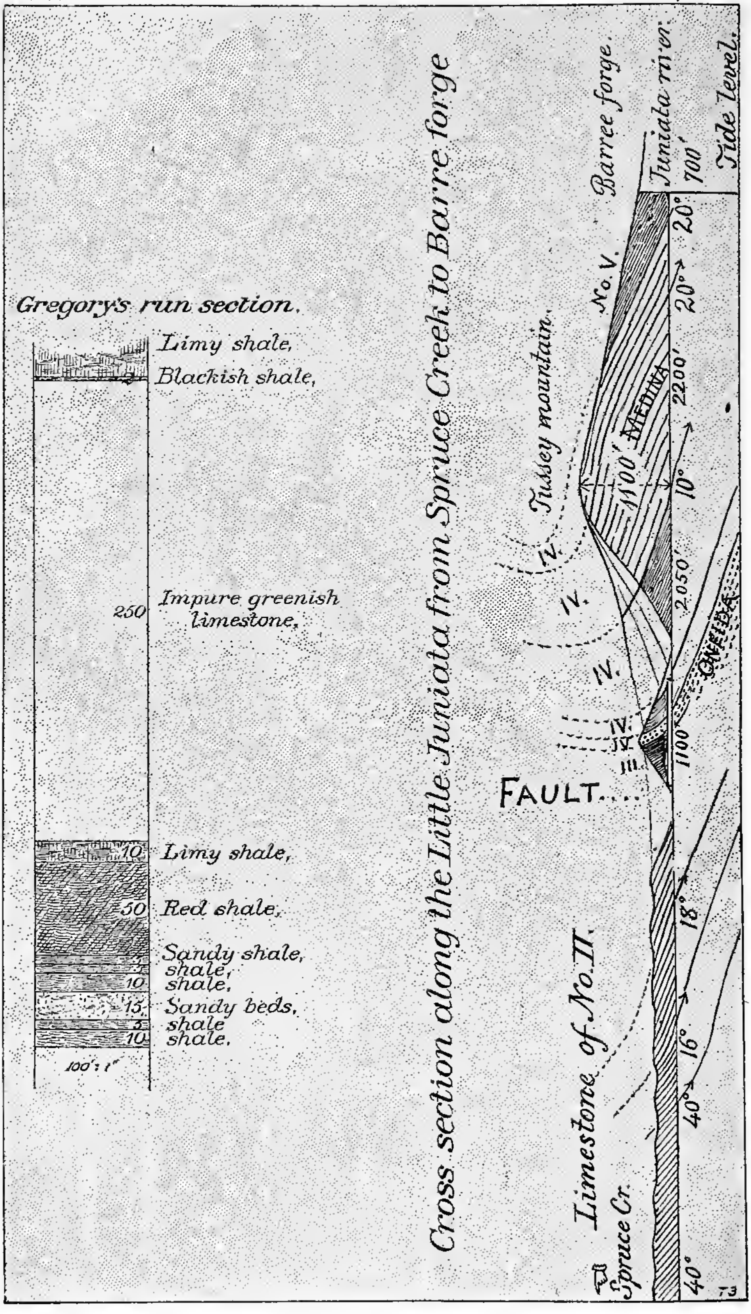
At Lock Haven, Dr. Chance's section (published in Report G^4, page 125,) reads as follows:

Sandstone, hard, massive, white, gray, and red, not well exposed (east crest), ...		695′
Sandstone, softer, and shale, ...	705′	1011′
Sandstone, hard, massive, with a few gray iron-specked beds, ...	188′	
Concealed (? soft sandstones, with some red bands),	118′	
Sandstone, hard, massive, dark gray, greenish gray, iron-specked (west crest), ...	155′	595′
Sandstone, hard, massive, not well seen, ...	440′	
Total of Medina and Oneida, ...		2301′

In Bellefonte gap, Prof. Rogers gives the thickness (I Geol. Pa., p. 129,) poorly exposed:

White Medina, ...	500′	1550′
Red Medina, ...	500′	
Gray Oneida, ...	550′	

In Lycoming county, Mr. Platt estimates (in Report G^2, p. 29,) from the imperfect exposures that the upper of IV is only 100′, the middle 1200′, and the lower only 75′; *total of Medina and Oneida* only . . . . 1375′


Gregory's run section.
Limy shale,
Blackish shale,
250
Impure greenish limestone,
10 Limy shale,
50 Red shale,
Sandy shale,
shale,
10 shale,
15 Sandy beds,
3 shale
10 shale.
100' : 1"
Cross section along the Little Juniata from Spruce Creek to Barre forge
Barree forge.
Juniata river.
Tide level.
700'
No. V.
Tussey mountain.
MEDINA
1100'
2200'
2050'
ONEIDA
20°
20°
10°
IV.
IV.
IV.
IV.
IV.
III.
1100'
FAULT....
Limestone of No. II.
18°
16°
40°
Spruce Cr.
40°

To the north, east, and south-east of this no opportunity is afforded for measuring No. IV, except along the Blue mountain at the gaps of the Susquehanna, Swatara, Schuylkill, Lehigh, and Delaware rivers; and instrumental measurements have been made only at the last three, (see Reports D^3 and G^6,) as follows:

On the	*Schuylkill*	*Lehigh*	*Delaware.*
No. IV	*1400′*	*1125′*	*1565′*

In a southward direction, towards Virginia, the decrease in thickness (from 2722′ at Lewistown to 1898′ at Orbisonia) continues, (according to Prof. Stevenson's report, T^2, page 91,) being, in the Cove mountain of Fulton county, ... 1600′

Along Tussey mountain the same southward decrease in thickness is manifested.

In the Williamsburg and Waterstreet gaps of the Juniata river in Blair county, Prof. Rogers (Geol. Pa. I, p. 127) gives the following measurements, the first being of good exposures:

	Cove mountain.	*Tussey mountain.*
Upper of IV (white Medina,)	550′	500′
Middle of IV (red Medina,)	1050′	700′
Lower of IV (gray Oneida,)	500′	450′
	2100′	1650′

In the Yellow creek gap through Tussey mountain in Bedford county, Prof. Stevenson (Report T^2,) makes—

The white Medina,	800′	2035′
The red Medina,	1200′	
The gray Oneida (sandstone,)	35′	

the *white Medina* diminishing to 300′ at Bedford and 200′ in Evitt's mountain gap; the *red Medina* also diminishing but not easily measurable, and no *Oneida* to be found south of Raver's gap in Tussey mountain.

In Virginia the formation gets very thin.]

The Loraine and Utica shales, No. III.

This "Hudson River" formation, as it is also called, forming the border of Canoe, Sinking Creek, Spruce Creek and Nittany valleys and Black Log valley, a series of dark

Fault at Spruce creek gap of Tussey mtn.

Fig. 1.

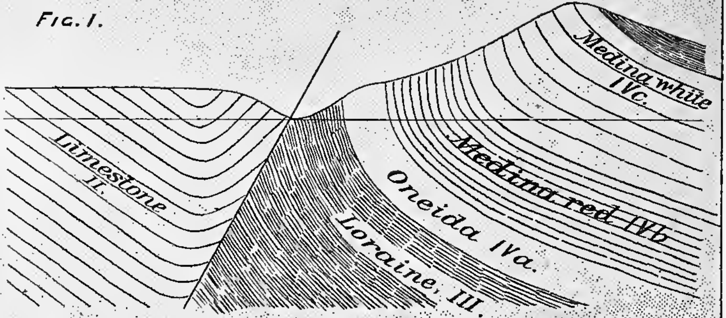
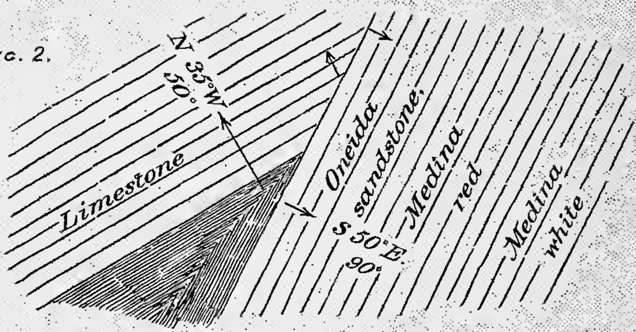
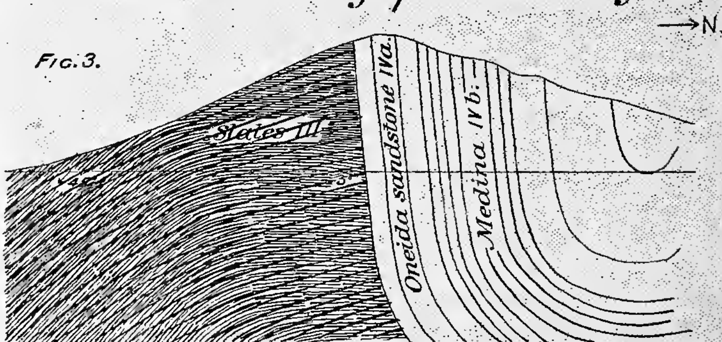


Fig. 2.



Fault at Port Clinton gap of Kittatinny mtn.

Fig. 3.



gray, often blackish or even black shales, seems to be only 300′ thick in the Spruce Creek tunnel, and in the Water-street gap, where a clean exposure from the Oneida sandstones down to the Trenton limestones permits a fair measurement.

The measurements made of the unsatisfactory exposures of No. III in the various gaps of Tussey, Canoe, Bald Eagle and Dunning's mountain in the course of the topopraphical survey of Morrison's cove, Canoe valley and Sinking creek valley made by Mr. Sanders, led Mr. Platt (in Report T, p. 18) to assign to No. III a possible thickness of . . . . 900.′

Prof. Rogers (Geol. Pa., Vol. 1, p. 124) estimates in Nittany valley, *Loraine* 700′; *Utica* 300′; = ... 1000′. In Kishicoquillis valley, *Loraine* 1200′; *Utica* 400; 1600′.

But a carefully measured section in Logan's gap (into Kishicoquillis valley near Lewistown in Mifflin county) reported in F, page 55, and shown in the long section at page 47),*—and another instrumental section in Rockhill gap at Orbisonia in Huntingdon county, reported in F, p. 257, give much greater thicknesses, thus:*

	Orbisonia.		Lewistown.	
Loraine, ...	800′	1870′	937′	2304′
Utica, gray,	1070′		210′	
Utica, black,			302′	
Utica, gray,			855′	

On the Lehigh and Delaware rivers No. III is shown by Report D^3 to be considerably more than . . . . . 5000′

The decrease in the formation is therefore:

From the Lehigh water gap to Logan's gap (west) 100 miles, at the rate of at least 30′ per mile.

From Logan's gap to Rockhill gap in (south south-west) 33 miles, at the rate of about 15′ per mile.

From Rockhill gap to the Tussey mountain gap near Bedford, where Prof. Stevenson (Report T^2, page 93) estimated the thickness of No. III at 700′, (south-west by west,) 45 miles, at the rate of about . . . . 26′ per mile.

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*A curious mistake has been made on page 50, F, and repeated on page 49, T, where the Utica in Logan's gap is given as 695′ instead of 1367′.

From Rockhill gap to McConnellsburg in Fulton county [where No. III, although not measured is "certainly thicker" than about Bedford) nearly south 22 miles, the rate may perhaps be the same.

In view of the above facts it is improbable that 300′ represents the whole thickness of No. III in the Spruce creek and Waterstreet gaps through Tussey mountain, but must be accounted for by faults which have swallowed a part of the formation.

A fault, in fact, was discovered by Dr. R. M. S. Jackson, assistant on the First Geological Survey, which is thus described in the Geology of Pennsylvania, Vol. I, page 502: "At the gap of the Little Juniata . . on one side of a longitudinal ravine, the . . limestone dips 50°, N. 35° W.; and on the other side, only perhaps 150 feet distant, the lowermost beds of the [Oneida] gray sandstone dip almost 90°, S. 50° E.; all the [No. III] slates and shales disappearing in the dislocation." (See Fig. 1, in Plate XXIX.)

This fault is evidently the result of a sharp anticlinal roll, coming from the south-west and dying down rapidly north-eastward, and broken along its crest. As the fault rises and the jaws of the anticlinal widen south-westward, more and more of the slates of No. III come to the surface. At the tunnel only 300′ of the formation is thus released. (See Fig. 2, Plate XXIX.)

Other such faults occur in the State; notably the one at Port Clinton, on the Schuylkill river, where the Medina and Oneida rise vertically, and the slates of III lean their edges against the bottom surface of the Oneida. (See Fig. 3, Plate XXIX.)

In fact, there is a natural tendency to such faults whereever the formations are much folded; because when the rigid sandstone mass of No. IV is forced to move over the rigid limestone mass of No. II, whatever crushing and breaking and sliding is thus occasioned will be likely, of course, to take place in the intermediate soft clay slate mass of No. III.

The diagonal attitude of the Short mountain between the two Juniata gaps shows how a piece of the earth-crust has been here skewed round; and this could not occur without faults.

It is certainly remarkable that the same thickness of 300′ appears also in the Waterstreet gap. But the true lines of faulting have not yet been accurately obtained.

It has been asserted that the Palæozoic deposits were everywhere interrupted at the close of the Loraine (Hudson river) age, and that dry land was formed, eroded, and resubmerged; and that then a coarse and more or less irregular mass of sand and gravel (Medina and Oneida) were swept into the sea to lie irregularly in one place on a great thickness of slates, and in another place on merely what was left of the slate formation. Nothing favoring this view appears at any of the places in Pennsylvania where the contact of IV on III can be observed. And the gradual thinning of No. III westward is also opposed to that view.

A similar fault occurs in Leathercracker cove in Blair county, at the Henrietta mines, where the whole of No. III is swallowed up, and the limestones abut against the Oneida sandstone at the foot of Tussey mountain. (See Report T, page 196, and map of Morrison's Cove in atlas to Report T.)

It has also been asserted that a great change took place when all the limestones of No. II had been deposited and the slates of No. III came to be laid down over them. But in the Cumberland Valley many hundred feet of transition layers are exposed in the bends of the Connedogwinet creek, and 30′ of such beds of passage from limestone into slate deposits—thin blackish limestone layers, breaking into small pieces and weathering a deep brown—may be seen at Pattonville in Morrison's cove, and near Martinsburg; and in McKee's gap in Dunning mountain; and near Franklin forge on the Juniata, and north of Yellow Springs in Canoe valley, (T, p. 50.)

There is no brown hematite deposit at the bottom of the slates of No. III, or at the top of the limestones of II, in Huntingdon county, such as the great Henrietta mine deposits in Blair county, the great deposits in Path Valley, Cumberland county, the Moselem mine in Berks county, and the Balliot mine at Ironton, in Lehigh county.]

The Trenton and Calciferous, No. II.

Morris township occupies the north end of Canoe valley; and here, between Tussey and Canoe mountains a great anticlinal brings up an immense thickness of the Lower Silurian limestones No. II, as described in Report T, on Blair county, and shown in the great topographical map accompanying that report. The rocks of the valley are exposed along the Little Juniata river, first, as they rise from Spruce Creek tunnel to Wallace's old mill, and then sink again to the Union furnace at the end of Canoe mountain; and then, as they rise a second time to Birmingham, and then sink a second time, vertically beneath the Bald Eagle mountain.

The section obtainable along the river here is remarkable as the only one in Pennsylvania where regular and persistent dips (four times repeated) permit a measurement of the whole formation.*

The lowest beds appear on the great Nittany anticlinal at Birmingham, where Mr. C. E. Hall obtained *Potsdam fossils* in 1877.

Mr. Sanders' measurements divide the whole formation thus:—

Limestone, dark blue, blue and gray; the lower half magnesian, ...	5400′	
Sandstone, white, iron-stained, ...	40′±	6600′
Limestone magnesian (slates and sandstones towards the bottom,)	1160′	

Good pure limestone can be obtained at only a few places, one of which occurs near the bottom of the series, near Birmingham, where large quarries are worked for flux stone for iron and glass furnaces.

[The curious caves and trenches through which Sinking creek flows, alternately appearing and disappearing in its course, are excavated in a set of massive pure blue limestone beds which lie about one third way down in the series. The magnesian lower strata seem to have suffered less solution and erosion. (See wood cut from Mr. Leh-

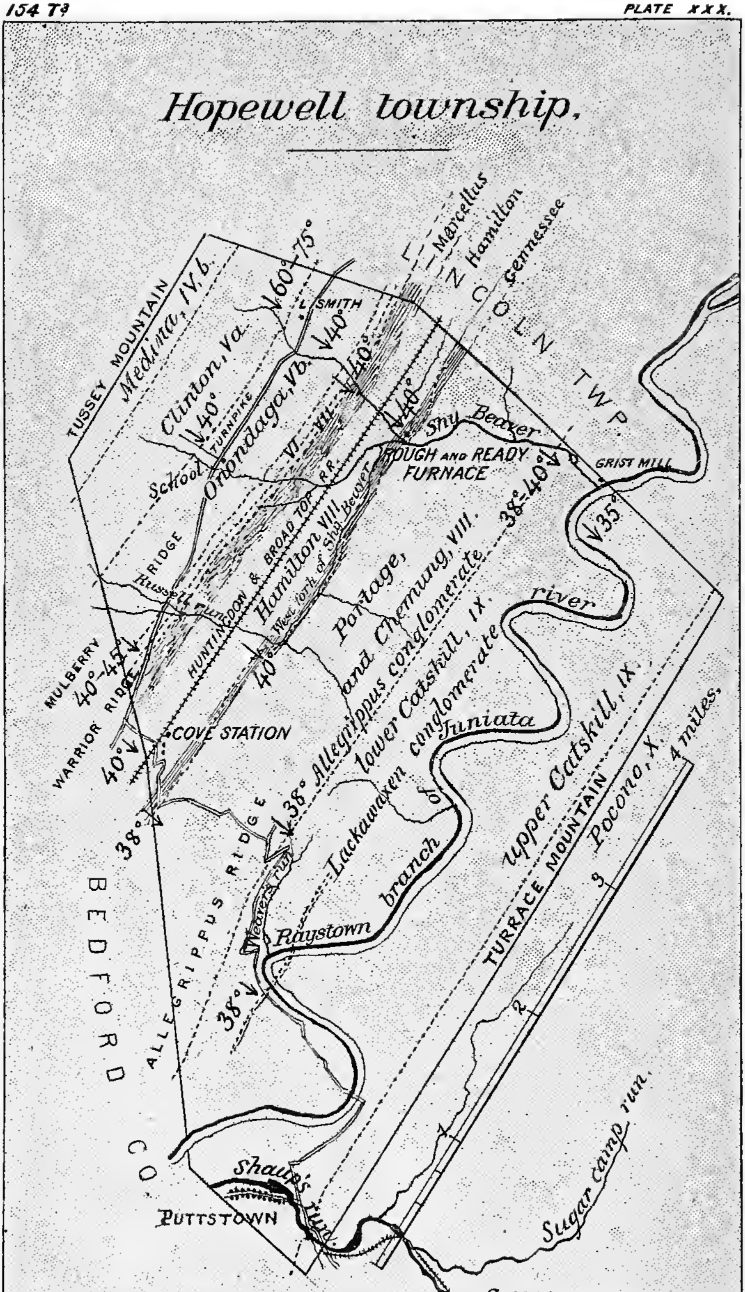
*The details will be given under the head of Franklin township, and Warrior's Mark township.

mann's sketch in 1839, reduced from Geol. Penn., 1858, I, p. 503.)

Great deposits of brown hematite ore are mined in cavities filled with clay holding the ore in every variety of form, and concentrated at the bottom of some of them in the form of pipe ore, as described in Report T^4 on Centre county. The great mines at Springfield, in Canoe valley, are described in Report T on Blair county. The Dorsey and Shoenberger ore deposits on the north line of Huntingdon county will be described at the end of this volume.

The zinc and lead veins of Sinking valley are described in Report T on Blair county. No such veins are known in Huntingdon county; but threads and nuggets and isolated crystals of galena may be expected to occur at any point in Nittany and Spruce Creek valleys where the limestones are well exposed; but they will not lead in any case to profitable mining operations.

For an account of the strata exposed along the Little Juniata see subsequent descriptions of Franklin and Warrior's Mark township.]


Hopewell township.
TUSSEY MOUNTAIN
Medina, IV, b.
Clinton, Va.
Onondaga, Vb.
L. SMITH
TURNPIKE
School
RIDGE
Russell run
HUNTINGDON & BROAD TOP R.R.
Hamilton VIII
West fork of Shy Beaver
Marcellus
Hamilton
Gennessee
LINCOLN TWP.
Shy Beaver
ROUGH AND READY FURNACE
GRIST MILL
Portage,
and Chemung, VIII.
lower conglomerate,
lower Catskill, IX.
Lackawaxen conglomerate
Juniata
river
branch of
Raystown
upper Catskill, IX.
TURRACE MOUNTAIN
Pocono, X.
4 miles.
MULBERRY
WARRIOR RIDGE
COVE STATION
38° Allegrippus
ALLEGRIPPUS RIDGE
Weavers run
BEDFORD CO.
Shoup's run
PUTTSTOWN
Sugar camp run.
COALMONT.
T3.

CHAPTER IV.

TOWNSHIP GEOLOGY.

1. *Hopewell.*

This township occupies the south-western corner of Huntingdon, along the Bedford county line, between Tussey mountain on the west, and Terrace mountain on the east.

The Catskill rocks No. IX crop out along the Raystown branch, which cuts sometimes into the base of the Catskill beds, and sometimes crosses the whole series nearly to its top at the foot of Terrace mountain.

At one of these great curves, on the road leading from Cove Station to Puttstown, (the most northern point of the curve being at the mouth of Weaver's run, where the road from Cove first strikes the Raystown valley,) the following section was constructed (see Sheet No. 2, Fig. 1):

Weaver's Run Section of IX.

1. Reddish sandstone, containing pebbles at base and *fish bones*,	4′
2. Green sandstone,	1′
3. Olive green, sandy shales,	25′
4. LACKAWAXEN CONGLOMERATE, (*Upper Chemung* of Stevenson,) a massive, greenish gray rock, very pebbly in streaks, quartz pebbles mostly flat, from the size of a pea up to a goose egg, some of the pebbles being *dark* and others *red* (jasper); also contains *fish bones* and pebbles of slate,	20′
5. Olive shales, sandy, containing *Spirifera disjuncta*,	8′
6. Reddish sandstone,	7′
7. Olive and greenish sandy shales,	35′
8. *Red shale* and *red sandstone*,	6′
9. Red and variegated shales,	20′
10. Olive sandy shales,	10′
11. *Red shale*,	5′
12. Variegated shale, (olive and red,)	8′
13. Concealed,	15′
14. Sandstone, massive, greenish gray,	20′
15. Concealed,	50′

16. Sandstone, massive, green, dip, S. 55°, E.$<$38°,	20′
17. *Red shales,*	20′
18. *Red sandstone,*	10′
19 *Red shales,*	15′
20. Green, sandy shales,	5′
21. *Red shale,*	5′
22. Reddish and green sandstone,	7′
23. Olive and *red shale,*	15′
24. Olive shales,	10′
25. Sandstone, greenish,	3′
26. Olive shales,	15′
27. Greenish gray, hard sandstone,	5′
28. *Reddish or purple shales,*	8′
29. Olive shales and sandy beds,	65′
30. Sandstone, massive, greenish gray, makes cliff,	10′
31. Mostly concealed, but showing some olive shales and green sandstone, dip, 38°,	600′
32. ALLEGRIPPIS CONGLOMERATE, (Lower of Stevenson,) a very hard, dark gray stratum, filled with flat, white quartz pebbles,	5′
33. Sandy and shaly beds, consisting of olive shales interstratified with hard, thin sandstones, the *Portage rocks* below mostly yellowish, sandy shales and thin gray sandstones, horizontal distance 250 rods, dip 38°,	2433′
34. *Genessee beds and Hamilton upper shales,*	450′
35. *Hamilton Upper Sandstone,* makes low ridge,	30′
36. *Hamilton Middle* soft shale, makes narrow valley to Cove station, the basal portion being quite fossiliferous,	225′
37. *Hamilton Lower* Sandstone, rather massive, makes sharp ridge along R. R. in vicinity of Cove station, *fossiliferous,* containing *Spirifera granulifera, S. medialis* and *Rhynchonella sp.,*	50′
38. *Hamilton Lower* Sandy shales and shaly sandstone, rather soft, dark olive, fossiliferous to base of *Hamilton* proper,	75′
39. *Marcellus gray shales,* light gray, interstratified with hard, sandy beds 6″-12″ thick,	325′
40. *Marcellus black slates,*	300′
41. *Limestone,* gray, shaly, interstratified with dark shales; fossiliferous, containing *Phacops rana* and other *Hamilton* forms,	25′
42. Dark, limy shales with a few, thin layers of greenish-gray, impure *limestone* at top,	55′
43. *Oriskany sandstone,*	65′
44. *Stormville shales* mostly concealed,	225′
45. Limestone, gray, impure,	15′
46. *Stromatopora bed,*	3′
47. Shales and shaly limestone,	5′
48. Limestone, gray, shaly,	10′
49. Limestone, rather massive, filled with fossils, *Stromatopora, Zaphrentis, Favosites, Atrypa reticularis,* and *Orthis oblata* being most numerous,	25′

50. Shaly limestone, containing *flint nodules*, ... 10′
51. Limestone, massive, blue, fossiliferous, ... 15′
52. Limestone, containing *nodules of chert*, *Atrypa reticularis*, ... 20′
53. Impure, shaly limestones, filled with *Crinoidal fragments*, *Chaetetes*, and *Atrypa reticularis*, ... 25′
54. Shaly limestone, ... 5′
55. Limestone, massive, light gray, coarsely crystalline, quite pure, quarried, ... 10′
56. Limestone, dark blue, pure, also quarried, ... 25′
57. Blue limestone, not so pure, ... 15′
58. Shaly, thin-bedded limestones, blue, ... 15′
59. Massive, blue limestone, ... 5′
60. Blue, thinly-bedded limestones, rather pure, once quarried, ... 20′
61. Gray, shaly, impure limestones to base of exposures, . . 20′
62. Concealed and impure shaly limestones to base of *Lower Helderberg*, ... 150′
63. *Salina beds*, consisting of impure, buffish and pale green, magnesian limestones which make "Mulberry" ridge; below come green, limy shales, and variegated beds; these are succeeded by the *red beds* at base, the sandy portion of which makes "Redstone" ridge, through which the long tunnel of R. H. Powell & Co. has been driven to reach the *Clinton fossil ore*, ... 1050′
64. *Clinton* upper shales in tunnel about . . . . 350′
65. *Fossil ore* from 6 inches to, ... 2′
66. *Clinton middle shales*, including *Iron sandstone* and "*block ore*" at base, about . . . . 600′
67. *Clinton Lower shales and slates*, ... 400′
68. *Medina white sandstone.*

Summary of the section.

Catskill (IX,) Nos. 1–12 inclusive,			150′
Chemung and Portage, including 150′ of No. 31, extending to base of No. 33,			2588′
Hamilton,	Genessee,	200′	1535′
	Hamilton,	630′	
	Marcellus,	705′	
Criskany sandstone, (VII,)			65′
Stormville shale (VII–VI,)			225′
Lower Helderberg limestone, (VI,)			393′
Salina beds, (V, *b*,)			1050′
Clinton, (V, *a*,)			1454′
Total,			8205′

The Lackawaxen conglomerate at the top of this section rises from the bed of the Juniata at an angle of 38° to 40°, and makes a great cliff bordering the river hill for several hundred feet. The sharp curve in the river at the mouth of

Weaver's run, causes its outcrop to recross the river 350 yards above where it first emerges from it, and the massive character of the rock produces a fall in the river nearly one foot high. *The quartz pebbles* in this stratum are very numerous and some of them quite large, all being rounded and mostly flattish. *The Jasper pebbles* at this locality are all flat, and some of them an inch in diameter. *The fish bones* seen in this conglomerate here are mere fragments broken up by waves on a shore.

I have put the base of the *Catskill beds No. IX* at 100′ below this conglomerate, where the *red beds* end with No. 12; but the dividing line might have been lowered to No. 28, the lowest horizon at which any *red beds* were observed; thus adding 223′ to the total thickness of IX, and taking that much from the *Transition beds*, (IX–VIII,) leaving the latter only 575′ thick.

This *Lackawaxen conglomerate* (No. 4) is the same as the *Upper Chemung conglomerate* of Prof. Stevenson in Bedford and Fulton counties; and although it is so much thicker than the Lower conglomerate, (No. 32,) the latter makes the higher ridge.

The *Allegrippus Lower conglomerate* is finely exposed along the road leading to Cove Station, and large blocks from its pebbly bed cover the slope of the ridge facing the Juniata. Although only 4′–5′ thick, it makes a very prominent mark in the topography of the high Allegrippus ridge. Its pebbles are somewhat flattish, composed of snow-white quartz, and cemented into a matrix of very compact, fine sand. The summit of the ridge is covered with small, pebbly bowlders from it, and at many localities the whole bed juts out of the ground as a low wall, sloping 38° to 40°.

The thickness of the *Chemung and Portage beds* of this section was obtained by taking the breadth of outcrops from the county map.

The top of the *Genessee* comes at the big bend in the road near the township line, 125 rods south from Cove station. Here we see *black slates* filled with *Avicula speciosa*, and *Goniatites complanatus*.

The Hamilton Upper Sandstone (No. 25) makes a low ridge or hump along the lower portion of the slope which bounds the western base of Piney Ridge.

Under this come soft shales (No. 26) which have weathered away into a narrow valley extending to Cove station.

The H. & B. T. R. R. runs for more than a mile between Cove and Rough and Ready Stations on the bottom shales, just on top of the *Lower sandstone.* In their lowermost 5′ to 10′ occur great numbers of *fossil shells* among which univalves predominate. (See the list already given on page 111.)

The Hamilton lower sandstone (No. 27) rises at Cove station, on a dip of 40° to 45°, into a sharp, narrow ridge separating the *Middle shale* vale from the *Marcellus* valley to the west. The sandstone is quite hard, and some of the layers are 2′ to 3′ thick, and fossiliferous in thin streaks.

The transition beds to the *Marcellus* are mostly concealed at the top of No. 29, but this dividing line has been assumed because below this come the peculiar dirty gray, or on weathered surfaces whitish shales at the top of the *Marcellus.* With the *black slates* under them, these make a valley just west from the *Hamilton sandstone* ridge.

The limestones at the base of the *black Marcellus* are mostly flaggy, greenish gray and impure, with fossils named already on page 115.

The Oriskany sandstone is decomposed to a considerable extent on either side of the gap cut through Warrior ridge at this point by the little stream. But at ¼ to ½ mile in either direction it again becomes massive and carries Warrior ridge up to a prominent height above the valleys.

The Lower Helderberg limestone was once quarried here by the Kemble Coal and Iron Company, of Riddlesburg, Bedford county, but the quarries are now operated by R. H. Powell & Co. of Saxton. The strata numbered 45, 46 and 47, are the only portions quarried for flux, the other beds being too impure. These 50′ of rocks are quarried in a long trench, all the beds dipping 40° to 45° to the S. E.

The Stromatopora bed (No. 36) is entirely composed of large *Stromatopora concentrica.* (See page 123.)

All of the layers of limestone above No. 19 are rather impure, and none of them quarried, but all are crowded with fossils which appear to cease with No. 45.

No. 43 represents the *Bastard limestone* of Columbia and Montour counties, by the same assemblage of fossils and the same peculiar buffish gray cast of color.

No. 45 is largely made of *Crinoidal fragments*, but it is the purest rock in the entire series, being preferred for flux by the furnacemen to any other.

Nos. 46 to 51 represent the *Bossardville beds* of Monroe county, a series of very dark blue, thinly bedded, or flaggy limestones, nonfossiliferous, and here 100′ thick down to the bottom of the exposures, and probably 150′ further down. (See Report G[6].)

Fossil ore beds.

The Clinton formation, No. V, makes a narrow band of outcrop along the base of Tussey mountain and has been explored for *iron ore* at several localities in this township.

Just across the Bedford county line, near where the foregoing section ends, the *fossil ore* has been extensively mined by R. H. Powell & Co.

The ore is obtained through two tunnels, one 650′ long, the other 826′; the latter beginning in front of *Redstone ridge*, and the former just on top of it. The main headings have been driven north and south in these tunnels to a distance of more than 1700 feet.

The ore was found of fair thickness when the mines were first opened, but after the main gang-ways had advanced a considerable distance the ore became thin and irregular, and has so continued up to the present writing (December, 1883), though the headings are still being advanced in the hope that the ore will again thicken to workable proportions.

No section of the Cove tunnels could be obtained, since much of the material passed through was decomposed and had to be cribbed out of the tunnels so that no exposures could be seen. But two miles south-west from Cove, R. H. Powell & Co. have just completed what is known as "Stoler tunnel No. 2," and a very accurate measurement of it was made; the dip being 44° or 45°, and the thickness of strata B being calculated from the horizontal distance A.

Stoler tunnel, No. 2. (*Plate XXVII, page 132.*)

	A.	B.
1. Concealed through surface *débris*,	62′	43′
2. *Red rock*,	35′	25′
3. Bluish gray shales,	110′	77′
4. *Red shales*,	100′	70′
5. Olive shales,	86′	60′
6. Blackish clay (originally limy beds),	68′	48′
7. Olive and yellowish shales,	69′	48′
8. Blackish clay (decomposed limy beds),	117′	82′
9. Shales, olive and bluish-gray,	90′	63′
10. *Fossil ore*,		——
Total thickness of all the strata,		516′
Distance from base of *red bed* (No. 2) to *fossil ore*,		448′
Distance from base of *red shale* (No. 4) to *fossil ore*,		301′

The dividing line between the *Clinton* and *Salina beds* is assumed at about the middle of No. 3, making the thickness of Clinton beds above the *fossil ore* at this locality, say, ... 400′

Stoler tunnel, No. 3, is ¾ mile north-east from No. 2, and begins 20′ back from the massive red bed which makes Redstone ridge.

A trial shaft was once sunk just at the Bedford line near Cove station, on Warrior's ridge by R. H. Powell & Co. Some *brown hematite* ore was discovered imbedded in *blackish shales*, and the deposit was regarded by some as the *Marcellus ore*, but the horizon is entirely below the *Oriskany sandstone*, and comes in the dusky beds which are so often found near the base of the *Stormville shales*. The ore is of rather fair quality, and if found in sufficient quantity would be a valuable deposit to work in connection with the *fossil ores* of the *Clinton* just west from it.

The Clinton fossil ore has also been exploited to a considerable extent by R. H. Powell & Co., on the land of J. B. Weaver, one mile and a half north-east from Cove station. The main tunnel begins in the *Clinton upper shales* and passes through 50′ or more of the *Barree limestone beds* at the base of the *upper shales*. The section here is as follows, beginning at the school-house on the Huntingdon and Bedford pike, near Solomon Weaver's:

Weaver tunnel section. (*Plate XXVII, page 132.*)

1. Buffish and pale green, impure, magnesian limestones dipping S. 70° E. 40°,	Salina,	100′		
2. *Red shale,*		5′		
3. Buffish limestone, impure,		3′		
4. *Red shale,*		5′		
5. Pale green, limy shale,		10′		
6. *Red shale,*		8′		
7. Variegated shales (red and green,)		5′		
8. *Red sandstone, massive,*		25′		
9. Concealed to mouth of tunnel 450′, dip 40°,	300′		460′	
10. Concealed and blue limestone,	100′			
11. Shales, olive and gray,	50′			
12. Sandstone (ore SS.,)	10′			
13. *Fossil ore* hard calcareous,			6″-10″	
Total,				622
Distance from base of massive *red saudstone* (No. 8) to the *fossil ore,*			460′	
Distance at Stoler tunnel (as above),			448	

All the beds, Nos. 1 to 8, and 50′ to 75′ of No. 9, belong to the *Salina* (*Onondaga*) *series;* and this exposure gives a good illustration of the alternate *red* and *pale green* beds always found near the base of the magnesian limestones.

Two other tunnels, each about 75′ long, were driven into the ore 200′ west from the longer tunnel, but the ore was thin and hard in both.

Two slopes were also sunk on the ore 150′ distant from the tunnels; in one the ore was 14″ thick and not calcareous, but in the other it was thin and hard.

Some dark blue limestone was cut in the main tunnel belonging to the lower part of the *Barree* beds.

Shy Beaver creek drains the northern half of this township into the Raystown branch, and cuts almost squarely across the rocks past Rough and Ready station. The following section was made by careful pacing:

Shy Beaver section. Sheet No. Fig. 2.)

1. Concealed red shales and green sandstones, horizontal distance 420′, dip 35°,	240′
2. Sandstone, very massive, greenish-gray,	10′
3. *Red shale,*	6′

4. Shales and sandstone, horizontal distance 180',dip 35°, . 105'
5. *Red shale,* . . . . 8'
6. Sandstone, shales and concealed, ... 50'
7. LACKAWAXEN CONGLOMERATE, a coarse greenish sandstone, containing great quantities of rounded, flat pebbles some of which are *dark*, and others red (jasper); also *fish bones*, ... 10'
8. Sandy shales, mostly greenish, some reddish, dip 37°, ... 150
9. Sandstone massive, grayish white, ... 15'
10. Olive shales, greenish sandstones and concealed, 790', dip 37°, ... 475' } 900'
11. Sandstone, massive, greenish, ... 12'
12. Shales, olive green, green sandstone and concealed, 234', dip 37°, ... 140'
13. Olive shales, 180', dip 37°, ... 108'
14. ALLEGRIPPUS CONGLOMERATE, large flat pebbles, 0' 8''
15. Hard, sandy, fossiliferous beds containing many *crinoidal fragments* in lowest 75' and also *Productellas, Spirifers, Pterineas*, &c., 500', dip 37°, ... 300'
16. Concealed, 2600', dip 38°-40°, ... 1660'
17. Flaggy sandstones, and yellowish olive shales all *Portage beds*, but its base the lower limit of that series horizontal interval, 1000', dip 39°, . . . 620'
18. Concealed, including the *Genessee beds* at top and the *Hamilton Upper shale* below, 620 , dip 39°, . 385'
19. Concealed with some olive shales at top (Hamilton upper), ... 50'
20. Hard, sandy beds *Hamilton upper sandstone*, makes a low ridge, ... 55'
21. Concealed, soft shales (*Hamilton middle*), make valley, horizontal distance, 325, dip 39°, . . 200'
22. Hard sandstone, containing *Spirifera granulifera, Athyris spiriferoides, Rhynchonella sp? Hamilton lower sandstone*, makes ridge at Rough and Ready station, . 75'
23. Concealed, *Hamilton lower shale*, to base of *Hamilton* proper, dip 42°, . . . 100'
24. *Marcellus gray shales*, with interstratified hard layers, 250'
25. *Black slates*, with limestones at base, dip 42°, ... 350'
26. *Oriskany sandstone*, ... 70'
27. *Stormville shale* (concealed), ... 200'
28. Impure limestone, a ledge at top containing *chert* and *stromatopora*, ... 75'
29. *Stromatopora bed*, makes cliff, ... 8'
30. Gray limestone and concealed, ... 50'
31. Blue limestone, good, ... 25'
32. Limestone, and concealed to base of *Lower Helderberg series* proper, dip 40°, ... 250'
33. Pale buffish, magnesian beds, *upper Salina*, dip 40°, . . 230'
34. Massive, buffish limestone, impure, makes a low ridge, . 20'
35. Gray pale green and buffish tinted, magnesian limestones, 265'

36. Buff, impure, sandy limestones and pale green shales; these beds make the summit of Mulberry ridge, 180′
37. Concealed, pale green shales, impure limestones, and variegated beds, ... 250′
38. *Red sandstone*, makes summit of Redstone ridge, . . . 25
39. Concealed and olive shales, ... 150′
40. *Red shales*, ... 35′
41. Olive shales and concealed, ... 225′
42. *Ore sandstone*, ... 10′
43. *Fossil ore*, ... 1′
44. Concealed and *middle olive shales* dipping 60°-75°, visible for . . . . 300′

Summary of the section.

Catskill beds (IX), Nos. 1-8 inclusive,			579′
Chemung-Catskill (VIII-IX), Nos. 9-12 inclusive,			642′
Chemung and Portage, Nos. 13-16 inclusive,			2689′
Genessee, No. 17 in part,			200′
Hamilton, the rest of No. 17-22 inclusive,			665′
Marcellus, Nos. 23-24 inclusive,			600′
Oriskany sandstone (VII), No. 25,			70′
Stormville shales (VI-VII), No. 26,			200′
Lower Helderberg (VI), Nos. 27-31 inclusive,			408′
Salina,	Upper magnesian limestones, Nos. 32-35,	695′	1070′
	Middle shales, variegated beds, No. 36,	250′	
	Lower red beds, Nos. 37+100′ of No. 38,	125′	
Clinton,	Upper shales, 50′ of No 38 and Nos. 39-40,	310′	621′
	Ore sandstone, No. 41,	10′	
	Fossil ore, No. 42,	1′	
	Middle shales and slates visible, No. 43,	300′	
Total rock thickness,			7744′

The measurements through the *Chemung* and *Portage beds* as well as the *Chemung-Catskill* portion of this section are not strictly accurate, since Shy Beaver creek cuts obliquely across the strike of the measure, at angles varying from 10° to 15°, and in the reduction of the section to a course at right angles with the strike some errors would necessarily be made, though they cannot be large. It is possible that I have made a little too much allowance for the oblique direction of Shy Beaver, and that the measurement through the *Portage*, *Chemung* and *Chemung-Catskill*, should be increased by 200 or 300 feet of rocks.

The conglomerate, No. 7, certainly represents the *upper conglomerate* of Stevenson in Bedford and Fulton (T²).

The Allegrippus conglomerate, No. 14 (lower of Stevenson), is only 8″ thick where exposed along the Shy Beaver road; but its thickness is quite variable and it may be 4 or 5 feet thick at as many rods distant from the exposure. It is a mere mass of white quartz pebbles cemented into a matrix of grayish-brown sand. It lies 900′ below the *Lackawaxen conglomerate*, and I regard it as identical with a conglomerate in the eastern counties lying 50′ to 100′ below the top of the *Chemung formation proper*.

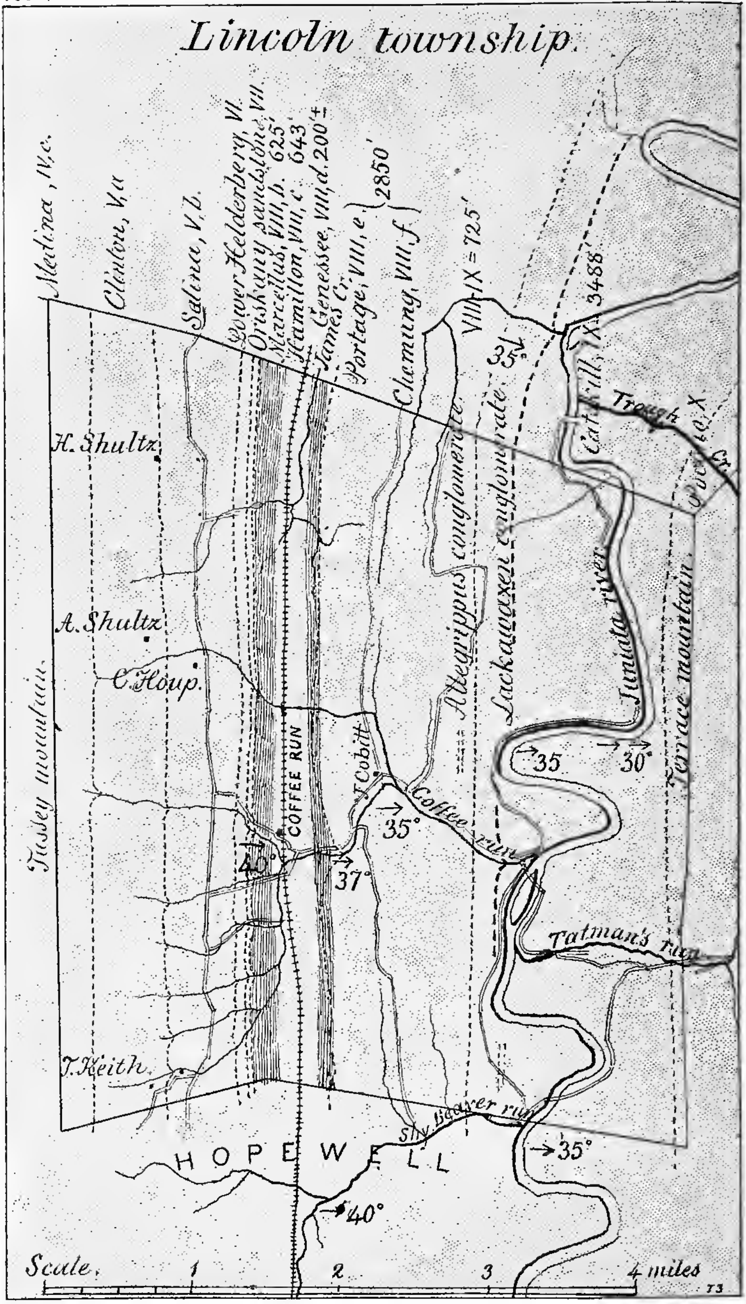
The Portage beds, No. 16, including 400′ or 500′ of the concealed interval No. 15, are a series of yellowish, sandy shales, interstratified with hard, grayish-brown, thin layers of sandstone, in all not far from 1000′ thick. Being much harder than the *Hamilton series* beneath (west), the *Portage* cliffs rise abruptly into a high ridge generally called Piney ridge, which borders the eastern line of the *Hamilton* (valley) *outcrop* all the way across this township, and by which one can easily decide, even when the outcrops are covered up, where the dividing line between the *Portage* and *Genessee* should be placed.

The Genessee was not seen in this section, its rocks being completely concealed, but in the general section I have given it a thickness of 200′. This is possibly too large, but if so, the extra thickness deducted would be added to the *Hamilton proper*, immediately below, so that the entire thickness of the *Hamilton group* would remain the same, viz: 1465 feet.

The Hamilton upper and lower sandstones make ridges on either side of Shy Beaver creek, the *lower* being the more massive, and making the ridge at the high trestle just south from Rough and Ready station.

In the *Marcellus* valley, except along the road cuttings, the outcrops are entirely concealed by sandstone rubbish which has slid down over the *Marcellus* from the slope of Warrior ridge.

The Oriskany sandstone (*VII*) could not be accurately measured in the gap of Shy Beaver through Warrior ridge, since the rock is very much decomposed at its crop, and its contact with the underlying *Stormville shales* is indefinite, though the thickness I have assigned (70′) cannot be more


Lincoln township.
Medina, IV, c.
Clinton, V, a
Salina, V, b.
Lower Helderberg, VI.
Oriskany sandstone, VII
Marcellus, VIII, b. 625'
Hamilton, VIII, c. 643'
Genessee, VIII, d. 200'±
James Cr.
Portage, VIII, e
2850'
Chemung, VIII, f
VIII-IX = 725'
Catskill, IX. 3488'
Pocono, X
Trough Cr.
H. Shultz
A. Shultz
C. Houp.
T. Keith
Tussey mountain
COFFEE RUN
J. Cobitt
Coffee run
Allegrippus conglomerate
Lackawaxen conglomerate
Juniata river
Terrace mountain
Tatman's run
Shy Beaver run
HOPEWELL
35°
35
30°
35°
37°
40°
35°
40°
Scale. 1 2 3 4 miles
T3

than 20′ in error. The ridge on each side of the Shy Beaver gap has a height of 300′ to 400′ above the water.

The Lower Helderberg limestone (*No. VI*), quite well exposed in the gorge, was once extensively quarried as a flux for Rough and Ready furnace, one mile east. The only beds of the section pure enough to quarry were No. 30, and the basal part of No. 29.

The Salina (*Onondaga*) *series* (*No. Vb*) I make begin with the pale green, and buffish nonfossiliferous, magnesian beds of No. 32. This gives to the formation its regular upper magnesian limestone, middle variegated, and lower *red* divisions, and the same thickness (1070′) as (1175′) east of the Susquehanna. The bottom part of the uppermost sub-division (No. 35) is *sandy limestone.* Some of the beds are almost *sandstones.* These make the low irregular rolling *Mulberry ridge* which runs through the middle of the Onondaga valley ; while the sandy *red beds* near the bottom of the *formation* make the sharp *Redstone ridge.*

The "soft block" fossil ore bed, 1′ to 1½′ thick, and rich, was once mined by stripping, or sinking short slopes along the outcrop, on the land of Mr. Smith, 1000 feet west of the turnpike, for Rough and Ready furnace.

About one mile north-east from Cove station, a branch of the west fork of Shy Beaver creek cuts through the *Hamilton lower sandstone* ridge across the railroad, showing the following section: (See Sheet 2, Fig. 4.)

West fork of Shy Beaver section.

1.	*Portage flags.*	
2.	*Genessee and Hamilton upper shales,*	470′
3.	*Sandstone, Hamilton upper,* makes low ridge, dip 40°, .	35
4.	Concealed, soft shales (Hamilton middle), ...	225′
5.	*Hamilton lower sandstone,*	50′
6.	Sandy shales, and shaly sandstones, ...	25′
7.	Grayish white shales interstratified with thin sandstones,	150′
8.	Concealed, ...	200′
9.	Black slate, ...	200′
10.	Concealed, limestones and shales, ...	125′
11.	Oriskany sandstone.	

Summary of section.

Genessee, about	200′	1480′
Hamilton proper to base of No. 6,	605′	
Genessee, Nos. 7-11,	675′	

This gives for the three sections of the whole *Hamilton group* in Hopewell township a thickness of 1465′, 1550′ and 1480′, the average of which, 1500′, cannot be far wrong.

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2. *Lincoln.*

This township lies next north of Hopewell, between Tussey and Terrace mountains. The Raystown branch flows along its eastern side at the base of Terrace mountain, receiving the drainage of the township through Coffee run and its branches. One of its curves, just below the mouth of Coffee run, cutting into the base of Terrace mountain, nearly to the top of the *Catskill formation* (*No. IX*), gives, together with Coffee run, the following section: (See Sheet No. 2, Figs. 3 and 6.)

Coffee run section.

1.	*Pocono sandstone No. X.*	
2.	Concealed, (No. X, and top of No. IX,)	600′
3.	*Red beds*, mostly shales, some sandstone, dip 30°,	1270′
4.	Sandstone, massive, greenish-gray,	10′
5.	Concealed,	15′
6.	Sandstone, massive, reddish,	10′
7.	*Red shale* and sandstones,	115′
8.	Sandstone, massive, greenish-gray,	25′
9.	Shaly sandstone,	20′
10.	Sandstone, massive, greenish,	10′
11.	*Red shale* and red, shaly sandstone,	17′
12.	Sandstone, massive, grayish-green,	20′
13.	*Red shale,*	15′
14.	Reddish-gray sandstone and *red shales,*	20′
15.	Concealed,	10′
16.	Reddish-gray, massive sandstone,	20′
17.	*Red sandstone* and *shales,*	40′
18.	Olive, sandy shales, and sandstones *fossiliferous*, containing *crinoidal fragments*, *Spirifers* of the *disjuncta* type, and other fragmentary forms,	115′
19.	*Spirifer bed* (*S. disjuncta*,)	1′
20.	Concealed, olive and greenish shales, with *red beds* at base, dip 35°,	300′
21.	Sandstones, greenish shales, and concealed,	220′

22. Green sandstones, olive shales and *red beds*, ... 525'
23. *Conglomerate, Lackawaxen, (Upper,)* a very hard, dark gray rock, some portions of which are filled with *flat quartz pebbles*, ... 10'
24. Sandstone, rather massive, not pebbly, ... 15'
25. Concealed, and *red shales* to base of *Catskill*, ... 85'
26. Olive beds, green sandstones, and *red shales* to lowest *red beds* seen, . . . 475'
27. Concealed, olive shale, and thin fossiliferous shales, containing the *Allegrippus (Lower) conglomerate* at about 400' below the top, and extending for 3330' with dip of 35° to forks of road near J. Cobitt's, . . 1900'
28. Olive and yellowish shales, and flaggy sandstones to base of *Portage beds*, 2000', dip 37°, ... 1200'
29. Concealed and black slates (*Genesee*,) . . . . 110'
30. Concealed and olive shales (*Hamilton upper*,) . 165'
31. Hard, sandy beds, *fossiliferous*, making low ridge, dip 39°, 30'
32. Darkish, soft shales (*Hamilton upper*,) . . . 160'
33. *Sandstone, Hamilton Upper*, makes ridge, contains *Spirifera mucronata, S. granulifera*, and *crinoidal fragments*, ... 28'
34. Concealed in valley (*Hamilton middle shales*,) . . . . . 200'
35. *Sandstone*, massive, *Hamilton lower*, . . 50'
36. Sandy shales, (*Hamilton lower*) to base of *Hamilton* at Coffee run station, . 100'
37. *Marcellus* grayish and dirty white shales and concealed, 250'
38. *Black slate*, dip 40°, ... 300'
39. Impure *limestone* and limy shales, ... 35'
40. Concealed, ... 40'
41. *Oriskany sandstone*, ... 60'
42. *Stormville shales*, ... 200'
43. *Lower Helderberg limestone*, impure beds and concealed, 50'
44. Buffish-gray, (*Bastard L. S.*) fossiliferous limestone, 20'
45. Gray, crystalline limestone, good, ... 8'
46. Blue limestone, pure, ... 20'
47. Bluish-gray, impure beds, ... 30'
48. Concealed to base of *Lower Helderberg beds* about . 250'
49. *Salina beds*, buffish, impure, magnesian limestones, pale green shales with *red beds* at base, making Redstone ridge, 1000' north-west from Huntingdon and Bedford pike, ... 1150'
50. *Clinton upper shales*, &c., ... 350'
51. *Fossil ore*, 6''–18'', ... $1\frac{1}{2}$
52. Middle shales with *Iron sandstone*, and "*Block*" *ore* at base, ... 600'
53. *Clinton lower shales*, ... 400'

Summary of the section.

Catskill beds, (IX,) . . . . 3488'
Chemung-Catskill VIII-IX, No. 26, and 250' of No. 27, . . . 725'
Chemung and Portage, (1650') of No. 27, and No. 28, ... 2850

Hamilton, Nos. 29-40.	Genesee,	200′	1468′
	Hamilton,	643′	
	Marcellus,	625′	
Oriskany (No. VII,)			60′
Stormville shales,			200′
Lower Helderberg limestone (No. VI,) (Nos. 43-48,)			378′
Onondaga Salina (No. V b,) (No. 49,)			1150′
Clinton (No. V a,)	Upper shales,	350′	1351′
	Fossil ore (6″ to 1′ 6″),	1′	
	Middle shales and "Block ore,"	600′	
	Lower shales and slate,	400′	
Total thickness of the section,			11,670′

Some of the measurements were taken by scale from the county map in places where the creek flows along the strike or not at right angles to the same. The total horizontal length of the section measured on the township map at right angles to the strike is 18,500′. The dips are 40° through the lower half, and only about 35° in the upper portion. Assuming an average dip of 37° the thickness of the entire series ought to be 11,100′.

No. 2 interval is simply an estimate from the outer margin of the great curve in the river below Coffee run bridge up to where the *Pocono conglomerate* crops out in a cliff from the mountain nearly vertically above the river.

This is the only locality within that portion of Huntingdon county surveyed by me where the *Catskill (No. IX)* beds could nearly all be observed in detail, and hence more than ordinary interest attaches to that part of the section.

The main mass of the *red beds* begins at No. 20, and some geologists would doubtless place the base of the *Catskill beds* there, cutting off 855′ from the latter and leaving only (3388′-855′ =) 2533′ for the thickness of the *Catskill beds*, thus increasing the *Chemung and Portage* by 855′+725′ (VIII-IX), giving these rocks a thickness of (2850′+855′+725′) 4430′; results not far from those given by Rogers, Stevenson, Ashburner, and all those who have previously studied the rocks of this region. (See this discussed on pages 90, 91, above.)

No. 23, *the Lackawaxen conglomerate*, makes a bold cliff along Coffee run, rising in long ledges far up toward the hill tops. It contains many *flat quartz pebbles* and an occasional *red one* (jasper), some fragments of shale, and some pieces of *fish bones*.

No. 27, *the Allegrippus conglomerate* was not seen in place, but many pieces of its very pebbly layers lie scattered over the surface at about 400 feet below the top of No. 27. This puts it 1000′ beneath the *Lackawaxen conglomerate.*

The Chemung and Portage rocks are made nearly 200′ thicker here than in Hopewell township; but it is possible that they have been slightly overestimated.

The Hamilton group foots up 1468′, which is very close to the average thickness in Hopewell township.

Three Hamilton sandstones appear here on Coffee run instead of the usual number, two; and each one makes a separate ridge along the strike (N. 25° E.). The *lower sandstone* being thicker and more massive than either of the other two, makes much the highest ridge, running along nearly parallel with the railroad and just east of it at Coffee Run station.

The Hamilton lower shales, beneath this sandstone, have been largely quarried at Coffee Run station for the deep fill across the valley of the stream. In these shales, just south of the station, were seen *Spirifera granulifera*, *Tropidoleptus carinatus*, *Rhynchonella sappho*, *Lingula densa*, and several other characteristic *Hamilton* forms.

The Marcellus shale begins near the railroad and makes a valley across to the foot of Warrior ridge. It is seen fairly well exposed along the lane which leads north-westward from the railroad to the pike, just west of Coffee Run station, and here the section was measured.

No. 39. This limestone makes a low elevation in ground just before we reach Warrior ridge. It is impure, of a bluish-green color, and slightly fossiliferous, species of *Ambocœlia* being most numerous.

The Oriskany sandstone is not exposed in cliffs on Coffee run, but large blocks of it are scattered over the eastern slope of Warrior ridge.

The lower Helderberg limestone crops out on the western slope of the ridge, and has been quarried and burned to a considerable extent north of Coffee run station by Mr. Jno. Donaldson, principally for local supply on the surrounding farms. Only 28′ to 30′ of the beds can be used in burning (Nos. 45 and 46), the others being shaly and magnesian.

No. 44. *The Bastard limestone* of Columbia and Montour counties seems to be represented here by a buff colored rock, containing *Atrypa reticularis*, *Strophomena rhomboidalis*, *Rhynchonella formosa* and many small branching corals, principally *Chaetetes*, *Cladopora* and other forms.

The hard, impure limestones near the center of the *Onondaga* (*Salina*) *formation* (No. V b) make the well-defined Mulberry ridge across this township. Its middle portion runs near the pike north from Coffee Run station. The hard, sandy, *red beds* near its base make the Redstone ridge about 1000′ north of the pike.

At a distance of 1575′ from the pike runs another ridge, apparently made by the *Clinton ore sandstone*, although the ore itself has not been opened in this vicinity.

West from this ridge the surface rises gently, everywhere so littered up with *débris* that no rocks are seen in place until at 3500′ from the Bedford pike (at 1375′ A. T.), the top beds of the white *Medina* (*No. IV*) appear, and a steep rocky slope ascends to the summit of Tussey mountain.

The *Pincher* (or *Fouse*) *tunnel*, near the northern line of the township, was driven into the mountain after the block ore. Mr. Edward McHugh, the superintendent, took notes of the rocks cut in the tunnel and has kindly furnished me with the following account of them: (See Plate XXVII, p. 138.)

Pincher (*Fouse*) *tunnel section.*

1. Loose *débris*, timbered, (180′; dip 35°),	103′
2. Yellow, blue, and greenish shales interstratified with occasional "spars" or hard sandy layers (525′), . . .	300′
3. Gray sandstone (7′), ...	4′
4. "Bogus iron ore" (*iron sandstone*), ...	5′
5. Slate and "spars," and hard gray sandstone, . .	6′
6. *Iron ore*, very hard and lean, analyzing only 22 per cent of metallic iron (9′ 2″), ...	5′
7. Slate and clay mixed with "spars,"	7′
8. Gray sandstone with seams of slate (14′; dip 35°), . .	8′

9. Hard lead-colored slate (16½'),	9'
10. Clay and slate (1'),	¼'
11. Gray, hard sandstone (40' 6"),	23'
Total cross thickness of the beds cut,	470'

The *Lincoln fossil ore bed* crops out about 400' feet below (east from) the entrance to the tunnel, and was once mined there in two or three drifts, though the ore was only 10" to 12" thick.

The *block ore bed* in the tunnel is nothing but very ferruginous sandstone. This is the only place which I have seen where the *Clinton middle* shales could be rather accurately measured, and the result (600') may be accepted with much confidence; since the *fossil ore* crops out directly east of the tunnel, and the interval was carefully paced. According to Mr. McHugh, the *block ore* crops out 1200' up the mountain side from the mouth of the tunnel, 384' vertically above it.

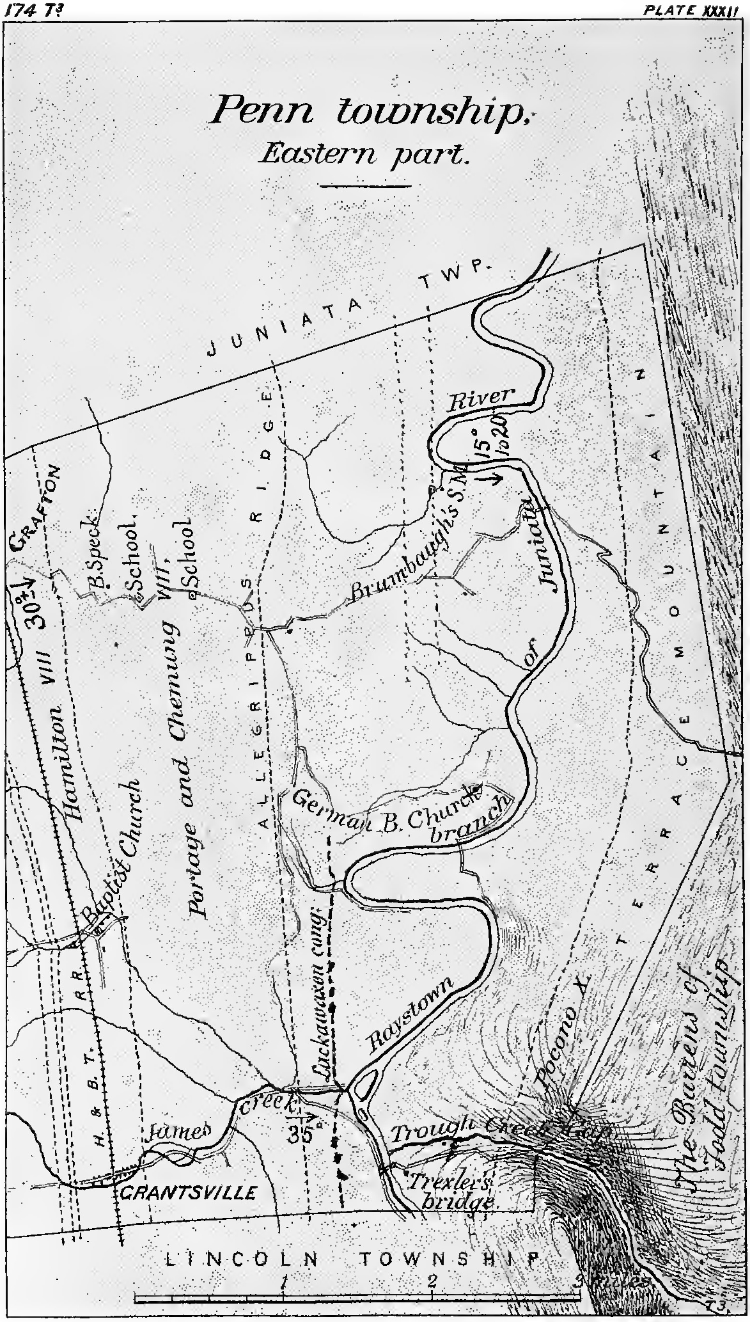
The fossil ore has been exploited at several localities in this township.

At Mr. Keith's opening, near the Hopewell township line, it was 8" to 10" thick.

On Mr. Anthony Shultz's land, where it was once mined both by stripping and by tunneling, and hauled to Paradise furnace in Todd township, it is reported 10" to 12" thick, occasionally thickening to 15". The fragments of ore seen about the entrance to the old drift seem quite rich in iron.

The "Kittie Houp land" is the only promising ore tract in this township. Like all the other *ore tracts* in the township it is owned by R. H. Powell & Company. Some test holes and drifts sunk on the Houp land show 12" to 14" of excellent ore; and as there is a lift of nearly 200', and a run of ore 1200' to 1500' long, it may prove to be valuable property, the only fear being that the *ore* will get *hard* or *limy* when prospected further below the surface, which is the tendency of all the *fossil ore* yet dug in this township.

The company have recently driven a trial tunnel on the land of Mr. Henry Shultz, one mile from the Penn township line, 120' long to the *fossil ore*, and headings 200' north and 50' south; but the bed proved thin, lean, and faulty.


Penn township,
Eastern part.
JUNIATA TWP.
GRAFTON
30°±
B.Speck
School
VIII
School
Hamilton VIII
Portage and Chemung
ALLEGRIPPUS RIDGE
Brumbaugh's S.M.
River
15° to 20°
Juniata
of
TERRACE MOUNTAIN
Baptist Church
German B.Church branch
H. & B. T. R.R.
Lackawaxen cong.
Raystown
Pocono X
James creek
35°
CRANTSVILLE
Trough Creek Gap
Trexler's bridge
The Barrens of Todd township
LINCOLN TOWNSHIP
1
2
3 Miles

This tunnel was driven in 180′ *beyond the fossil ore* with the mistaken expectation that the dip would change and the ore come down to be cut a second time. The 180′ was driven through bottom shales, which only exhibited a slight roll, not enough to bring the ore down to the level of the tunnel.

The *Marcellus beds* are frequently seen in the cuts of the railroad entirely across the township.

The *Pocono rocks* are finely exposed along the gap of Totman's creek through Terrace mountain, consisting principally of massive gray sandstones and conglomerates.

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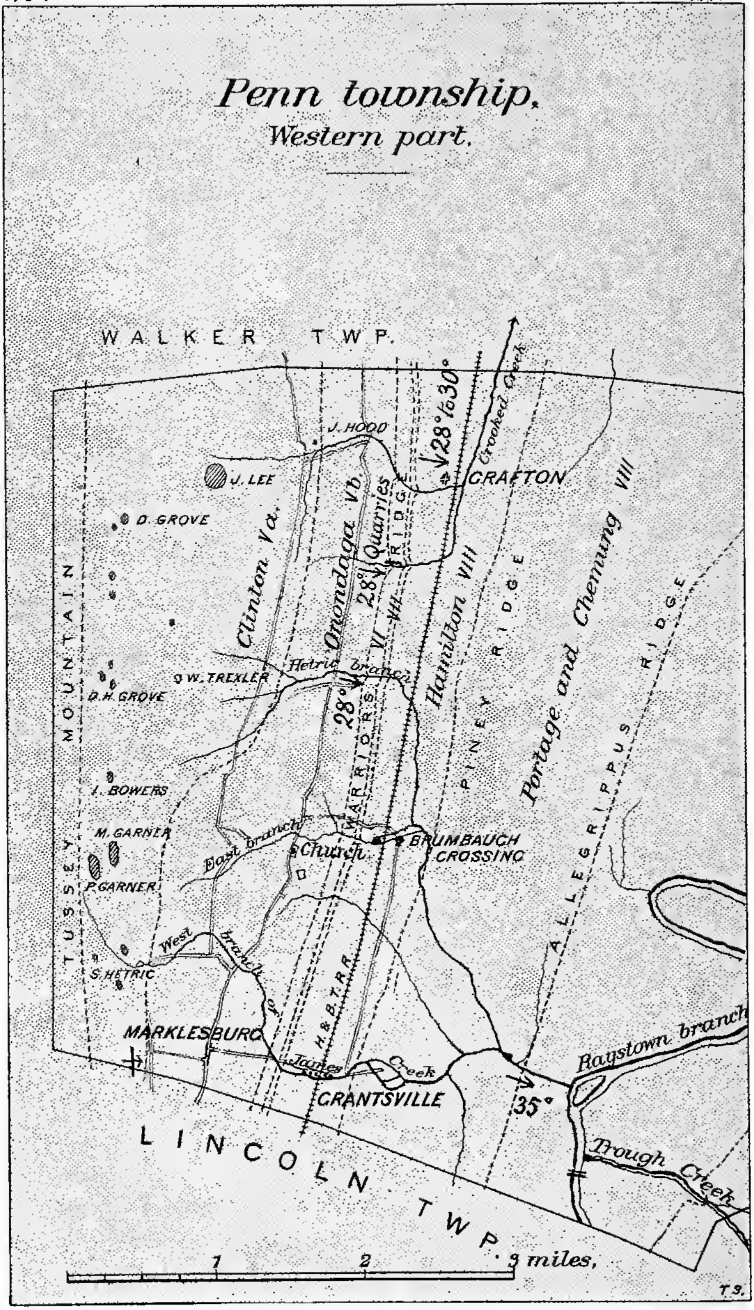
3. *Penn.*

This township is a large area lying next north from Lincoln, extending from the summit of Tussey mountain to that of Terrace mountain here (owing to the dip) getting farther and farther apart, viz: 1400 rods at the Lincoln line, and 2400 at the Walker-Juniata line.

The *Raystown branch* still keeps its course north-eastward along the base of Terrace mountain, through this township, confining its extraordinary bends to the *Catskill belt*. *James creek* cuts across the formations near the southern line and *Trough creek* completes the section by a deep gap through Terrace mountain. (Sheet No. 2, Fig. 7.)

Trough creek and James creek section.

1. Massive sandstones and conglomerates holding some thin *streaks of coal* near the top, in Terrace mountain, 600′
2. *Shoup's run shales;* dark; very *fossiliferous* in lowest 25′, *Spirifera*, *Rhynchonella*, and *Productus* forms being very numerous, ... 100′
3. Massive sandstones and transition beds down to top of No. IX, ... 600′
4. *Catskill rocks*, mostly *red beds*, make a gentle topography and are therefore largely made up of shales, except in upper portion where some sandstones are found, . . . 2000′
5. Concealed to north end of Trexler's bridge, ... 1200′
6. Green sandstones, *red*, and olive shales (dip 30° to 35°), 627′
7. *Conglomerate*, *Lackawaxen* (upper), coarse, and very pebbly in upper half, more flaggy sandstone below (dip 35°), ... 15′


Penn township.
Western part.
WALKER TWP.
LINCOLN TWP.
TUSSEY MOUNTAIN
J. HOOD
J. LEE
D. GROVE
W. TREXLER
D.H. GROVE
J. BOWERS
M. GARNER
P. GARNER
S. HETRIC
MARKLESBURG
GRANTSVILLE
CRAFTON
BRUMBAUGH CROSSING
Church
Clinton Va.
Onondaga V b.
Quarries
28°
28° to 30°
VI VII
WARRIORS RIDGE
Hamilton VIII
PINEY RIDGE
Portage and Chemung VIII
ALLEGRIPPUS RIDGE
Crooked Creek
Hetric branch
East branch
West branch
of
James Creek
H.&B.T.R.R.
Raystown branch
Trough Creek
35°
1
2
3 miles.
T.S.

8.	Concealed to base of *Catskill*,	100′
9.	Olive shales, and *red beds* alternating (VIII-IX),	655′
10.	Concealed (*Chemung* and *Portage rocks*), 5000′ (dip 35°),	2850′
11.	Dark, slaty beds (Genessee) and concealed Hamilton upper shales),	350′
12.	Sandy, and limy, hard beds (Hamilton upper sandstone), *fossiliferous*, containing *Spirifera ziczac*, *Atrypa reticularis*, *Fucoids*, and many crinoidal fragments,	38′
13.	Soft, dark olive shales (Hamilton middle),	275′
14.	*Hamilton lower sandstone*, quite massive, makes steep ridge,	75′
15.	Concealed (*Hamilton lower shales*),	75′
16.	*Marcellus beds* to H. & B. T. R. R. at Markleeburg station,	450′
17.	*Marcellus slates*, limestones near base,	250′
18.	*Oriskany sandstone*,	50′
19.	*Stormville shales*,	225′
20.	*Lower Helderberg limestone*,	350′
21.	*Salina beds*,	1050′
22.	*Clinton upper shale*,	350·
23.	*Fossil ore*,	1′ to 2′
24.	Middle slates, with iron sandstone, and *block ore* at base,	600′
25.	Lower slates,	400′
26.	*Medina sandstone* in Tussey mountain.	

Summary.

X.	*Pocono and transition beds* (Nos. 1 to 3),			1300′
IX.	*Catskill beds* (Nos. 4 to 8),			3942′
VIII.	*Chemung-Catskill beds* (No. 9),			655′
	Chemung and Portage (No. 10),			2850′
	Hamilton,	Genessee,	200′	1513′
		Hamilton,	613′	
		Marcellus,	700′	
VII.	*Oriskany sandstone*,			50′
	Stormville shales,			225′
VI.	*Lower Helderberg limestone*,			350′
V.	*Onondaga* (*Salina*) beds,			1050′
	Clinton,	Upper shales,	350′	1352′
		Fossil ore,	1′-2′	
		Middle shales and "Block" ore,	600′	
		Lower shales,	400′	
Total of strata X to V,				13,267′

1. The uppermost beds of the *Pocono* in this section were obtained just across the line, in Todd township, in immense cliffs along the gorge of Trough creek.

2. These shales are finely exposed along a cutting in the road which descends Trough creek, a few rods south from the Penn-Todd line; usually dark gray; at times nearly *black*; the bottom part so filled with the remains of

Brachiopods and other marine organisms that some layers become impure limestones.

3. The basal portion of the *Pocono beds* in this section could not be clearly separated from the *Catskill* beds under them, on account of *débris* from the cliffs. Perhaps 100′ or 200′ should be taken from the *Catskill* (IX) and included in the *transition beds* (X-IX) above it.

4. This wide *soft red shale belt* along the Raystown branch is conspicuous in all the ploughed fields along the river.

7. *The Lackawaxen conglomerate* rises from the bed of James creek about 300′ above its mouth, and getting up the steep hill-side at an angle of 35° makes a high ridge overlooking the river. The rock has the following structure from top downward: massive conglomerate and fish bone rock 3′; shaly sandstone 5′; massive sandstone 7′; total 15′. The uppermost portion is a perfect mass of quartz, pebbles, pieces of slate, and some *fish bones*. No *jasper pebbles* were observed here.

The *Allegrippus conglomerate* (which I put 100′ to 200′ beneath the top of the *Chemung*) should come in the concealed interval from No. 9, down for several hundred feet.

The *Marcellus rocks* make a valley at Marklesburg, which the railroad follows across the township.

The *Oriskany sandstone ridge* (Warrior's ridge) is gapped by James creek above Marklesburg station and slowly recovers its height north and south from the creek.

The Lower Helderberg limestone is seen cropping out all along up James creek to where the road crosses that stream, at the southern line of Marklesburg borough. Here the *Salina beds* begin and extend west for 250 rods. This unusual breadth of outcrop belt is due to the fact that three or four low anticlinal axes make these rocks roll at the foot of Tussey mountain.

The Clinton ore, both *fossil* and *block*, were once mined quite extensively in the vicinity of Marklesburg. The Cambria Iron Co., of Johnstown, formerly got ore here. Mr. Gundry (the mine-boss for the Cambria Co. while they were engaged in shipping iron ore from Marklesburg,) informed me that one of the tunnels (the one below the Williamsburg pike) is 673′ long; that the dip is 45° to 50°; that the *block ore* bed at the end of the tunnel was 3′ to 4′ thick, and that it yielded to an analysis by T. T. Morell: Iron, 44.25; Silica, 27.91; Alumina, 2.66; Lime, 0.22; Magnesia, 0.26; Phosphorus, 0.68.*

The upper tunnel above the road, on the *block ore*, at Marklesburg, passed in through the measures for 139′, and found the ore very much the same as in the lower tunnel.

The fossil ore bed has been extensively mined in the vicinity of Marklesburg, on the lands of Messrs. Hetric, Garner, Bowers, and others. On the Isaac Bowers land, one mile and a half east from Marklesburg, many thousand tons of ore have been mined by Grove Bros., of Danville, Pa., and shipped to their furnaces there. The bed rises and falls in four low waves, emerging at last to the surface far up on the mountain, and these rolls add much to the extent of the mining area, making it 250′ to 300′ wide on the Bowers tract, reckoning from the outcrop to the greatest practicable depth below the surface. The ore on this tract varies from 1′ to 2′ in thickness, and is a quite rich *soft block*, comparatively free from lime. A considerable quantity of ore still remains on the Bowers tract, owned by Grove Bros.

Just south from the Bowers tract and adjoining it, Mr. Andrew B. Franks owns the *fossil ore* for 156 rods. A trial tunnel 55 yards long found the bed 10″ to 12″ inches thick, overlaid by 9′ of hard *ore sandstone*; but with a dip of 60°, so that there is only a breast of 30′ to the surface; and the bed does not come down again, as it does in the rolls on the Bowers tract. Elevation of tunnel mouth 1175′ A. T. Mr. McCreath's analysis of two pieces showed iron, 55.550; phosphorus, 0.580; siliceous matter, 7.910.

By beginning a tunnel in front of "Redstone ridge"

[*Twenty years ago I examined an open cut on this ore when first opened, and measured it across. As I recollect it, the whole bed was thirty-four feet thick (34′,) the upper and lower parts being a deep red, highly ferriferous sandstone, and in the middle was a stratum of solid ore between 5′ and 6 thick. It was then known by the workings to the east of it that this was an exceptional thickness.—J. P. L.]

near the southern end of the Franks property a very large strip of the *fossil ore* would be accessible, 400′ to 500′ wide and 156 rods long; but how much of it would prove *valuable ore* cannot be known. On the neighboring farms to the south, where the bed has been struck in long tunnels under deep cover, the bed is thin and the ore hard. A tunnel here would be 300 yards long.

Fossil ore.—At 15 rods south from Mr. Franks' tunnel, Grove Bros. attempted to drift into the mountain to the *fossil ore* a few yards north from where its outcrop is seen on the Franks tract, but the hump on the mountain which was supposed to be the "*ore ridge*" proved to be only a heap of Medina sandstone rubbish from the steep slope above, and the drift was abandoned at 50 yards.

At 125 rods south-west from Mr. Franks' tunnel, and 250 feet north of Franks' line, Grove Bros. have taken a considerable quantity of *fossil ore* from the Ocker tract, reaching it by a tunnel 55 yards long at an elevation of 1275′ A. T. The *main ore bed* was 15″ to 20″ thick; back of it lay *soft fossil ore* 6″ to 8″ thick; both were taken out together. Nothing has been done at these workings for several months, but a considerable quantity of ore yet remains to be mined on this tract.

Just south-east from Mr. Franks' ore tract runs Redstone ridge, 825′ from the outcrop of the *fossil ore.* As the dip is 60° in his tunnel, the interval (825′) would indicate the existence of a small roll; but if there be one, it is not large enough to bring the *fossil ore* near enough to the surface to work.

This was demonstrated by a tunnel on the Bowers tract, which began 400 feet in front (south-east) of the *fossil ore.* The operator expected to strike a roll and get the ore at 40 to 50 yards; but the roll proved to be so gentle that the ore lay 150′ below its crest, and the tunnel was abandoned.

On the south-east side of the Redstone ridge (which runs 825′ from the *fossil ore* outcrop) four small rolls repeat the ridges seven times before we come to the last one, at the turnpike near J. Mattern's. Thus, *eight distinct Redstone ridges* exist within a breadth of one half mile, representing eight outcrops made by four anticlinals. But these rolls flatten out very fast to the south, for just beyond Mr. Mattern's the limy shales of the *Middle Salina* arch over them, and make a broad, flat plain, extending back to the foot of the mountain, where the only remaining *Red ridge* outcrop runs; and this state of things continues to the southern township line.

The following section was measured along the road which leads north-westward past Mr. Andrew Franks', from the railroad to the turnpike:

Section at Andrew Franks'.

(1.)	*Marcellus beds*, concealed, about	500′.
(2.)	*Oriskany sandstone*, ...	50′
(3.)	*Stormville shales* and *Lower Helderberg limestone*, dip 28°, S. 60° E.; horizontal dist., 1,170′, . .	540
(4.)	*Upper Salina beds*, buff, and pale greenish magnesian limestones, dip 28°; distance 1,220′, . .	570′
(5.)	*Middle Salina shales* to Bedford pike, hor. dist. 400′; dip 28°, ...	185′

The Stormville shales make up about 200 feet of interval No. 3, leaving say 340′ for the thickness of the *Lower Helderberg limestone* proper. *Brown hematite iron ore* occurs scattered over the ground near the base of No. 4, or in the vicinity of "Mulberry ridge," and it is possible that a considerable body of it could be found, for nuggets of 100 pounds' weight lie on the surface. Mr. Franks dug a small hole, and found several pieces of ore, a sample of which gave the following results on analysis by McCreath: Iron, 44.550; Phosphorus, 0.65; Siliceous matter, 18.780.

Another sample gave: iron, 58.175; phosphorus, 0.216; siliceous matter, 7.910.

This is the same ore that has been mined so long near Everett in Bedford county on the H. & B. T. R. R.

Brumbaugh's crossing on the H. & B. T. R. R. is one mile and three quarters north-east from Marklesburg station and in passing from this northward, the following section was made:

Section at Brumbaugh's crossing.

(1.)	*Marcellus black slate* from R. R., ...	75′
(2.)	*Limestones* and shales, dip 25°–30°, ...	75′
(3.)	*Oriskany sandstone*, ...	50′
(4.)	*Stormville shales*, 400′ hor. dip 30°, ...	200′
(5.)	*Lower Helderberg limestones*, and *Upper Salina beds*, 1500′ to the turnpike, dip 30°, ...	750′

The exposures at the base of the *Lower Helderberg limestones* in this section are poor, so that the exact dividing point between it and the *Upper Salina magnesian beds* could not be made out, but the separating point should be placed about 350′ below the top of the limestone beds, which cannot be more than 30′–40′ in error.

The limestones at the base of the *Marcellus* here make a low ridge along the foot of Warrior Ridge, so that their outcrop may be easily followed. They have a dull greenish-gray cast, and are quite impure.

A bed of *black shales*, 3′ to 4′ thick, is seen in the cuts of the turnpike, going north from the forks of the road at Isaac Bowers', where the preceding section terminates. It belongs in the *Middle Salina shales*, and not far from their top.

Brown hematite ore occurs about one half mile east from the cross-roads at the Isaac Bowers house, and midway in the 400′ of magnesian limestones at the base of No. 5 of the section, on the land of Mr. Benj. Grove. The ore has never been explored, but several tons of *lump ore* have been gathered from the surface in a basin-like depression near the middle of a field. There is doubtless a considerable quantity of ore of a rather good quality, if one may judge from the lumps on the surface. A specimen analyzed by Mr. R. P. Patterson, chemist for the Alburtis Iron Company, gave 59 per cent. of metallic iron, but this specimen may have been richer than the average.

The *Benj. Grove tract* extends back to the mountain, along the base of which a large amount of *fossil ore* has been mined by Grove Bros. of Danville, and a considerable quantity remains to be taken out. Mr. McCreath's analysis showed: iron, 50.925; sulphur, 0.016; phosphorus, 0.515; lime, 1.430, and siliceous matter, 13.690.

The Guisinger tract adjoins the Benj. Grove property on the north and also contains some *fossil ore*, although a considerable portion of the ore is too deeply buried by a downward roll to be of workable value, even if accessible. The basin is so deep that it has preserved the *red beds* which here make a second *Red ridge* nearly half a mile north-west from the first, so that only the final dip of the ore is accessible on the north-west from the basin where it comes to day again.

One of the best ore properties along Tussey mountain in Huntingdon county adjoines the Guisinger tract on the east. It is generally known as the *Trexler land*, but is now owned by the Patterson heirs. The east branch of James creek heads in the mountain slope north of the Patterson tract. Its three or four head-runs crossing the Patterson property have worn away the soft rocks overlying *the ore sandstone*, leaving it the surface rock over a large portion of the land. The united stream trenches the property, rendering access to the ore very easy. The creek then cuts squarely across the measures eastward, gapping successively Redstone, Mulberry, and Warrior ridges to the railroad in the *Marcellus shale valley* where it turns southward along the strike. Connecting these exposures with another section that I measured along the road east from Grafton to Terrace mountain, I got the following section across the township: (See Sheet 2, Fig. 8.)

The Patterson section.

1. *Pocono and Pocono-Catskill beds* of Terrace mountain.	
2. *Catskill beds*, mostly *red*, ...	2500'
3. Coarse conglomerate, containing *fossil crinoids*, *Spirifers*, and other fragmentary fossils, .	20'
4. *Red shales*, green sandstones, and *red beds* at base, dip 15°-20°, ...	500'
5. *Red sandstone* at forks of road near Abram Grubb's filled with *Rhynchonellas* and *Spirifers*, ...	10'
6. Sandstones, and shales, very little *red*, ...	500
7. *Conglomerate Lackawaxen (upper)*, contains large pebbles of quartz, *Orthoceras sp.?* and a form resembling *Spirifera disjuncta* in large numbers, . .	20'
8. Concealed, sandstones (green) and *red beds*, ...	420'
9. Concealed, sandstone and shales, ...	275'
10. *Red shale (lowest red bed)*, ...	15'

11. Concealed, and olive or yellowish shales, ... 150′
12. *Conglomerate, Allegrippus (lower)*, makes Allegrippus ridge through this township, ... 5′-7′
13. Olive and yellowish shales and concealed to fork of road near D. Norris', ... 120′
14. Concealed, ... 400′
15. Sandy beds, weathering reddish gray in road, ... 5′
16. *Chemung shales*, and hard thin sandstones slightly *fossiliferous*, ... 1100′
17. *Portage* yellowish shales, and grayish flags, dip 25°-30°, 800′
18. *Genessee shale*, a series of thin blackish, shaly beds, containing large numbers of *Avicula speciosa* and *Goniatites complanatus* at top, ... 120′
19. Yellow and olive shales, ... 75′
20. Olive fossiliferous beds, containing crinoids and other fossils, ... 55′
21. Limestone, impure, (*Tully horizon* of G[7]), contains *crinoids* and *Atrypa reticularis*, ... 5′
22. Dark olive shales, slightly fossiliferous, *Hamilton upper shales*, ... 175′
23. Hard, sandy, and limy beds (Hamilton upper sandstone), containing *Spirifera ziczac, Fucoids, Atrypa reticularis* and many *crinoidal fragments*, ... 35′
24. Soft shales (Hamilton middle), ... 225′
25. *Hamilton lower sandstone*, massive, makes ridge, . . 50′
26. Concealed to base of Hamilton beds, ... 100′
27. *Marcellus gray and black slates*, ... 650′
28. Limestone and shales, ... 75′
29. *Oriskany sandstone* (VII), ... 50′
30. *Stormville shales* (VII-VI), ... 225′
31. *Lower Helderberg limestone*, ... 375′
32. Greenish and buff, magnesian limestones, (*Upper Salina*), ... 375′
33. Greenish shales and hard, impure limestones, passing into variegated shales below, ... 550′
34. Hard, *red*, sandy beds, (Redstone ridge,) . . . . 25′
35. *Red shales* and variegated beds to base of *Lower Salina*, 175′
36. *Clinton Upper shales*, including (*Niagara*?) limestones (8′ to 10′ thick) 75′ above the *fossil ore*, ... 340′
37. *Ore Sandstone*, ... 10′
38. *Fossil ore*, ... 1′-3′
39. *Clinton Middle shales*, including "block" ore at base, 600′

Summary.

IX.	*Catskill beds*, Nos. 2-7, and 100′ of No. 8,			3650′
	Catskill-Chemung, the rest of No. 8-10,			610′
VIII.	*Chemung.*	*Chemung proper*, Nos. 11-16,	1780′	2580
		Portage beds, No. 17,	800′	
	Hamilton.	Genesee, Nos. 18-20,	250′	1565′
		Tully limestone,	5′	
		Hamilton, Nos. 21-26,	585′	
		Marcellus, Nos. 27 and 28,	725′	

VII.	*Oriskany sandstone,*			50'
	Stormville shales,			225'
VI.	*Lower Helderberg Limestone,*			375'
V.	*Salina beds.*	Upper,	375'	1125'
		Middle,	550'	
		Lower,	200'	
	Clinton.	Upper shales,	340'	952'
		Sandstone ores,	10'	
		Fossil ore,	2	
		Middle shales,	600'	
	Total thickness of IX to V,			11,107'

The length of this section from the base of Terrace mountain to the Medina outcrop in Tussey is, by the map, 2,000 rods, or 6¼ miles, the dip being 15° to 20° in the upper portion, increasing to 25° and 30° near the middle, and dying away to 20° again in the lower portion of the Salina, which, together with the Clinton rocks, is pressed into a series of low folds along the base of Tussey mountain, spreading the *fossil ore* over a much wider area than one continuous dip would give, and at the same time rendering it available for mining, at a minimum cost for tunneling, as compared with other localities along the base of Tussey mountain in Huntingdon and Bedford counties.

2. The upper portion of the *Catskill* was not measured in detail, but was calculated from the breadth of its outcrop, (500 rods,) the prevalent dip being S. 55° E. 15° to 20°.

3. The occurrence of *Crinoids* and *Spirifers* in these beds would be considered evidence of their *Chemung age*; but the occurrence of a considerable body of *red beds* at the base of No. 4, and some thin ones even as far down as No. 10, (1700' below the point at which fossil *Spirifers* and *Crinoids* were seen,) would place a portion at least of these beds in the *Catskill formation.*

7. *The Lackawaxen conglomerate* is a very massive rock, and makes a great cliff along the hill. It is full of large quartz pebbles, some of which are 2" to 3" long, and 1" or more in width and thickness. *No jasper pebbles* were here noticed; but fossil *Spirifers* are numerous, and one specimen of a small *Orthoceras* was seen.

The interval between the *Lackawaxen* and *Allegrippus conglomerates* is 860' feet in this section.

The *Allegrippus conglomerate* fragments are very plentiful along the crest of Allegrippus ridge, and in some places so cover up the surface that one could readily believe the stratum from which they come to have a thickness of 25′ to 30′; but it is seldom more than 5′. The fragments are small (6″ to 1′ in diameter) and filled with mostly rounded, snow-white pebbles, in a matrix of coarse gray sand.

15. These rocks make a reddish streak across the road; and at first glance it looked as if a *red bed* lower than No. 10 had here come into the series; but on closer examination the red color was seen to be produced by the oxidation of included iron; freshly fractured surfaces are not red, but bluish gray. Therefore No. 10 remains the *lowest red bed* in the series, 2580′ above the top of the Genessee, about the same distance as everywhere in Pike, Monroe, Luzerne, Columbia, Montour, and Northumberland counties.

16, 17. *The Portage shales and flags* are separated from the *Chemung* in this section merely by lithological characters; where the hard sandstones of the *Chemung* proper (No. 16) stop, and give place to underlying yellowish shales, and olive-gray flags (No. 17); but there is no sharp line of division between the two formations.

18. *The Genessee* has been made to include in this section the yellow and olive shales which underlie the *black beds* and overlie the *impure limestone* (No. 21); although they look so much like Hamilton shales that nothing but the intervention of the *Tully limestone* (No. 21) would suggest their being included in the Genessee formation.

22. *Grammysia elliptica*, well preserved, was found near the middle of No. 22; also *Spirifera medialis*, *Orthonota medulata*, *Ambocœlia umbonata*, and many other forms.

23. These hard limy layers make a low ridge along the north-west face of the hill slope which leads up to the *Portage outcrop* in *Piney ridge*. A large *Spirophyton* is especially numerous in these beds; and great numbers of *Spirifera ziczac* are also seen.

24. *The Hamilton middle shales* are thicker than usual at this point, and they make a slight depression in the sur-

face; the *Hamilton lower sandstone* (No. 25) under them outcrops as a bold ridge.

27. *The Marcellus beds* are largely concealed in the valley which they make between the foot slope of the *Hamilton lower sandstone* ridge and the south-eastern base of *Warrior ridge*, save occasional outcrops of *black slate* along the road cuttings and the low terrace made by the *Selinsgrove lower limestone series*, just at the base of the Warrior ridge slope.

The rest of this section from the *Oriskany sandstone* down to the *Clinton fossil ore* was measured along the east branch of James creek which crosses the railroad near A. S. Grove's, 1½ miles south of Grafton.

31. *The Lower Helderberg limestone* occupies the western slope of Warrior ridge and (when the *Oriskany sandstone* is absent) it extends to the crest of the ridge, and in some places over it on to its eastern slope. The limestone beds have not been quarried along the east branch of James creek; but they crop out along its bluffs.

32. The bottom beds of the *upper Salina* make a low cliff or steep bluff along the Salina valley so that the division between them and the *middle Salina* variegated shales is well marked. The upper beds of the middle Salina contains some sandy limestones which make *Mulberry ridge;* this begins to slope up just west of the turnpike and gets to be 150 or 200 feet high above the general level of the valley to the east of it.

34. The hard *red beds* of *Redstone ridge* are seen just opposite the residence of Mr. J. Hood, and crop out just above it; while the *softer* underlying *red shales* (No. 35) make the northern slope of the ridge and are in great measure concealed. If the *Niagara formation* extends into Pennsylvania, it can only be represented by some *bluish-gray* thin, flaggy limestone layers, which crop out further up the stream, and overlie the *fossil ore* by 75′ or 100′. The limestone is not pure although it is said to slack fairly well and to answer for agricultural purposes.

37. *The Clinton ore sandstone* comes to the surface in a low anticlinal at 25 rods west from where the James creek

road crosses the Brack road, south of the Trexler (Patterson) farm house. A shaft was here sunk through the second sandstone to the *fossil ore* by Mr. Patterson on the crest of the anticlinal. *The ore* was found at a depth of 11 feet, but it was quite hard and limy. The dip westward then carries the *fossil ore* so deep under ground that the *lower Salina red beds* are preserved in the next basin, south of James creek, just across the line from the Patterson property. Then the rocks begin to rise toward the mountain again, to the crest of another anticlinal 150 rods from the first one. This brings the *fossil ore* so close to the surface that it was struck in a trial tunnel only 3 yards long driven by Mr. Patterson. The ore bed, according to Mr. Patterson, is here 3 feet thick; and 40 tons of ore were taken out in driving on it only a short distance.

This second anticlinal roll rises north-eastward; brings the *bottom slates* to the surface; and throws off the ore bed each way in two outcrops.

On the western outcrop the bed sinks for a short distance and then begins to rise again. After reversing its dip about three times, it turns up sharply towards the west and soon crops out for the last time on the slope of the mountain.

The best developments of the *fossil ore* on the Patterson tract are found along the northern (Hetric) branch of James creek.

Here five openings have been made on the *fossil ore bed* and it has been found in good workable thickness in all of them, varying from 1′ up to 2′, and of excellent quality. A considerable quantity of ore has been mined here and shipped to Saxton, and other furnaces in Pennsylvania. The little stream cuts squarely across all the folds, exposing the ore in the hillsides for a distance of nearly 50 rods in breadth; while the run of the ore is over 1000 yards.

The first anticlinal roll crosses the stream at 600 feet from the county road, which runs parallel with the turnpike and 200 rods west of it. This is the same roll on which Mr. Patterson sunk the before-mentioned shaft, further south, where it does not bring the ore to the surface. But here the roll is slightly higher, and the ore is lifted to the surface. An old drift is seen on it here near the crown of the roll, put in by Mr. Alonzo Trexler, the former owner of the property. I learned from Mr. Patterson that the ore was 20″ inches thick when first struck, but thinned away to 10″ when followed some distance into the hill.

A second anticlinal roll runs parallel to and at the distance of 900 feet west of the first. This roll on the north side of the stream brings the ore to the surface along two outcrops between which runs a narrow strip of underlying *middle slates*, entirely across the property, northward. South of the stream the roll declines, lets the two ore outcrops come together, and so the bed unbroken arches over under a covering of the *sandstone.*

From a drift near the crown of this *second roll* Mr. Patterson is getting *block fossil ore*, soft enough to mine easily, but coming out in large rectangular blocks. The bed has a thickness of 15″ to 24″ and has thus far yielded approximately a ton of ore per square yard of surface mined. Its composition is shown by the following analysis made by Mr. McCreath:

	A.	B.	C.
Iron,	54.950	52.400	53.900
Sulphur,	.012	.009	.011
Phosphorus,	.469	.129	.138
Lime,	1.130	.070	.070
Siliceous matter,	9.690	14.860	12.510

A. One of the *richest looking* hand specimens that I could find on a dump containing several tons.—B. A strip of ore, entirely across the bed, consisting of 12 pieces.—C. A strip of ore nearly across the bed and consisting of 8 pieces. The specimens were dried before analyzing. As the ore usually contains a considerable quantity of moisture, owing to its porous character, a fair estimate would give it an average of 50 per cent of iron throughout, or about 2¼ tons of ore to a ton of iron.

Several small waves run west of the *second roll.*

The third roll then follows, running at a distance of 950′ from the *second roll;* and here Mr. Patterson has a drift from which a considerable quantity of ore has been taken. The bed has about the same thickness and quality as at the other drift. This *third roll* also brings up the underlying *middle slates* and makes two ore outcrops. The western outcrop sinks and the bed very soon basins and then rises finally to the surface on the slope of the mountain.

On the opposite (south) side of the stream the same bed was once extensively mined by the Grove Bros. of Danville, Pa., but their mines were idle when I visited the locality. The ore is said to have about the same thickness as on the Patterson tract.

These rolls increase in height going north, lifting the *fossil ore* into the air so that it has been all washed away, leaving only the short and steep east dipping bed of the *first roll;* but the ore here is so thin and lean that it may be neglected in the broad statement that no *fossil ore* of any considerable value exists in Penn township to the north of the Patterson tract. Search has been made at many places without success, although a thin bed has been found occasionally on the east dip, like that of Mr. Jno. Hood's.

The ore sandstone makes a sharp, narrow ridge near J. Hood's, at the northern line of the township on the arch of the *first roll.* Here a tunnel was once driven through the sandstone to the *fossil ore* which was found to be too lean and thin to mine.

The Marcellus black slate is finely exposed in a deep railroad cut, about one half mile northeast from Brumbaugh's crossing, and vast numbers of *Styliola fissurella* occur in it.

A branch of Crooked creek cuts through Warrior ridge, half a mile west of Grafton, exposing the rocks. Here I obtained the following section: (See Plate XXIII, Fig. 3.)

Trexler's limestone quarry section.

(1.)	Coarse, gray, crystalline limestone,	10′
(2.)	Blue shaly limestone,	5′
(3.)	Bluish-gray, good limestone,	20′

These are only the beds of the quarry itself, but the strata of No. VI are exposed here for a distance of 700′ horizontal with a dip of 28°, S. 55 E., giving them a thickness of, say 325′.

A little further up stream the underlying buffish magnesian beds of the *upper Salina* rise and occupy the ground nearly to the turnpike ; and are then succeeded by the *middle grits and shales* of Mulberry ridge.

Over the *No. VI limestones* are seen the *Stormville shales ;* and over them the massive *Oriskany sandstone* (*No. VII*) in isolated outcrop patches occupies the eastern slope of Warrior ridge.

At Grafton station and westward the following section was measured : (See Plate XXIII, Fig. 2.)

Grafton section.

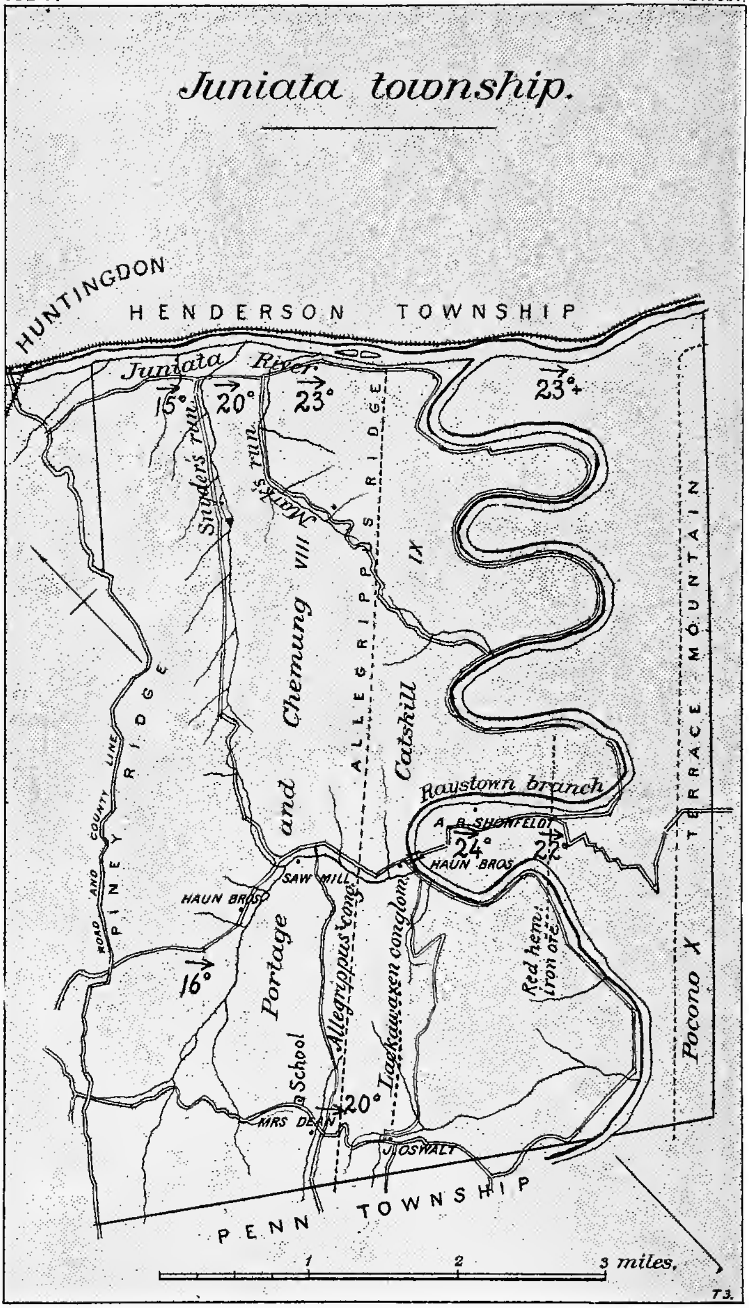
1.	*Black Marcellus shales* with limestones near base, dip 28°-30°, S. 55° E,	265′
2.	*Oriskany sandstone,*	50′
3.	*Stormville shale,*	225′
4.	Shaly, impure fossiliferous limestones, containing *Stromatopora bed* near center,	75′
5.	Impure, light gray limestone (bastard),	20′
6.	Gray, crystalline limestone,	10′
7.	Blue limestone,	10′
8.	"Nigger Head" (cherty limestone),	2′
9.	"Ironstone" (hard limestone, ferruginous),	4′
10.	Gray limestone,	5′
11.	Black limestone,	7′
12.	Dark blue, shelly, impure limestone, visible,	20′
	Total thickness of strata,	693′

Nos. 1 to 6. *These Lower Helderberg limestone beds* are extensively quarried just above Grafton by R. H. Powell & Co. to flux Powelton furnace. None of the other beds in the formation are pure enough. Bed No. 6 is preferred for flux ; but bed No. 7 makes the whitest lime.

Analyses of specimens taken from the different beds gave Mr. McCreath the following results :

	A.	*B.*	*C.*	*D.*	*E.*
Carbonate of lime,	95.536	98.035	94.642	95.446	93.035
Carbonate of magnesia,	1.589	0.908	2.800	1.135	1.816
Oxide iron and alumina,	0.490	0.410	0.370	0.520	0.730
Phosphorus,	0.011	0.006	0.006	0.006	0.006
Siliceous matter,	1.850	0.420	1.730	2.350	3.480

A, upper half of bed No. 6 of the section ; *B*, lower half ; *C*, bed No. 7 ; *D*, bed No. 9 ; *E*, bed No. 11.


Juniata township.
HUNTINGDON
HENDERSON TOWNSHIP
Juniata River
Snyder's run
Marks run
PINEY RIDGE
ROAD AND COUNTY LINE
Chemung VIII
and
ALLEGRIPPUS RIDGE
Catskill IX
Raystown branch
A. B. SHONFELDT
HAUN BROS
SAW MILL
Portage
School
Allegrippus cong.
Lackawaxen conglom.
Red hem. iron ore
TERRACE MOUNTAIN
Pocono X
MRS DEAN
J. OSWALT
PENN TOWNSHIP
1 2 3 miles.
T3.

4. Juniata.

This township lies between Penn township and the Juniata river, and between Terrace mountain and Piney ridge, and its series of rocks extends from the *Pocono sandstone* (*No. X*) in Terrace mountain to the *Portage beds* in Piney ridge.

The Raystown branch is so serpentine that it takes a course of more than 12 miles to make the 5½ mile transit of the township.

The rocks are fairly well exposed along the Juniata river road opposite Huntingdon, south-eastward. Here the following section was constructed: (See Sheet 2, Fig. 9.)

Juniata river (south bank) section.

(1.)	*Catskill beds* from end of Terrace mountain to junction of Raystown branch with main Juniata river: horizontal distance 450 rods; dip 23°-24°, . .	3000′
(2.)	Red, massive sandstone, containing *fish scales* (*Holoptychius*) and *bones*, ...	20′
(3.)	Concealed, ...	350′
(4.)	Fragments of Lackawaxen *conglomerate*, with *fish bones*, seen on the surface here.	
(5.)	Concealed, ...	50′
(6.)	Fragments seen here, containing *Spirifera*, *Clidophorus*, *Chonetes*, and other fossil forms.	
(7.)	Concealed; dip 20° to 25°, ...	1075′
(8.)	*Very fossiliferous beds*, containing *Ambocœlia gregaria*, *Productella hirsuta; Spirifera mesocostalis*, *S. disjuncta*, *Stictopora*, *Fenestella*, and large numbers of *Crinoidal fragments*.	
(9.)	Concealed, and sandy beds to forks of road at crossing of Marks' run; dip 23°, ...	1150′
(10.)	Sandstones and flaggy beds making cliffs to forks of road at McMurtrie's S. House; dip 18° to 22°, . .	800′
(11.)	*Portage, flaggy sandstones*, making cliffs; dip 15° or 16°, ...	500′
(12.)	*Genesee* formation in Walker township.	

Summary.

IX. Catskill beds (Nos. 1 to 5), ...	3420′	6945′
Catskill-Chemung (part of No. 7,)	675′	
VIII. Chemung and Portage (part of No. 7 to 11),	2850′	

1. The upper portion of the *Catskill* interval was calculated from the map. But the whole 3420′ agrees well with the measurements in Lincoln (3600′) and Hopewell (3900′)

townships. The thickness assigned to the *transition beds* was that obtained elsewhere.

8. *The Stony Brook fossiliferous beds* of Columbia, Montour, and Northumberland may be represented by beds here seen only in fragments on the surface, which are a perfect mass of fossils, *Ambocœlia gregaria* being especially numerous, while *Spirifera*, *Productella*, and *stictopora* are very abundant, although the assemblage of fossils is not the same. The small pieces of conglomerate scattered over the ground at 250′ to 300′ above No. 8 indicate the outcrop of the *Allegrippus conglomerate.*

The Portage rocks near the base of the section rise in the river cliffs to the crest of Piney ridge. The Juniata river is here a comparatively narrow gorge.

Another section across the township was made along the road which leads south-east from McConnellstown to Haun's Bridge and over the summit of Terrace mountain, as follows: (See Sheet 2, Fig. 11.)

Haun's Bridge section.

1. *Pocono* and transition beds (mostly red shale.)	
2. *Catskill red beds*, 350 rods, dip 22½° having a thin bed of *specular iron ore* at 1600′ below top, ...	2200
3. Green, and reddish brown sandstones, containing many fossils up to the highest beds also alternating beds of *red shale;* horizontal extent 200 rods, dip 24° S. 40°, E.,	1325
4. *Lackawaxen conglomerate*, a massive greenish gray sandstone, with thin pebbly streaks filled with white and *red* (jasper) pebbies, *fish teeth*, and comminuted *shells*,	15′
5. Concealed to base of *Catskill series*, ...	100′
6. Greenish gray sandstones and shales having *Ambocœlia gregaria*, *Productella* Sp.,? and a form resembling *Atrypa aspera*, ...	100′
7. Sandstone and shales, greenish, with many fossils near base, including *Productella*, *Spirifera disjuncta*, *S. mesocostalis*, *Crinoidal fragments*, and many other fossils, ...	150′
8. Concealed, ...	630′
9. *Allegrippus Conglomerate*, ...	5′
10. *Chemung beds and Portage flags*, distance 9500′, average dip 16°, ...	2565′
11. *Genessee slate* in edge of Walker township.	

Summary.

IX. *Catskill beds*, (Nos. 1 to 5,)	3640′	7090′
Catskill-Chemung, (Nos. 6, 7, and part of 8,) . . .	750′	
VIII. *Chemung and Portage beds*, (remainder,)	2700′	

Since this total is only 145′ greater than that obtained along the Juniata river (6945′) neither can be very far from the truth.

No. 1 is practically all *red shale.*

The occurrence of a thin streak of *specular iron ore*, 1″ to 2″ thick, 1600′ below the top of these red shales, is remarkable. An attempt to mine it was once made on the land of A. B. Shonefeldt. Pieces picked up in the fields were at first regarded as *meteoric iron.* The ore could not yield more than 70 per cent of metallic iron.

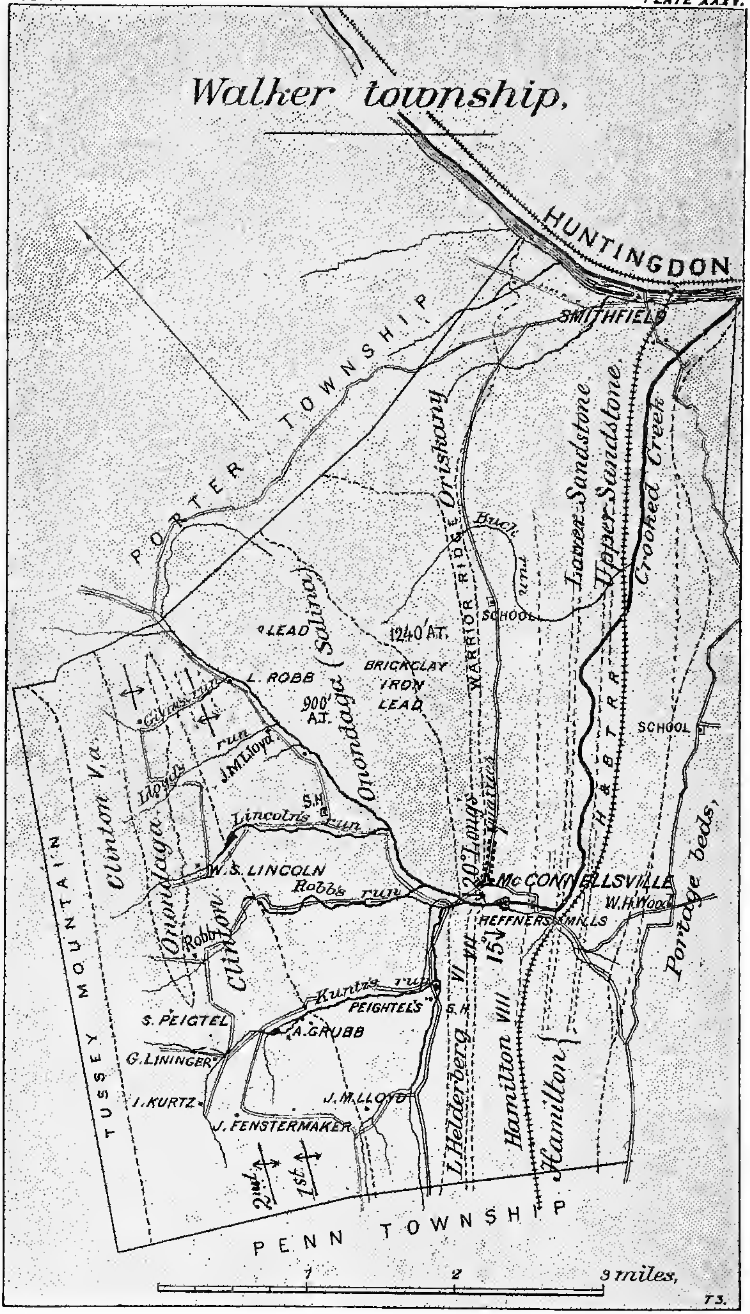
No. 3. Some beds near the top of No. 3, along the Raystown branch, are crowded with *fossils* which have a decided *Chemung face*; but the beds are undoubtedly *Catskill*, unless we found the classification entirely on *fossils.* In that case the limit of the *Chemung* formation would be carried up to the top of No. 3, and then Chemung and *Portage* together would be 4890′ thick ; nearly double their reputed thickness in New York.

No. 9. *The Allegrippus conglomerate* makes a high ridge ; and its pebbly blocks are scattered over the ground, some of which hold *fossil shells* in a fragmentary condition.

No. 10. The *Chemung* and *Portage rocks* having here a dip of only 16° (S. 40 E.) spread out over a belt nearly two miles broad. The lowest *Portage* beds crop out a short distance beyond the line, in Walker township, along the steep face of Piney ridge overlooking the valley of Hamilton rocks. On the top of Piney ridge these rocks spread as a wide belt of yellowish sandy shale and flags, making poor farm land, but susceptible of improvement by the use of fertilizers.

The *Allegrippus conglomerate* makes an outcrop near Mrs. Dean's, just north of the cross-roads, near the Penn township line ; but is here much less pebbly than usual ; and the dip of the *Chemung* and *Portage* rocks has here increased to 20°.

The Lackawaxen conglomerate marks its outcrop southeast from Mrs. Dean's by pebbly blocks scattered over the surface near Mr. Oswalt's. Several *red beds* occur here


Walker township.
HUNTINGDON
SMITHFIELD
PORTER TOWNSHIP
Orishany
Buck run
WARRIOR RIDGE
Lower Sandstone
Upper Sandstone
Crooked Creek
SCHOOL
LEAD
1240' AT.
Onondaga (Salina)
BRICKCLAY
IRON
LEAD
L. ROBB
900' AT.
Calvins run
Lloyds run
J.M.Lloyd
S.H.
Lincoln's run
H. & B. T. R. R.
SCHOOL
Clinton V.a.
Onondaga
W.S. LINCOLN
Robb's run
20° Longs
McCONNELLSVILLE
W.H.Wood
HEFFNERS MILLS
Portage beds,
TUSSEY MOUNTAIN
Onondaga
Robb
Clinton
Kuntz's run
PEIGHTELS
S.H.
S. PEIGTEL
A.GRUBB
G.LININGER
I. KURTZ
J.M.LLOYD
J. FENSTERMAKER
VI
VIII
15 V
L.Helderberg VI
Hamilton VIII
Hamilton
2nd.
1st.
PENN TOWNSHIP
1
2
3 miles,
T.S.

between the two conglomerates; the lowest red bed being at least 500′ beneath the Lackawaxen conglomerate.

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5. *Walker.*

This township stretches from Tussey mountain east to the borough of Huntingdon and is drained entirely by Crooked creek which flows into the Juniata river just below Huntingdon.

Its formations underlie those of Juniata township, beginning at the top with the Portage beds in Piney ridge and ending downwards with the Medina sandstone beds of Tussey mountain. Its south-eastern line runs along the top of Piney ridge, a rocky outcrop of the hard Portage flagstone strata. The slope below the cliffs contains the Genessee slate and Hamilton upper shale, which occupy about two thirds of the height of the ridge.

The south-east dip at the Penn township line is 25° to 30°, but grows flatter north-eastward until at the river it is only 5° or even less.

The *rolls* which were observed in the *Clinton* and *Salina areas* to the south-west in Penn township extend through Walker along the base of Tussey mountain; the first one running at a distance of one and a half miles from the crest of the mountain.

These rolls, three of which are pretty well defined, have their maximum development near the Penn township line where they bring the *fossil ore* repeatedly to the surface; which they do not do further on towards the river; so that the ore gets covered deeper and deeper by the overlying shales. Only one outcrop of the *ore bed* then remains on the flank of the mountain, and that is thin, lean, and hard; so that a large portion of the *Clinton belt* in this township is destitute of *fossil ore.*

At the point however where these *dying anticlinals* have so far subsided as to spread out the *ore bed* over a considerable area with only a slight covering above, we find it in fine condition; namely, from about half a mile from the

Penn line for nearly a mile north-eastward; the best development of the ore being just west of the branch of Crooked creek which flows past Mr. A. Grubb's house.

The following section was made across the township through McConnellstown: (See Sheet 2, fig. 11.)

McConnellstown section.

1.	*Portage flags* in Piney ridge.	
2.	*Genessee black* and *olive slates*,	250′
3.	*Limestone* (*Tully*) 2′ visible,	5′
4.	*Hamilton beds* including the *Upper Sandstone*, near its center,	400′
5.	*Hamilton Lower Sandstone*,	50′
6.	Sandy shales and flaggy sandstones,	50′
7.	Bluish gray, limy beds, having at base three hard, limy and siliceous iron-bearing layers 6″–10″ thick, separated from each other by 3′–4′ of shales,	50′
8.	*Marcellus shales*, dark gray and bluish, filled with fossils, *Leiorhynchus limitare*, *Goniatites marcellensis*, *Ambocœlia umbonata*, and many other forms, especially numerous at 8′ to 10′ below the top, visible	100′
9.	Concealed across valley. Dip 15° (S. 45° E.), including *black slates*, and *limestones* at base,	550′
10.	*Oriskany Sandstone* (*No. VII*),	50′
11.	*Stormville shales*,	200′
12.	Concealed, containing impure limestones and *Stromatopora bed* near center,	100′
13.	Bluish gray, limy shales,	3′
14.	Gray limestone,	10′
15.	Blue, sandy limestone,	4′
16.	Gray limestone,	4′
17.	Blue limestone including nodules of *chert*,	5′
18.	Bluish gray limestone, dark blue or blackish in lower portion,	40′
19.	Bluish gray, shaly and flaggy limestones, visible	35′
20.	Concealed to base of *Lower Helderberg limestone No. VI.* Dip 20° (S. 45° E.),	150′
21.	*Salina beds.* Dip 15° to 20°,	1100′
22.	*Clinton Upper shales*,	350′
23.	*Ore sandstone*,	10′
24.	*Fossil ore*,	1′–2′
25.	*Clinton middle shales* and *block iron ore*,	600′
26.	*Clinton lower shales*,	400′

This section is a direct continuation of the last one across Juniata township, and summarizing the two, we get the following:

Summary.

IX.	*Catskill,*			3640′
	Catskill-Chemung,			750′
VIII.	*Chemung and Portage,*			2700′
	Hamilton.	Genesee,	250′	1455′
		Tully limestone,	5′	
		Hamilton,	550′	
		Marcellus,	650′	
VII.	*Oriskany sandstone,*			50′
	Stormville shales,			200′
VI.	*Lower Helderberg limestone* (Nos. 12-20),			351′
V.	*Salina (Onondaga)* beds,			1100′
	Clinlon.	Upper shales,	350′	1361′
		Ore SS.,	10′	
		Fossil ore,	1′ to 2′	
		Middle shales,	600′	
		Lower shales,	400′	
	Total thickness of IX–V,			11,607′

The Genesee beds are seen cropping out along the road which ascends Piney ridge south-east from McConnellstown, the highest of the layers passing under at the sharp turn in the road 1000′ from the cross-roads at W. H. Woods' on the Walker-Juniata line.

The contact of the Genesee with the Portage can here be finely seen, the dark gray and blackish slates of the *Genesee* giving place to the hard, gray, flaggy sandstones of the *Portage*.

Near the top of the *Genesee*, we find large numbers of *Cardiola*, *Speciosa*, and *Goniatites complanatus*.

The Tully limestone seems to be represented in the section by a hard, bluish gray, impure bed, 250′ below the top of the *Genesee*, though only 2′ of it is visible.

The Hamilton upper sandstone makes a low hump in the ground along the foot slope of Piney ridge. Where the road crosses it, many fossils are seen in it, among which are *Spirifera ziczac*, *S. mucronata*, *Stictopora* (*Sp ?*,) *Spirophyton*, *Crinoidal fragments*, and many other forms too badly broken for identification.

The soft shales between the two sandstones crop out just south-east of the railroad, at the McConnellstown station, and make a narrow valley, in which flows Crooked creek.

The Hamilton Lower sandstone comes up on the road leading from the station to the village of McConnellstown only a few yards from the station, and is there finely exposed in a cutting. It is quite hard, and makes a sharp ridge, which extends from this point to the Juniata river at Huntingdon.

The limy beds (No. 7 of the section) at the base of the *Hamilton* proper should be the *Selinsgrove upper limestone* of Northumberlond county.

Iron ore. The Hamilton proper is terminated below in this section by three very hard siliceous layers of carbonate of iron and lime, 5″, 8″, and 3″ thick, respectively, separated by 2½′ and 1½′ of shales (proceeding from above downwards.) At 8′ to 10′ below the lowest of these layers, *fossils of the Marcellus formation* come in.

The junction of the *Hamilton* and *Marcellus* is finely exposed in the cuttings along the road from the station to McConnellstown.

These light bluish-gray *upper Marcellus shales* weathering whitish are exposed along the road to near Heffner's grist mill.

The Marcellus black slates are well concealed in this section except a few feet near the base of the group, seen along the road leading into McConnellstown.

The outcrop of the Oriskany sandstone, No. VII, is not seen in its passage through the village, but it crops out on the turnpike.

The Stormville shales occupy the summit and occasionally a portion of the southern slope of Warrior ridge, where they have frequently been deprived of their lime and bleached to a grayish-white slate or clay.

The lower Helderberg limestone, No. VI, beds crop out on each side of Crooked creek, just back of McConnellstown, in a series of bold cliffs. On the east bank of the creek they have long been quarried on the land of Mr. Washington Long. Here Nos. 12 to 20 of the section were observed. Bed No. 8 is the one principally quarried; it burns into a beautiful white lime which is sold to the plasterers at 10 cents per bushel at the kiln, or 14 to 15 cents delivered in Huntingdon.

Fossils, mostly fragmentary, are plentiful in all the beds above bed No. 17, *Crinoidal fragments* and *corals* (*Zaphrentis*, *Cladopora*, *Chaetetes* and other forms) being especially numerous. In the concealed interval No. 12, lying on the ground were seen several blocks of limestone containing *Stromatopora concentrica;* and a large piece of *Favosites helderbergiæ* was picked up which had weathered out from its matrix somewhere in this same interval, No. 12.

The Salina beds are seen cropping out along the road which leads north-west from Peightel's school house; 200 rods from which the *Salina lower* or *red beds* come up and make *Redstone ridge.*

The rocks continuing to rise to the north-west, the *Clinton upper shales* appear; and then, at Mr. Andrew Grubb's the *fossil ore*, on the back of the *first roll.* Here it has long been mined to a considerable extent by Grove Bros. of Danville, and lately by Mr. Isaac Kurtz by lease from Grubb. East from the stream the roll barely raises the *fossil ore bed* above water level; and a drift on it here, finding nothing but a thin seam of *limestone ore*, was soon abandoned. Over it lay 50′ to 60′ of limy shales; and more and more of this covering going north-east; therefore there can be but a slight chance for *soft ore* east from Kurtz's *on the first axis*, north-east of Kurtz's run; but south-west of it the roll rising quite rapidly elevates a large body of the ore to within a few feet of the surface in what is known as *Grubb's hill.*

Mr. Isaac Kurtz has four ore drifts on the Grubb land, from two of which he is now mining ore. The uppermost drift begins near the run and extends into the hill in two gangways about 100 yards, from which side-slopes have been driven in the ore, the thickness of which varies from 6″ to 15″. A parting of slate ("jack") often runs through the upper part of the bed; the upper bench is called the "*top block.*" The roof is a very hard, calcareous sandstone 9′ or 10′ thick.

From this opening 500 to 600 tons of ore have been mined, and an average sample from the dump analyzed by Mr.

McCreath, and thoroughly dried before analysis, gave the following result:

Iron,	49.775
Manganese,	.360
Sulphur,	.005
Phosphorus,	.207
Lime,	.380
Siliceous matter,	14.710

Four or five feet underneath the main bed of fossil ore there is usually present on the Grubb land a three or four inch layer of *soft ore*, called the "paint vein;" but it is seldom mined on account of its small size and distance from the main bed.

The Rock Hill (Orbisonia) fossil ore, *overlying the ore sandstone*, is here represented by a thin layer of "bastard ore," as Mr. Kurtz calls it. About 200 yards south-west from this drift, another old one is seen which was also put in by Mr. Kurtz, and a large quantity of ore was taken from it. In one part of the working a "limestone swag" came in and cut out the ore on the south-east dip. The interpretation of this mysterious language is simply this: That the *fossil ore bed* lying at a considerable depth below the surface has been protected from the action of water and remained in its original condition of an *iron-bearing limestone*. *The ore* in this drift is 10″ to 15″ thick, with 5″ to 6″ of "top block;" and 5′ below it, 3″ or 4″ of *soft ore*.

Further up the hill and near the crest of this *first roll*, another drift has recently been put into the ore by Mr. Kurtz. The gangway was 75 yards in when I visited the property, and sampled a pile of very fine looking ore on the dump for analysis by Mr. McCreath. It was found, after thorough drying, to yield:

Iron,	53.275
Manganese,	.129
Sulphur,	.009
Phosphorus,	.585
Lime,	1.660
Siliceous matter,	10.840

The high per cent of *phosphorus* in this sample, when compared with that last given, is explained by Mr. McCreath. This sample contained several *phosphatic pebbles*.

Mr. Kurtz a long time ago drove a tunnel to the *fossil ore* from the south-east slope of Grubb's hill, passing through the whole of the *ore sandstone*, and some of the overlying shales. He reports the *sandstone* as being excessively hard (somewhat calcareous), and the underlying *ore* so hard and lean that after mining a little the tunnel was abandoned.

Recently, another tunnel has been driven to the *fossil ore* on the Grubb land by Mr. Whitehead, of Huntingdon. This begins nearly on the crest of the *first roll*, just at the point of the hill above Mr. Grubb's house. The low dip made a long tunnel through the overlying sandstone, before reaching the *fossil ore* bed, which was found to be 10″ to 12″ thick, and about the same quality as at the Kurtz drifts.

Grubb's hill is made by the *first roll*, which carries the ore into the air over on its crest south-west of Grubb's run; but a shallow basin, the axis of which runs about 25 rods distant from that of the first roll, has preserved some patches of the *ore* on the summit of the hill.

Beyond this the *2nd roll* carries the ore again into the air; but it soon descends in a long slope on the north-western face of Kurtz's hill, from which a large body of rich ore has been mined by Mr. Kurtz and others. A *dried* specimen of this ore was analyzed by Mr. McCreath as follows:

Iron,	54.975
Manganese,	.223
Sulphur,	.008
Phosphorus,	.581
Lime,	1.960
Siliceous matter,	8.400

The mines on this north-west slope have not been operated for three years, but Mr. Kurtz assures me that the *ore* was fully as rich as the specimen analyzed. *Phosphatic pebbles* were doubtless present in the specimen analyzed, which would account for its high percentage of *phosphorus*.

The basin beyond the *second roll* is so deep that the *red rocks* at the base of the *Salina* are preserved in it. Its center line is not far from Mr. Isaac Kurtz's residence. The *fossil ore bed* buried so deeply in this fold must be hard and worthless; but on its north-west rise on the flank of the monntain it exhibits some very valuable ore deposits.

Along this its last outcrop Mr. Isaac Kurtz has mined it extensively on his own land, where it is a *soft spongy block ore;* much less *specular* than usual; and of a brownish-yellow color. A specimen dried and analyzed by Mr. McCreath gave the following:

Iron,	52.100
Manganese,	.173
Sulphur,	.002
Phosphorus,	.142
Lime,	.300
Siliceous matter,	14.040

Just east from Kurtz's land Mr. S. T. Brown of Huntingdon has a small tract, which ought to be valuable, if any judgment based on the slope of the surface is to be relied on.

On north-east from Kurtz's drifts the *fossil ore* has been mined a little by Peightel, Leiniger, and Lloyd.

South-west from I. Kurtz's the *ore* on the land of J. Fenstermaker, in a short trial drift, when first struck was only 3″ thick, but in 3 yards thickened to 10″, where the drift stopped.

South-west from Fenstermaker's, Messrs. Wm. Harris, J. and A. Wood and Jacob Fouse own farms on the *ore range*, on all of which some good ore could doubtless be obtained; especially in the basin next the mountain, which shallows up southward so that the *ore bed* is only 25′ to 30′ under cover in the deepest part of the basin.

The *fossil ore* was once searched for along the road which crosses the ore sandstone ridge from J. Fenstermaker's to J. M. Lloyd's, but without success. Two or three tunnels were driven through the *ore sandstone*, half-way down the south-east slope of the ridge on the land of James Lloyd; and one near the crest of the ridge on land of Solomon Kurtz; but no *ore* was found in any of them.

North-east from Grubb's run the *first roll* rapidly declines, so that on Robb's run, two thirds of a mile from Kurtz's run, it fails to bring the *ore* to water level. But on the next, or Lincoln's run, the ore rides over this *first roll* about 10 feet above the stream, and here it has been opened by the Grove Bros. on the very crown of the arch, at a point 200 yds. east of Mr. W. S. Lincoln's house. The ore was very hard and limy, and only a few tons were mined.

North-westward from Lincoln's the *ore* dips under so deep that the *Redstone ridge rock* is preserved in the basin, beyond which the ore rises again at 2500′ west from the Grove Bros.' drift.

Here it was once opened and mined a little by Mr. Lincoln, but is quite thin and hard.

In the basin between the two mines the hard *red beds* at the base of the *Salina* make two ridges, one where they go down to the north-west, and another where they come up again.

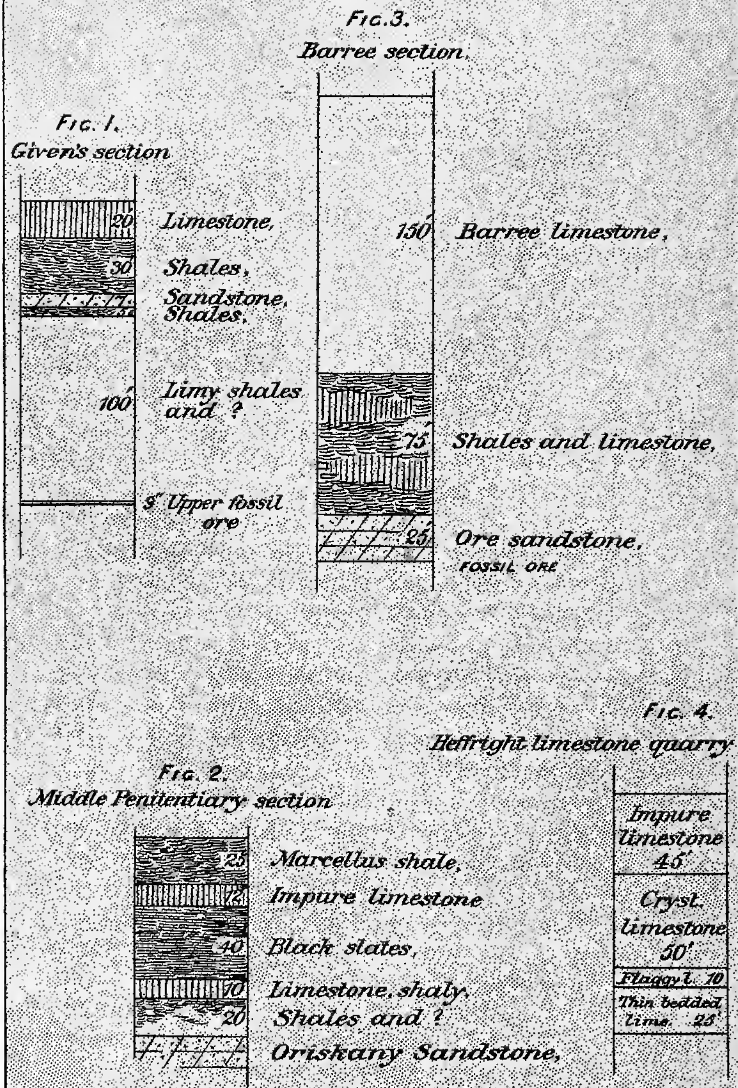
The *first roll*, or "Grubb's hill axis," declines still further as we follow it north-eastward from W. S. Lincoln's, so that half way between Lincoln's run and the next (Lloyd's) run, the shales and limy beds above the *ore sandstone* arch over the crown of the *axis*, burying the *fossil ore*, which must at that depth be valueless.

Just here, where the *regular fossil ore* bed of the *Grubb's hill axis* disappears underground, *another bed of fossil ore, nearly 300′ above it*, takes its place at the surface.

This upper fossil ore bed was once opened on the land of Mr. Livingstone Robb, and was supposed to be the *regular fossil ore bed*, although, curiously enough, it had no *ore sandstone* over it. The two beds were, however, exactly of the same character. This upper one was 10″ to 12″ thick, and filled with *minute fossils*, just like the bed which underlies the *ore sandstone*; and there was so little difference in the appearance of the two ores that Mr. R. W. Given disposed of several tons of the upper ore without question.

The stratigraphical position of this bed is in the interval between the *Saline* (*lower*) *red beds* and the Clinton *red beds*, and about 100 feet below the base of the hard, sandy layers which make Redstone ridge. *A thin bed of fossiliferous limestone* occurs at about 20′ under the *ore*, and the

Sections in Walker, Porter and West townships.



100' : 1"

T3.

ore deposit may properly be said to mark the uppermost limit of the *Clinton rocks.*

The *First roll*, or *Grubb's hill axis*, crosses Given's run 1400′ west from the forks of the road, near L. Robb's, where it barely brings to the surface above water level the lowest *Clinton red beds.*

The *Second roll* runs $\frac{3}{8}$ mile further west. Its crest or axis passes near R. W. Given's, where the following section was observed in a cutting along a by-road: (See Plate XXXVI, fig. 1.)

R. W. Given's Section.

1. Limestones, blue and shelly, magnesian,	20′	
2. *Red shales*,	30′	
3. Sandstone, hard, red, (makes Redstone ridge),	7′	162′
4. *Red shale*,	5	
5. Limy shales and concealed,	100′	
6. *Upper fossil ore*, 8″ to 10″.		

As will be seen from the above section, the *upper fossil ore* comes at about 100′ below the base of the hard *red beds* which are found in the bottom portion of the *Salina.*

The *Second roll* here barely lifts the *ore* above water level. It immediately descends again westward, but in a short distance the rocks are seen rising again in that direction, and the *upper ore horizon* emerges, followed by the *Clinton red beds*, and then 150′ to 200′ of *limestones* and *limy shales.* Finally, at half a mile west of Mr. Given's, the *ore sandstone* emerges and makes its characteristic ridge or terrace along the foot of the maintain.

The (lower) *fossil ore* was once exploited here on its last outcrop in land of Mr. R. Brenneman by Mr. Miller, who tunneled for it 50′ through the *ore sandstone*, but found it *hard* and *limy.*

The north-eastern half of this township seems, therefore, to be destitute of any valuable *fossil ore* for the *upper bed* is local and generally *hard*, even where it is best developed. It was once opened at the southern end of Mr. Given's land, about one half mile from his residence, and it was there 8″ or 10″ thick, but somewhat sandy. Mr. L. Robb informs me that it can be traced from the arch of the

Grubb's hill axis at the opening on his land south westward for nearly a mile, he having frequently plowed up pieces of it in the fields.

The Redstone ridge hard sandy beds come up on Given's run at 600′ north-west from the forks of the road at L. Robb's, and make a double ridge on the crown of the Grubb's hill arch : one where the beds come up, and another where they descend again 200 yards to the north-west.

In passing still further south-east, in the vicinity of Mr. Robb's, the limy beds and shales of the *Salina middle*, and the magnesian limestones of the *Salina upper measures*, come in, and make the well-known Mulberry ridge, through which the Crooked creek cuts a gap further south.

A remarkable layer in the Middle Salina shales, *a very hard siliceous rock*, only 8″ or 10″ thick, is exposed at the road-side, half a mile below Mr. L. Robb's, and although it contains a small quantity of lime, it is frequently more like a quartzite than anything else. Its great hardness has no doubt helped to make Mulberry ridge, although it is so thin a layer that its outcrop is concealed by *débris*. Mr. L. Robb, who has studied the geology of his vicinity quite thoroughly, states that he has observed this bed at only one or two other localities in the county.

Rounded bowlders of iron sandstone, and other rocks which seem to have come from Tussey mountain, lie at an elevation of 900′ A. T. on the land of J. M. Lloyd, half a mile south-east from Mr. Robb's. Associated with them are *flint* and common *white quartz*, much of which appears to be *rounded*.

Half a mile further east of this is a knob of Lower Helderberg *limestone* rising to 1240′ A. T. on the land of James Black.

Lead ore (*galena*) in small masses has been found at many localities in this township, along the north-west base of Warrior ridge, at the horizon where the *Salina upper beds* join on to the *Lower Helderberg limestone* proper ; in fact so plentiful are these crystals of *lead ore* that some may be picked up on most every farm which borders the north-western slope of Warrior ridge. These scattered nuggets are especially numerous on the land of Mr. Martin, one mile north from McConnellstown, which has led to the expenditure of a large amount of money in search of a regular vein or paying deposit of lead.

Several shafts have been sunk through the *magnesian limestones* of the *Upper Salina* to depths of from 20′ to 60′, and a tunnel was driven in to a considerable distance; but all to no purpose, as the ore could not be found in paying quantities, although a sum variously estimated at from $8,000 to $10,000 has been expended in exploitation. The *ore* occurs in thin seams of calcite which have accumulated along the joints, and vary in breadth from an inch up to one foot, or even more. Of course these seams are not likely to grow larger, but on the contrary will generally grow smaller, the further they are followed in from the surface, since they have evidently been formed by the percolating waters following along the joints, and widening them, but afterwards refilling the same and depositing the *lead* from solution. The *ore* occurs at the same geological horizon as the *lead and zinc ores* of Northumberland and Columbia counties, (see G[7].) viz: at the very base of the *Lower Helderberg limestone*, which thus seems to be a very generally distributed *galena-bearing horizon;* but in this township, or county for that matter, there is not the slightest hope of ever finding any valuable deposits of *lead.*

The Oriskany sandstone is a prominent feature in the topography of this township, rising as it does from a low valley of *Marcellus slate* into the conspicuous elevation known as Warrior ridge. This sandstone rises from the bed of the Juniata river at the eastern line of the township, nearly opposite the mouth of Bryan's run, and from that point slopes up gently to the summit of Warrior ridge, the south-east dip being seldom more than 10° and often less; in fact there seems to be some slight rolls passing through the *Oriskany area.*

Wolf rocks is a locality on Warrior ridge near Mr. A. P. Wilson's, where large blocks of *Oriskany sandstone* constitute a rock city. These masses worn and standing apart are 50′ or 60′ high.

The Stormville shales have been finely exposed on the Penn township line in a tunnel driven into the base of Warrior ridge on the land of Mr. Eisenberg. The tunnel was begun on the south-eastern face of the ridge with the expectation of reaching, or rather testing, the *Marcellus iron ore*; but since the tunnel starts in where a gully has been worn out of the ridge by a small stream, it failed not only to strike the *Marcellus beds*, but even missed the *Oriskany sandstone*, the latter having been disintegrated and almost completely removed from the south-eastern slope of the ridge, so that the tunnel began just beneath its horizon. Of course some *black beds* were found in the tunnel, and these were naturally enough regarded as *Marcellus rocks;* but they were only the *black limy beds* which are always found in the *Stormville shale series*, where unaffected by moisture. When I visited the locality the tunnel had penetrated the ridge about 100 yards, and had not yet passed through the *black beds* (which were not struck until the tunnel had been driven more than half its length); so, at the end of the tunnel Mr. Gage had a hole drilled down to a depth of 10′, and he reports that the rock, after passing through two or three feet of *black* material, became a gray limy shale.

Mr. Gage had some of the *black rock* analyzed, and the portion he sent for analysis was found to contain about 85 per cent *carbonate of lime.* Some badly preserved *fossil shells* were noticed in the black material on the dump, though they were too fragmentary for identification.

The Oriskany sandstone outcrop from McConnellstown north-eastward follows closely the turnpike until that turns south, at B. Collin's, near the Juniata river.

The soft shales between the *Hamilton upper* and *lower sandstones* are finely exposed in a deep cut of the railroad a quarter of a mile west of the Juniata river bridge, as dark or ashen-gray layers which gradually weather and crumble down into loose pieces from a fourth to a half inch in diameter. This "slate gravel" is shovelled like sand, and makes an excellent road metal.

About 50 rods south from the railroad cut, and just north from where the country road crosses Crooked creek, a bank of *Hamilton beds* are seen which cannot be far from the horizon of the *Hamilton upper sandstone.* These beds form a cliff about 30′ high where they have been quarried away for ballast, and road fillings, and in some of them were seen *Phacops rana*, *Orthonota undulata*, *Spirifera mucronata*, *Stictopora sp.?* and *Crinoidal fragments.* The rocks dip only 6° to 8° at this locality.

The following section is exposed along the turnpike just above the Middle Penitentiary: (Plate XXXVI, fig. 2.)

1. *Marcellus dark shales*, ...	25′	107′
2. Greenish-gray, impure *limestones* and limy shales,	12′	
3. *Black slates*, and concealed, seen along road for 600 feet, ...	40′	
4. Bluish-gray *limestone*, and limy shales, ...	10′	
5. Dark shales and concealed, ...	20′	
6. *Oriskany sandstone*, top only visible.		

The section given above represents the *limestone beds* at the base of the *Marcellus.*

The upper bed, No. 2, seems to correspond to the one with which the *Marcellus iron ore* is associated in southern Huntingdon, but no sign of *ore* is to be seen at this locality. It is possible that No. 3 is a few feet too thick since the dip may be less in the concealed portions than I found it in the exposed slates.

The lower bed of limestone, No. 4, is more compact than the upper, and some portions of it are pure enough to burn into lime.

A terrace is seen bordering the Juniata river, just back from the Middle Penitentiary buildings, rising with a bluff-like scarp to 40′ above the flood plain of the river, or 65′ above the present bed of the river, and 670′ A. T. On this terrace are found many bowlders of transported rock, some angular ones of *Medina sandstone* (3′ to 4′ in diameter), and a vast number of small rounded polished stones.

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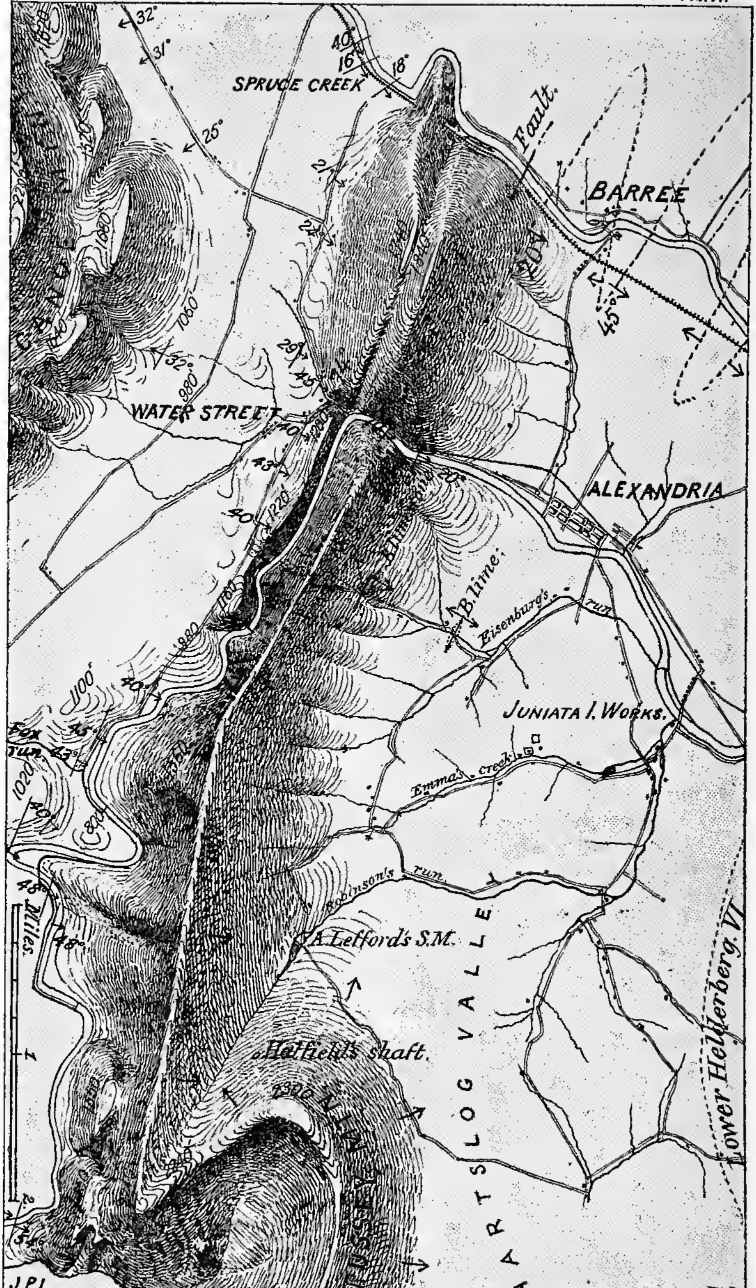
6. *Porter.*

This large triangular township lies north of Walker township, along Tussey mountain. Through it flow the


SPRUCE CREEK
Fault.
BARREE
WATER STREET
ALEXANDRIA
B. lime.
Eisenburg's run
Juniata I. Works.
Emma's creek
Robinson's run.
A. Lefford's S.M.
Hatfield's shaft.
HARTSLOG VALLEY
Lower Helderberg VI
Fox run
Miles
J.P.L.
T.3.

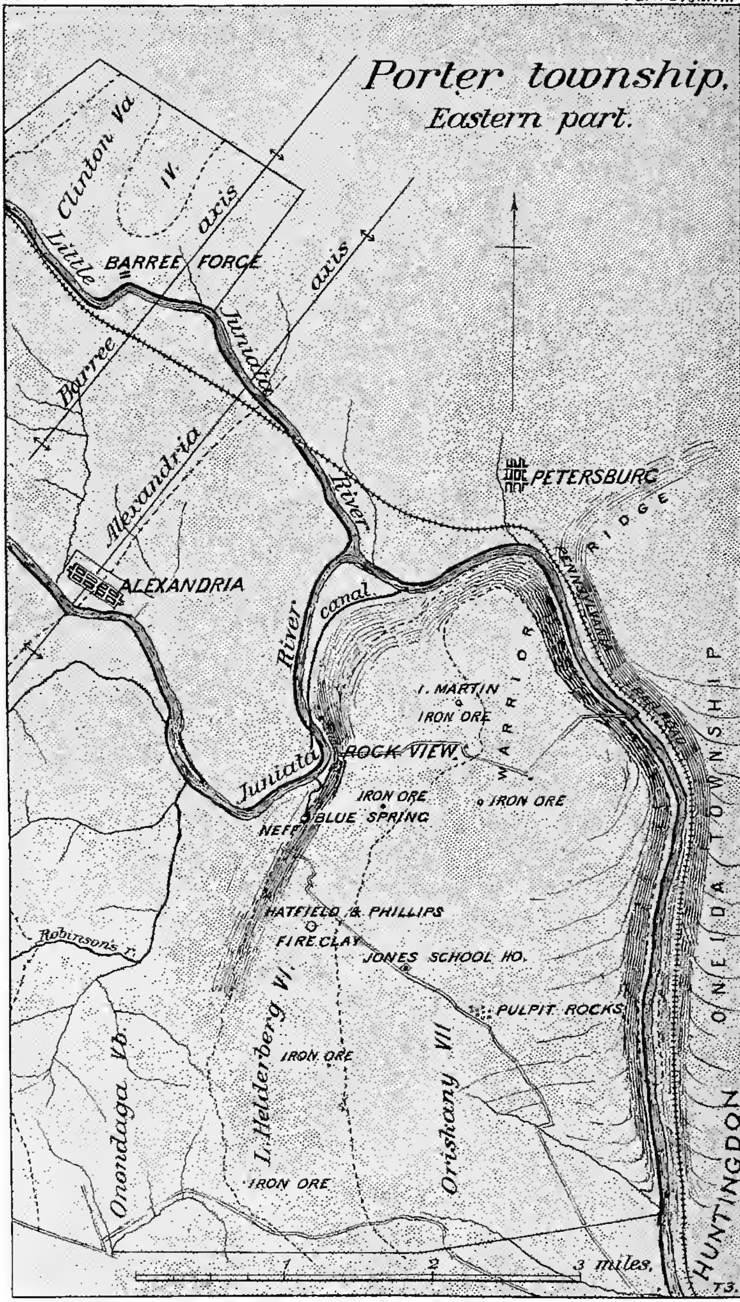
Frankstown branch and Little Juniata rivers, which uniting at the gorge of Warrior ridge make the Juniata river, which then borders the township to its south-east corner.

A synclinal loop in Tussey mountain occurs at the south-western corner, and in front of it, a projecting anticlinal knob, which incloses a similar loop in Blair county, as shown in the Atlas sheets of the Morrison cove map, published with Report T. The basin of the loop rises rapidly south-westward; is filled with Clinton shales, and drained by Robinson's run into the Juniata at the Juniata Iron Works, 1½ miles below Alexandria. The anticlinal axis which makes the cove in Blair county runs through the knob north-eastward to Alexandria.

From the head of the Loop Tussey mountain runs N. 10° E. 3½ miles; then N. 30° E. 2 miles to the Water Street gap; then N. 23° E. 2 miles to Spruce creek gap; and then N. 52° E. to the northern corner of the township. Tussey receives the local name of *Short mountain* between the two gaps, which, cut through the mountain to its base, add greatly to the picturesque scenery of this part of Huntingdon county, and furnish fine opportunities for the study of the Clinton, Medina, and Oneida formations.

The course of the Frankstown branch after issuing from its (Water Street) gap is remarkable. It flows E. S. E. 1¾ miles past Alexandria; then S. S. E. 1¾ miles to the foot of Warrior's ridge on a straight course to Huntingdon. But here (½ mile below the iron-works) it turns and flows N. E. and N. 2 miles along the foot of the ridge, to meet the Little Juniata. The combined Juniata then flows S. E. ½ mile; then N. E. ¾ miles under the limestone cliffs; then turns at a right angle; enters the gorge (of limestone capped with sandstone); flows through it S. E. 2 miles, and then due south 3 miles to the township corner at Huntingdon.

Warrior ridge is at its greatest height in this township, in some places rising to an elevation of 1250′ A. T. (the Pennsylvania railroad station level at Huntingdon being 622′ A.T.; at Petersburg 678′; and at Barree 724′ A. T.) This is owing to the low and frequently reversed dips which cause the massive *Oriskany sandstone* to rise so slowly westward


Porter township,
Eastern part.
Clinton Va
IV.
axis
Little
BARREE FORGE
axis
Juniata
Barree
Alexandria
PETERSBURG
RIDGE
River
ALEXANDRIA
canal
River
WARRIOR
I. MARTIN
IRON ORE
ROCK VIEW
Juniata
IRON ORE
IRON ORE
BLUE SPRING
NEFF
HATFIELD & PHILLIPS
FIRE CLAY
JONES SCHOOL HO.
Robinson's r.
PULPIT ROCKS
L. Helderberg VI.
Oriskany VII
Onondaga VIb.
IRON ORE
IRON ORE
ONEIDA TOWNSHIP
HUNTINGDON
1
2
3 miles.
T3.

that its outcrop extends much farther west than in Walker township. In many places on the crest of Warrior ridge the sandstone may be seen forming *rock cities*, isolated piles of rock 50′ high, with passage-ways from one to ten feet wide between them. One of these localities near the road to Alexandria is especially named the "Pulpit rocks."

At some points along this road, across Warrior ridge, the *Oriskany* has been wholly removed, leaving the top of the ridge composed of *Stormville shales*, which, at several localities, have been quarried for road fillings. They have a buffish gray color when their lime has been leached out, and they are sparingly fossiliferous.

A short distance west from the cross-roads at Jones' school-house, a large bowl-shaped depression is seen in Warrior ridge, covering more than one acre of ground. It has, of course, been formed by the solution of the underlying *Lower Helderberg limestones*, thus allowing the overlying *Stormville shales* to fall into the cavern. Large caves may exist in this region, since the depression spoken of drains many acres, and the water must have an outlet somewhere along the Juniata river; and this indicates that the Limestone No. VI is the main water-bearing formation from which the people of the Huntingdon trough can get a plentiful supply of water by boring artesian wells to it.

The top limestones come to the surface half a mile west from Jones' school-house on the Alexandria road. Here is *Hatfield and Phillips' clay bed.*—Just before the *limestone* comes up, the overlying *Stormville shales* have been extensively decomposed along the western slope of the ridge, making a large bed of clay, which has been mined and shipped to iron furnaces along the line of the Pa. R. R. at Johnstown, Pittsburgh, and other points by Messrs. Hatfield and Phillips. The large surface excavations have been deepened to more than 50 feet. The clay is now taken out through a tunnel, far enough down the hill to drain the excavation, and passing through clay the entire distance. The tunnel goes under the present road, and from its mouth a tramway leads around the hill to the drying apparatus. whence, after being thoroughly

Pulpit rocks of Oriskany Sandstone,

Fig. 1.

Fig. 2.

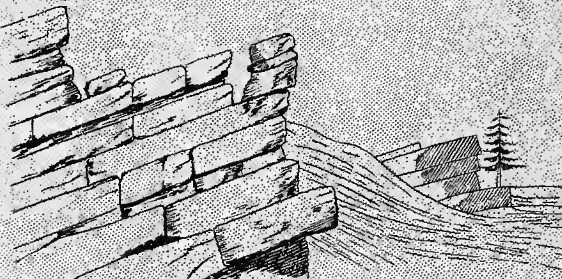


Fig. 3.

Fig. 4.

T3.

dried, the raw clay is hauled to a mill on the Frankstown branch and passed through crushers and sifters for shipment. That the clay has resulted from the decomposition of the *Stormville shales*, the lime and other soluble matter having been dissolved and removed, leaving only the siliceous and aluminous materials as clay, is certain, because the excavation shows the decomposed and structureless clay passing gradually into the stratified shales at the bottom of the excavation on the inner side next to the hill; and similar clay deposits are found at many points along Warrior ridge wherever the surface configuration has favored the decomposition of the *Stormville shales.*

Brown hematite iron ore is found along the base of the clay beds just at the contact of the *Stormville shales* with the underlying *lower Helderberg limestone.* The occurrence of the ore in this situation is evidence that it originated from the *Stormville shales*, the iron having been leached out of them and deposited in the limestone layers underneath.

A short tunnel was driven on the outcrop of the ore, and several tons of nuggets taken out. A line of *iron nodules* crop out all around the base of the clay, and have been dug into at several places, showing a large quantity of ore. An analysis of the ore (3 pieces, analyzed dry) by Mr. McCreath showed:

Iron,	43.075
Manganese,	.072
Sulphur,	.008
Phosphorus,	1.382
Lime,	.090
Siliceous matter,	19.640

The *phosphorus* seems excessive and all the ore may not hold as much. A considerable quantity of iron ore could be obtained by washing at this locality if water could be procured for that purpose.

Brown hematite iron ore was once mined to a considerable extent on the land of Mr. Isaac Martin, 1½ miles north of Hatfield and Phillips' clay bank. The ore was shipped on the canal to Mt. Union furnace; but since the abandonment of the canal from Petersburg to Hollidaysburg no ore has been mined. It is in the main *wash ore;* and the insufficient supply of water makes mining operation more difficult and expensive than it would otherwise be. The ore lies near the top of the *limestone*, about the same horizon as the Hatfield and Phillips' ore. Martin's ore was mined by a shaft, as well as by stripping. Considerable lump ore was taken from the drifts and shafts which did not need washing. Four pieces of *wash ore* picked up at the old workings were dried and analyzed by Mr. McCreath with the following result:

Iron,	34.050
Manganese,	.360
Sulphur,	.012
Phosphorus,	.799
Lime,	.120
Siliceous matter,	31.070

Rock View is a great cliff of *lower Helderberg limestone, No. VI*, ¾ of a mile south-west from Mr. Martin's, rising almost perpendicular from the river to a height of nearly 400′, and commanding an enchanting view of nearly all of Hartslog valley, walled in by Tussey mountain with its two gaps through which the blue outline of the Allegheny mountain appears in the distance. The locality is on the land of Mr. H. G. Neff. From the valley below the Rock-View limestone cliffs resemble a bluff of *Oriskany sandstone, No. VII*, but it is composed of the more massive layers of No. VI, nearly a mile west of any outcrop of the *Oriskany*. The lower part of the steep consists of *Salina* (*Onondaga*) *upper limestone beds*. These magnesian beds are pretty well exposed along the road at the foot of the hill.

Blue spring, a large fountain of water which rises near Mr. H. G. Neff's house, is simply the drainage of the region to the south, which, sinking through the limestone passages, collects underground and finds an exit from the magnesian limestone instead of making a surface stream. Caverns of course exist beneath the hill. The water is very clear and cold and would make an excellent trout pool.

The beautiful valley (Hartslog) enclosed by the Frankstown and Little Juniata rivers back from their junction has been worn out of the *Salina limestones* and shales. Its surface is in many places covered with a thick deposit of local drift stuff from the outcrops of the mountain, heaps of bowlders, such as are seen along the road from Alexandria to Petersburg, and in height reaching to the summit of the divide between the two rivers, 100′ above the river beds, and 750′ A. T. Many of the bowlders are rounded; but most of them are angular, and some of these are 2 or 3 feet in diameter.

The Clinton beds curving round the high knob of Tussey mountain fill the Loop to more than half-way up the mountain slopes. From the Loop northward the Clinton belt widens to 1⅓ miles at the Juniata, and 2½ miles at the Little Juniata. This broadening is caused by several rolls which come from West township.

The *fossil ore* of the Loop has been considerably exploited by Mr. Samuel Hatfield, who gave me the following account of his operations.

In a shaft 35′ deep near the foot of the mountain the *fossil ore* was found 2½ feet thick and immediately back of it a bed of *hematite*, 3′ thick. The late John Morley, chemist for the Cambria Iron Company, examined these beds *in situ* and gave Mr. Hatfield a very favorable opinion of their value. An attempt was made to reach these ores by a tunnel, but the material and trash through which it penetrated proved so loose and mud-like that the tunnel caved in, and the Pennsylvania canal (on which the ore would have been transported) having been abandoned about this time, the effort to mine the ores was not prosecuted further.

Several other drifts and trial shafts also found the *fossil* and *hematite ores* of good thickness.

Mr. Hatfield made an attempt to develop the "*block ore*" at the base of the *Clinton middle shales*, and with this view began a tunnel nearly half-way up the mountain side, and drove it 140 yards, passing entirely through the "*block ore*" and stopping in the *Clinton lower shales*. The "block ore" proving very sandy at this point, it was not considered the *true* "*block;*" so the tunnel was extended in hope of discovering some better bed beneath it. I collected three samples from the dump which were analyzed by Mr. McCreath and yielded:

Iron,	33.475
Manganese,	.147
Sulphur,	.025
Phosphorus,	.609
Lime,	1.880
Silica,	36.200

North of the Loop no *fossil ore* of any importance has been found along the base of the mountain as far as the Little Juniata river; for the *anticlinal* rolls are too gentle to bring the *fossil ore* horizon up to the surface; and the only outcrop of it runs at some distance up the foot slope of the mountain, which is not of a shape favorable to the formation of good ore. The bed was once exploited on the lands of J. Allen and A. Lefford, along the base of Tussey mountain, but it was too thin and hard to warrant mining.

The "*block ore*" makes its appearance half way up the Tussey slope, but as usual it is too siliceous to be of value.

There are several *rolls* found in the rocks of this township in passing from its eastern border westward to Tussey mountain. Several such rolls are in the Warrior ridge region, but they merely flatten the general east dip, and seldom reverse it to the west.

The Loop or Alexandria anticlinal may be seen on Eisenberg's run at the road-crossing, 100 rods N. W. of Mrs. E. Eisenberg's house, and a little over a mile from the county line on the crest of the mountain.

Here the *red ridge* of the *Salina lower beds* is thrown up; and on the crest of the arch *Barre limestones* come to the surface for a short distance; but the dip being sharply reversed westward they go under again; and the *Salina lower* and *middle rocks* descend (westward) in a broad belt, and then rise again. About 125 rods from the county line the *Clinton upper shales*, the *Barre limestones*, and the *ore sandstone* crops out again and finally. The outcrop of the *fossil ore* is here thin.

On the east dip of the Alexandria axis, near its crest on Eisenberg's run, there are exposed at the road-side:

Eisenberg run section.

1. *Soft red shale,* . . . . visible 10′
2. Gray and yellowish shale, ... 1′
3. Hard red sandy beds, ... 10′

The last stratum, No. 3, is the rock which makes Redstone ridge in the township to the south. Here it has decreased in thickness to such an extent that although it still makes a ridge, it is not high enough to be very noticeable. This low ridge however may be observed running on parallel to and 200 or. 250 yards north of the road from Mrs. Eisenberg's house to Alexandria.

The axis of the anticlinal runs through the middle of the borough of Alexandria and crosses the Pennsylvania railroad 350 rods east of Barre station, or half a mile southeast of the west township line. The arch rises so rapidly northward that the arch of the *fossil ore horizon*, which on Eisenberg's run is 150′ to 200′ underground, is at the Little Juniata 200′ to 250′ in the air.

In a cut on the Pennsylvania R. R., 100 rods east of Barre station, the following section was made: (See Plate XXXVI, Fig. 3.)

Barre station section.

1. *Barre limestone,* a series of thin-bedded blue and bluish gray limestones interstratified with gray shales slightly *fossiliferous,* . . . . . . 150′
2. Bluish gray shales interstratified with occasional bands of limestone, *fossiliferous,* . . . . 75′
3. Very hard calcareo-siliceous rock (*Ore sandstone*), . . . 25′
4. Place of the *fossil ore* (not seen).

This section is very interesting from the fact that it shows a notable development of the limestone beds over the *fossil ore* horizon. The S. E. dip is here for the most part 45°, but varies from 30° to 70°; the beds cleanly exposed in the wide cut of the railroad; and the *ore sandstone* at the base of the section making a low ridge across the line.

A species of *Favosites* was seen near the top of the limestones, about the size of one's fist, and weathered out from the surrounding matrix. The limestones contain shells in a fragmentary condition.

The limestone layers in the 75′ of shales are almost entirely confined to the upper half, and a small brachiopod is very numerous in the limestones and shales near the top of the 75′, while near the bottom are seen many *Rhynconellas*, *Aviculas*, and other fossil shells, but in a very fragmentary condition.

The Ore sandstone is so limy at this locality that one would at first glance call it a genuine *limestone*; but on closer inspection, it is seen to contain a large amount of siliceous material, possibly 60 or 65 per cent, and it is here more than double its usual thickness, and a very massive rock. Exposed in the cut to atmospheric action, the lime has been partially leached from its outer coat, which has acquired a dark brownish color.

The fossil ore should be found near the base of No. 3. Its place was covered up when I visited the locality, but Mr. Mumper says that he has seen it here in as a thin calcareous layer.

West of this cut everything is concealed (along the railroad line) to and for 300 yards beyond Barre station, where a series of exposures begin and continue, with scarcely any interruption, for several miles, in the railway cuts, permitting me to make the following section between Barre and the west end of Spruce creek tunnel: (See Plate XXVIII.)

Spruce creek gap section.

1. *Clinton middle shales* exposed for 1400′; dip 20° S. E.,	480′	
2. Concealed pieces of *block ore* seen on the surface,	100′	985′
3. Olive and reddish sandy beds to 2880′ from top of No. 1; dip 20°,	405′	
4. *Medina*, gray and white sandstones, 2920′; dip 20°,		1000′
5. *Red shales* and sandstones, seen along railroad for 2400′ to east end of Spruce creek tunnel, the railroad however not running squarely across the dip (which is still 20°) about,		700′
6. Concealed in the tunnel,	200′	300′
7. *Oneida conglomerate*,	100′	
8. *Hudson river shales, No. III*,		300′
9. Limestones of No. II.		

The thickness of the *Clinton measures* in the above section may seem excessive, but yet the construction will not make them any less. There cannot be an interval of more than 50′ from the top of the section to the horizon of the *fossil ore.*

A fault near the watch-house crosses the railroad at the base of No. 3 of the section. The massive white sandstones of the *Medina* have been broken and pushed out over the *Clinton lower shales.* The character of the *fault* is well exhibited in the railway cutting, but its extent could only be estimated, at not less than 200′, nor more than 500′.

The block ore in Short mountain is too siliceous for use. Specimens were collected, and analyzed by T. T. Morell:

Iron,	41.100
Phosphorus,	0.500
Lime,	0.290
Magnesia,	0.230
Alumina,	3.930
Silica,	25.950

The *Oneida conglomerate* of this section should include the 200′ of concealed rocks, which help to make the high hogback, around the north end of which the Little Juniata winds, and through which the Spruce creek tunnel is driven. The 100′ of *Oneida conglomerate*, in the section, make a line of great cliffs along the west slope of the hog-back.

The Hudson river (*Loraine*) *slates, No. III,* are seen cropping out at the western end of the *Spruce creek* tunnel; and it is very remarkable that here only 300′ of these beds intervene between the base of the *Oneida conglomerate* and the top of the No. II limestones; whereas, where measured in Blair county by Mr. Sanders, No. III has a thickness of 1100 feet. But a fault here runs along west of the hog-back, and has swallowed up a large part of the formation. (See page 144 above.)

Barre furnace and forge, on the north bank of the Little Juniata, were built to work the *fossil ore* which is found north of the river. At present the furnace runs principally on brown hematite ore from Franklin township.

The fossil ore was once mined to a considerable extent on its final outcrop just north from Mrs. Mumper's residence, where it is seen dipping southward at the rate of 15° or 20°. The ore is there 2′ to 2½′ thick, hard, and limy and would not average more than 30 per cent of metallic iron. The rocks continue dipping south until the bottom of the syncline is reached near the residence of Mrs. Mumper, and then the dip being reversed the rocks rise rapidly bringing up the *Barre limestone* in the field just above the furnace where it has long been quarried for flux. Only 6′ or 8′ (the upper half) of the limestone layers are used. It is a bluish-gray rock somewhat crystalline, and much streaked with calcite. Its composition as shown by Mr. McCreath's analysis being:

Carbonate of lime,	89.911
Carbonate of magnesia,	2.028
Oxide of lime and alumina,	1.790
Phosphorus,	.014
Siliceous matter,	5.660

As analyzed by the late D. J. Morley, chemist for the Cambria Iron Company, the upper portion of the bed was shown to contain: Carbonate of lime, 96.000; a strong trace of phosphorus; sulphur, 0.750; and the lower portion: Carbonate of lime, 91.000; phosphorus, a trace; and sulphur, 0.190.

A short distance south-east from where the *Barre limestone* is quarried near the furnace, we come to the crest of the *Barre anticlinal* which lifts the *Clinton fossil ore* and its overlying *ore sandstone* into a high sharp ridge, which gets higher and higher as we follow it northward until the *Medina sandstone* is brought up, and the roll enters the flank of Tussey mountain.

The fossil ore has been exploited and mined to a considerable extent along both sides of the *Barre axis*, both by drifting and stripping. One of these localities is one mile and a half north-east from the furnace, where the ore lies near the surface on the crest and sides of a considerable hill. The ore was soft here and quite rich, its only covering being the *ore sandstone.*

Where the *Barre axis* crosses the Little Juniata river a few hundred yards below the furnace, the olive shales and slates rise from beneath the *fossil ore* on a very steep dip, and are carried up 150′ to 200′ above the water level. Then the dip is reversed and the rocks pitch south-east at an angle of 60° to 80°, which soon puts the olive slates under the river bed again, and brings down the *fossil ore* and *ore sandstone*, and then the *Barre shales and limestone.* These are finely exposed along the river road.

Here about 75′ of the *Barre limestone* beds are exposed at the roadside where it was once quarried for flux at the furnace; but the beds were here too impure, and the quarry has been abandoned.

The fossil ore has been exploited by Mr. Mumper about a mile from the river, just east of the road which goes north from the river 200 rods below the furnace. The locality is situated on the northwest slope of the *Alexandria anticlinal;* the tunnel begins in the *Barre limestone;* the ore was struck at 110 yards, where it is 15″ thick but quite *hard* and *limy. The ore sandstone* above it is very hard, and much difficulty was experienced in driving the gangway through it. The dip is 30° to 35°, and the *ore* is thus soon carried into the air, there being very little *soft ore* even at the outcrop.

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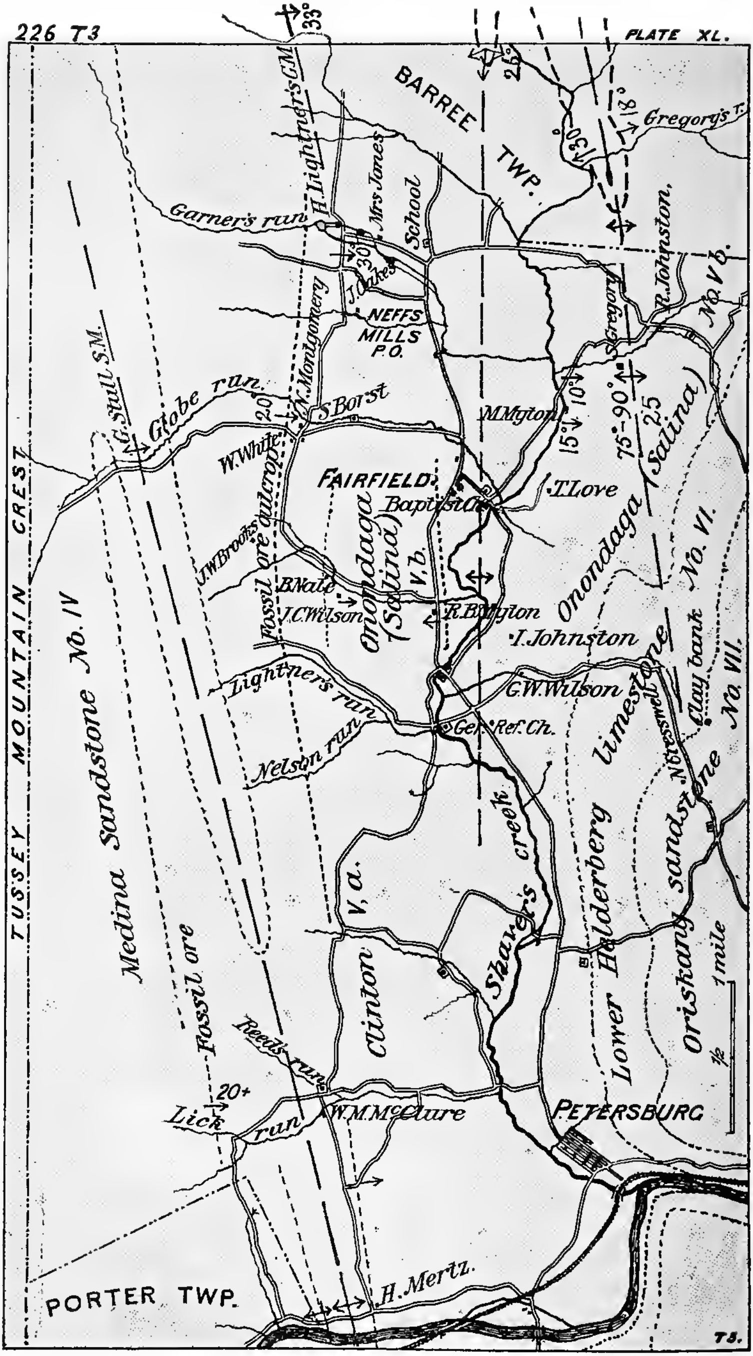
7. *West and Logan.*

West township, bordering the north bank of the Little Juniata for nearly 7 miles from Tussey mountain toward Huntingdon, has been divided and its eastern portion called *Logan township.*

Shaver's creek flows through a broad valley gathering the drainage from Tussey mountain on the north, and Warrior ridge on the south.

The Alexander and Barre axes elevate the *Medina sandstone* into high, sharp ridges upon the foot slope of Tussey mountain, slightly diagonal to its crest. The gentle rolls of Shaver's creek valley and Warrior's ridge passing into Barre township also bring up the *fossil ore.* Those of Warrior's ridge escape from its northern flank in a series of offsets, which gradually reduce the ridge to its natural width in Barre township. Cliffs of sandstone between 400′

PLATE XL.


BARREE TWP.
Gregory's r.
TUSSEY MOUNTAIN CREST
Medina Sandstone No. IV
Fossil ore
G. Still S.M.
Globe run
Garner's run
H. Lightner's G.M.
Mrs Jones
School
J. Oakes
NEFFS MILLS P.O.
N. Montgomery
S. Borst
W. White
Fossil ore outcrop
J.W. Brooks
B. Nale
J.C. Wilson
FAIRFIELD
Baptist Ch.
Onondaga (Salina) V, b.
R. B. Myton
M. Myton
T. Love
Gregory
R. Johnston
Johnston
No. V b.
Onondaga (Salina)
I. Johnston
G.W. Wilson
Ger. Ref. Ch.
Lightner's run
Nelson run
Shaver's creek
Clinton V, a.
Lower Helderberg limestone
Oriskany sandstone
No. VI.
Clay bank
No. VII.
N. Creswell
Reeds run
Lick run
W.M. McClure
20+
PETERSBURG
H. Mertz
PORTER TWP.
1 mile
1/2
T3.

and 500′ high (above the level of the river) face the northwestern side of the ridge. In some places the surface is strewn with its masses; in others it has crumbled into loose sand; and in others the sand has been washed away, leaving the *Stormville shales* or even the uppermost beds of the *Lower Helderberg limestone No. VI* at the surface of the ground.

No. VI is well exposed along the Juniata river in the railway cuttings. The top layers rise from the river bed not far from the township corner; and in 150 rods get to be 200′ above the stream. Here the pure limestone layers have for a long time been quarried for ballast by Mr. Frank Heffright. (See Plate XXXVI, Fig. 4.)

Heffright's Quarry section.

1. Gray and buffish limestones, impure, ...	45′
2. Limestone, gray, crystalline, at top, becoming dark blue below, and passing into thin, flaggy impure beds at base,	50′
3. Dark blue, flaggy limestone, ...	10′
4. Light gray, thin-bedded limestones, ... visible	25′

The dark gray, coarsely crystalline layers at the top of No. 2 represent the *gray limestone bands* which are so highly valued for flux at the Powellton and other furnaces. This stratum is here about 6 feet thick, and, coming at the very top of the quarry, under a great mass of the tough impure limestones in No. 1,* has been quarried to only a small extent. It is full of *fossil* remains, principally *crinoidal fragments*, and has a fetid odor when broken.

The main mass of the quarry rock, No. 2, extends along the railroad in a bluff which has been quarried back for two or three rods from the very edge of the railroad, the road-bed of which was cut out of the limestone at this point. The rock breaks into clean, angular blocks, which are durable, and prized for ballasting the track, hundreds of car-loads being annually used on the road.

Potter's clay.—One half mile north-west from Heffright's quarry a large deposit of bluish white clay lies beside the

* *Bastard limestone* of the Columbia and Montour county quarry sections. See Report G⁷.

railway track, on the land of Mr. Kennedy Myton; and the clay is burned into excellent pottery. The deposit is exposed in a bank 10′ high at the level of the R. R., 30′ above the river. A bed of rounded bowlder-trash covers the clay. The clay may be a result of the decay of the impure limestone layers at the bottom of No. VI.

From the Pottery towards Petersburg appear thin bedded, shaly gray, and bluish, impure limestones; and then just below Petersburg station the overlying yellowish, limy shales, and buffish, magnesian limestones at the top of the *Salina series*.

Clay bed on Warrior ridge.—On the north-west slope of Warrior ridge, on the land of Mr. Creswell, a bed of very good clay has been mined for a long time and hauled to the railroad at Petersburg. As the bank had not been operated for two years none of the exposures were fresh; but it was plain that the clay occurring near the top of No. VI has resulted from the decay of these impure limestones and of the *Stormville shales* above them.

The first anticlinal roll on the Barre township line north of Warrior ridge, crosses Gregory's run half-way between R. Johnson's and S. Gregory's, bringing up the bottom beds of the *Salina*. The *hard red sandy layers* make a low ridge as usual, dipping 25° (S. 40° E.), close to the axis of the roll. Nearly opposite S. Gregory's, the *Salina red beds* dip north-west, from 75° to vertical and even overturned.

On this north-west dip the following section is exposed along the road opposite S. Gregory's: (Plate XXVIII.)

Gregory's run section.

1.	Limy shales and gritty beds, making a ridge,		
2.	*Blackish shale,*		2′
3.	Impure, greenish limestones, magnesian,		250′
4.	Greenish, limy shales,		10′
5.	*Red shale,*	50′	100′
6.	*Hard red sandy beds,*	5′	
7.	*Red shale*	5′	
8.	Marly, yellowish gray shales,	10	
9.	*Red sandy beds,* quite hard, make *Redstone ridge,*	15′	
10.	Marly shales,	5′	
11.	*Red shales,*	10′	

No. 2 is a thin *dark shale* very much resembling one seen in the *Salina beds* of Penn township.

Nos. 5 to 11 are rocks that are found along *Redstone ridge*; but the *ridge* is made by Nos. 6 and 9 alone, all the other beds being soft. We have here 100 feet of *red rocks* exposed, and probably 50′ more below the base of No. 11 that are concealed; this makes the entire *red group* of the *Salina* 150 feet thick, or not quite half of its thickness 100 miles to the north-east.

Where the road crosses Gregory's run, ⅛ mile further down the stream, the *Salina shales* are seen dipping 20°, S. 40° E.; a basin, therefore, intervenes between this point and S. Gregory's.

At the Shaver's creek crossing, near M. Myton's, (400 yds. further west along the road,) the *Salina red beds* dip 15°, S. E., and under them appear the limy yellow and olive beds of the *Clinton upper shales*. From here, the *Salina red sandy beds* keep on W. S. W. as a low ridge, passing just back of T. Love's house, and just south of R. Cunningham's and G. W. Wilson's; from Myton's west to Wilson's being 2⅛ miles.

A *second anticlinal roll* runs near the Baptist church, just below Fairfield, and crosses Shaver's creek repeatedly.

The *Salina red beds*, dipping N. W., make a bluff along the Petersburg road just below Fairfield, and their outcrop continues along the same until we come to near the forks of the road at R. B. Myton's, where the greenish, limy shales *above the red beds* appear. These greenish shales and limestones of the *Salina middle group* crop out along Myton's run, in passing north-west up the same from R. B. Myton's, until we come to J. C. Wilson's, where the *red Salina* again comes up, the axis of the *basin* being about half way between the two points.

On above Mr. Wilson's other *red beds* come up to the north-west; and at the crossing of the little run, 75 rods north from Mr. B. Nale's, the top red bed of the *Clinton upper shales* makes its appearance. Fifty rods further, near J. W. Brooks', the *Ore sandstone* comes up and forms a ridge, which extends (east) to N. Montgomery's, on Globe run, near the cross-roads.

A ridge of *red Salina* runs nearly parallel to the *Ore sandstone* ridge, and 50 to 70 rods south of it.

The sandstone (15′ thick) just above Mr. Montgomery's makes a cliff along Globe run, with dip S. 45°. E., 20° to 25°. Under it, 30 feet of olive slates are exposed. No trace of the *fossil ore* appears here, where it would certainly give evidence of its existence if present, and no *fossil* ore bed has been seen under the sandstone anywhere in this district.

Along the road up Globe run nearly everything is concealed beneath a thick sheet of *débris*, so that the structure cannot well be made out. It is possible that another *anticlinal roll* runs north of Montgomery's cross-roads.

The Alexandria anticlinal crosses Globe run at G. Stull's saw-mill, a mile above Montgomery's cross-roads. Here the *Medina white sandstone* makes an arch in a high ridge, which issues diagonally from the mountain.

From S. Borst's on Globe run, 500 yards below Montgomery's cross-roads, a low ridge of *Salina red beds* runs east, south of and parallel to the road to Lightner's grist-mill on the next run.

Just west of J. Oakes' this ridge crosses the road, and keeps on at the distance of about 100 yards north of the road to Garner's run.

South of this red ridge, near Mr. Oakes', another *red rock*, 10′ to 15′ thick, makes a red streak through the plowed fields. It must lie about 300′ above the *Redstone ridge bed.*

At 75 rods east from J. Oakes' is a cross-roads, and 1400 feet north of this cross-roads the *Ore sandstone* makes a well-marked ridge, but no *fossil ore* has been reported under it.

Garner's run cuts through the *red Salina beds* just north of Lightner's grist-mill, and the ridge which they make runs on into Barre township. The ore sandstone ridge also runs on, about 350 yards north of it.

The strata above the red beds at Lightner's mill dip 30°;

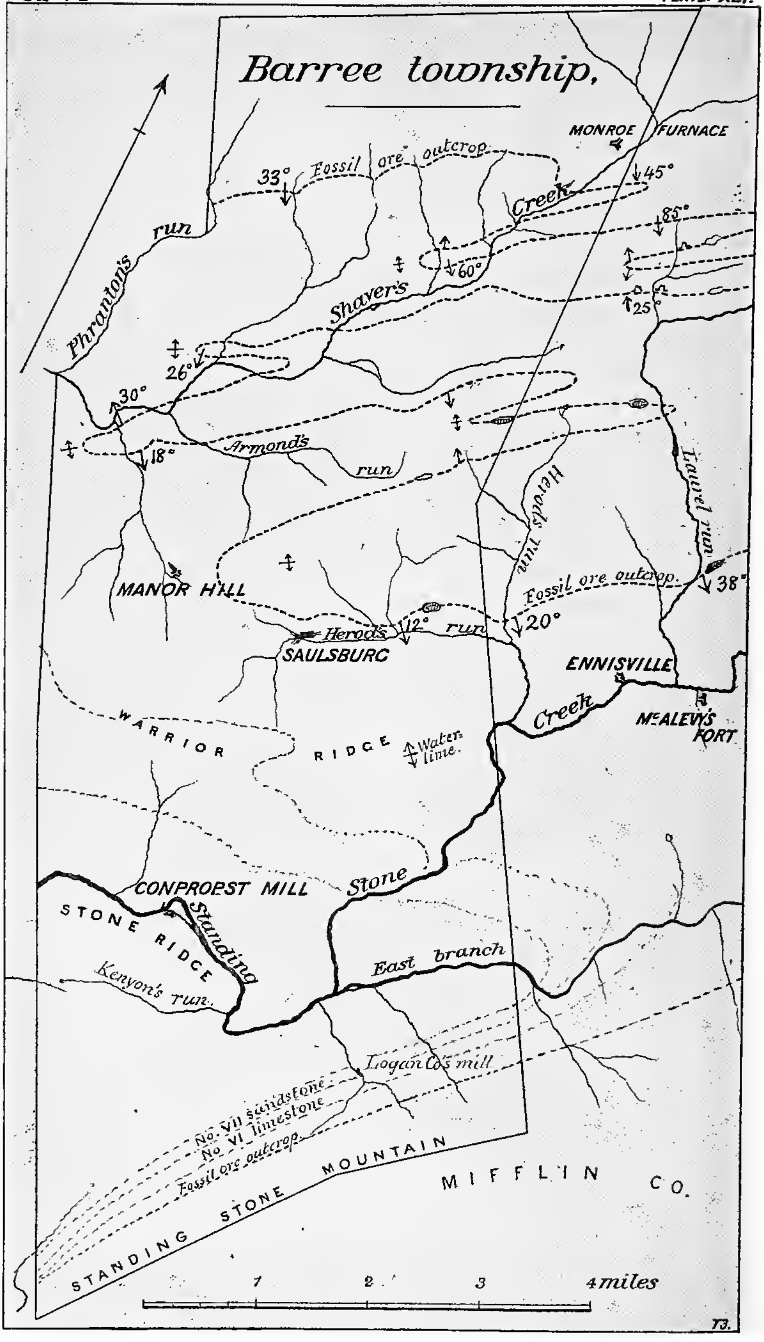
and 350′ above the *red beds*, a layer of *red shale* is seen 20′ thick, where the road crosses Garner's run near Mrs. Jones'. Above this *highest red bed of the Salina formation* lie impure, buffish, and pale green limestones which make a ridge. Below the *red bed* are limestones and limy shales of very much the same aspect, though not so hard.

The Alexandria anticlinal crosses the Little Juniata river near where the West-Porter township line starts. Here, at a cut along the river road, the *fossil ore* and its associated rocks are splendidly exposed. The ore comes up on a north-west dip, and then making a sharp turn reverses to the south, but immediately doubles back and is carried into the air on the crest of a ridge, 200′ high, made by the *Ore sandstone*; which, fully exposed along the road, consists of 20′ massive calcareo-siliceous rock with a shale parting near the center 2′ to 3′ thick. *The fossil ore* is here one foot thick, and very hard and limy, although completely exposed to the elements. Above the *Ore sandstone* lie 50′ or 75′ of bluish shales containing a few streaks of limestone; and over these lie the *Barre limestone* beds also well exposed along the river road.

On the south *side of the anticlinal* the sandstone descends at an angle of 25° to 30°, and disappears beneath the bed of the river just north from where the road turns off eastward at H. Metz's, 130 rods from the Porter township line.

South of this the upper Clinton beds soon come down and then the *Salina beds* occupy the river banks, with gentle undulations all the way to Petersburg.

The Fossil ore was once exploited on Lick run, near the northeastern corner of Porter township, 200 yards north of the road crossing, by Wm. McClure. The bed dips 20° to 25°, S. 45° E. and is 10″ or 12″ thick and very limy; while the sandstone above is massive. *The Salina red ridge* runs here at 100 yards south from the road which passes McClure's.


Barree township.
MONROE FURNACE
Fossil ore outcrop
33°
45°
85°
Creek
Shaver's
Phranton's run
60°
25°
26°
30°
18°
Armond's run
Herods run
Laurel run
MANOR HILL
Fossil ore outcrop.
38°
Herod's
12°
run
20°
SAULSBURG
ENNISVILLE
Creek
McALEVY'S FORT
WARRIOR RIDGE
Water-lime.
CONPROPST MILL
Stone
STONE RIDGE
Standing
East branch
Kenyon's run
Logan Co's mill
No. VII sandstone
No. VI limestone
Fossil ore outcrop
STANDING STONE MOUNTAIN
MIFFLIN CO.
1
2
3
4 miles
T3.

8. *Barree.*

[This township stretches N. N. W.-S. S. E. between two parallel lines 4 miles apart, and from Tussey mountain to Stone mountain, 12 miles, including Warrior's ridge, Stone valley, Stone ridge, &c. Standing Stone creek makes its great bend, and forks at the head of Huntingdon valley, inside the semicircular outcrop of the Warrior's ridge. But this semicircle is in fact (as shown on the map) a set of zigzags, produced by as many rolls coming from Jackson township, and corresponding to zigzags in the fossil ore outcrop laid down on Mr. Billin's special survey map, prolongations of the anticlinals of the Seven Mountain region on the Centre and Mifflin county lines.*

Shaver's creek flows from Jackson township along the foot of Tussey mountain, into Barree township at Monroe furnace (Logan Iron and Steel Works). It keeps on across the township (southwest) getting further away from the mountain as it crosses diagonally five outcrops of the Clinton fossil ore, brought up by three anticlinal rolls.

Roaring run from the mountain joins it at the Jackson line; and *Phranton's* run from the mountain at the west line. Three small runs are intermediate; but these three descend only from the long terrace-like spur of the mountain, which carries an anticlinal behind the last ore crop, and is the cause of the distance of the ore outcrop here from the crest of the mountain, namely 1⅝ miles on Phranton's run.

Armond's run flows west into Shaver's creek at P. Getty's, following down a basin between two long outcrops of fossil ore, and crossing one of them at J. W. Myton's within ⅛ mile of the creek.

Henry's run from Warrior ridge flows north-west past Manor Hill post-office into the creek, ½ mile below P. Getty's, just at an outcrop of the ore (dipping N.), having ¼ mile before reaching the creek crossed the counter outcrop (dip-

*This map was printed several years ago for Report S, and marked Plate IX. It is now transferred to this Report, T[3], to be published; circumstances having delayed the completion of Report S.

ping S.) The anticlinal, which casts off to the north and the south these two outcrops, is very sharp and straight; and keeps on (S. 50° W) into West township, being mentioned (page 228 above) as crossing Gregory's creek ½ mile above L. Myton's, where the rocks dip 90° northward and 35° southward. It then runs into Warrior ridge, making an offset in its flank east of J. Cunningham's.

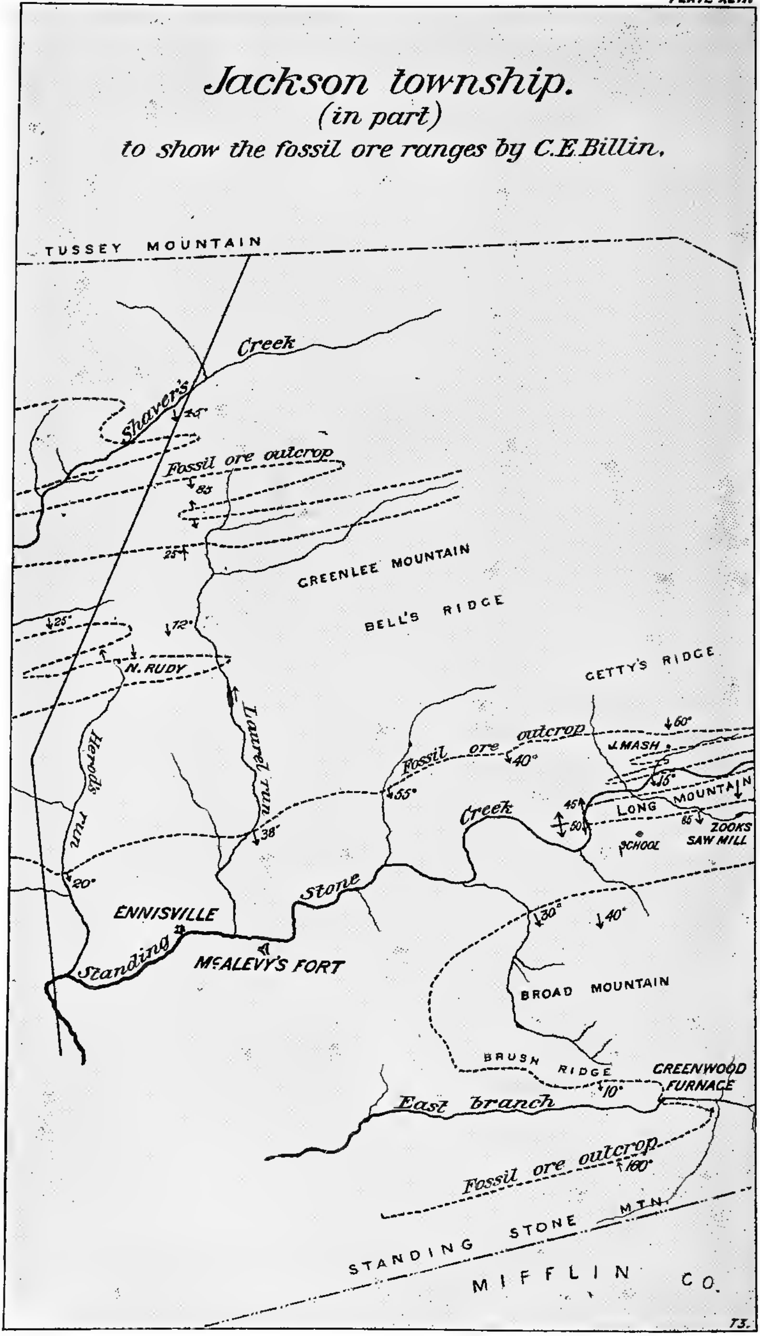
At Manor Hill P. O., a broad flat anticlinal crosses the township, one of its fossil ore outcrops running N. E., and the other east, past Saulsburg P. O., the two connecting in a semicircle ⅓ mile east of Manor Hall P. O. This anticlinal enters Warrior's ridge at the head of Gregory's run, but merely makes a curve in its flank.

Warrior's ridge is again set back (southward) opposite Wm. Stewart's and A. Cresswell's, and then runs on east to the Saulsburg road, at the Stewart manors. South of this, at C. Peichtal's, another anticlinal comes from Jackson township, and sets Warrior ridge back still further (southward) to R. T. Green's, C. C. Ash's, whence it runs on east to Standing Stone creek, at J. Huston's and A. and W. Couch's. Here the creek flows through the ridge, and comes out into the basin of overlying *Marcellus rocks* at T. Jackson's school-house, where the road crosses the creek. Warrior's ridge keeps on east to the Jackson line, and beyond it half a mile, where it comes to an end; its rocks (*Oriskany sandstone and Lewistown limestone*) basining up there and returning on a N. W. dipping outcrop, very steep and very narrow, across the east branch of Stone creek, and then south of it to the north side of the head of Mill creek, at the foot of Stone mountain, in the southern angle of the township. Its outcrop makes *Sand ridge*, which crosses into Henderson township a mile from the township corner (on the crest of Stone mountain) near John Wolfkill's house. The *Oriskany* outcrop of *Sand ridge* is cut by a run which enters Stone creek just below its forks (P Wilson's saw-mill,) the outcrop being visible ¼ mile below the Logan Iron and Steel Co.'s saw-mill dam. The same outcrop is also cut by another run at J. B. Henderson's, ½ mile east.

The triangular space 3 miles long on a base of 3 miles (along the Henderson-Oneida line) is a trough of overlying Marcellus, Hamilton, Genessee, Portage and Chemung rocks, deepening south-westward. The great bend of Stone creek takes place as soon as it gets through Warrior's ridge into the trough, its effort being to scoop its channel in the soft Marcellus shales which fill the head of the trough and then belt off both ways west into Oneida township and S. W. into Henderson township; the northern belt hugging the south foot of Warrior's ridge, and the southern belt the north-west foot of Sand ridge. It looks upon the map as if the two branches of Stone creek after joining meant to take the south-west belt for a channel to the Juniata; in that case Mill creek would have received them. But after trying this route for a mile from the forks to Millikin's, Stone creek turns back *north* for a half a mile, then *west* a mile (to Conprobst's Mill P. O. and then follows the northern belt south-west through Oneida county to within 3 miles of the river, where it cuts *south-east* across the Hamilton rocks into the overlying soft Genessee shales and then runs *south-west* along them under the Portage sandstone bluffs to the river.

This curious devious course pursued by Standing Stone creek is easily explained. The northern belt of Marcellus shales is broadened by a gentle south dip from Warrior's ridge; the southern belt of steep N. W. dips is very narrow and shut in between the *Oriskany* Sand ridge, and the *Hamilton sandstone* ridge. Erosion would go on more rapidly in the former than in the latter belt, and the present creek merely represents the last stage of the process up to the present time.

This example is full of instruction for those who wish to understand the principles of topography; proving as it does that the sculpturing of the surface of the Appalachian region was not a rapid, but very slow process; and that it was effected on mechanical principles by no other agency than the ordinary rainfall which drains off now, just as it has been draining off in all ages since the coal era, along the easiest channels which it could make for



Jackson township. (in part) to show the fossil ore ranges by C.E. Billin.

itself under the infinitely varied circumstances of stratification and plication combined.

The backward semicircular course of Stone creek from Milliken's round to Conprobst's Mill P. O. is explained by the Portage sandstone outcrops of Stone ridge north of *Murray's* run and *Kenyon's* run curving round south and south-west to return into Henderson and Brady townships as *Little ridge*. The amount of Chemung rocks inside the trough of Portage rocks is very small in this township.

The description of the fossil ore outcrops as determined by Mr. Billin in his topographical survey of the Seven mountains, and as exhibited on his map-sheet, published with this report, will be found under the next head of *Jackson township*.]

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9. *Jackson.*

[This township occupies the northeast end of the county, where Tussey mountain along the north line and Stone mountain along the east line lose themselves together in the Seven Mountains of Clinton county.

Shaver's creek ridge, *Greenlee mountain*, *Bell's ridge*, *Getty's ridge*, *Long mountain*, and *Broad mountain*, are six intermediate anticlinal spurs which project westward from Clinton county; Bell's and Getty's ridges making up together the *Bear Meadow mountain*.

Shaver's creek heads in the narrow red shale valley between Tussey mountain and Shaver's creek ridge, and flows west into Barree township.

Muddy run and Laurel run head in a deep cove between Shaver's creek ridge and Bear Meadow mountain, and flow south into Stone creek at McAlevy's Fort.

Little Laurel run cuts across the ends of the two spurs of Bear Meadow mountain, and enters Stone creek 1½ mile above the Fort.

Stone creek heads on the Clinton county line and flows west down the broad red shale valley between Bear Meadow mountain and Broad mountain; Long mountain being so called because it is the shortest of them all, and splits in two the head of the valley on the county line; *Ross run* and *Detweiler's run* being two of its branches heading between Bear Meadow mountain and Long mountain; the main Stone creek heading between Long mountain and Broad mountain.

The *East branch* of Stone creek heads in Mifflin county and flows west along the rich fossil ore outcrops between Broad mountain and Stone mountain; receiving nothing but spring-brooks until it enters Barree township and unites with main Stone creek; with one exception, viz:

Furnace run, which heads in the fault in Stone mountain, and curves round the broken spur to *Greenwood furnace.*

Barr's saw-mill run heads near the furnace and flows west by north into the main Stone creek, a mile above McAlevy's Fort.

Herod's run flows south along the west township line into Stone creek, nearly 2 miles below the Fort, or 1 mile below Ennisville.

All the mountainous half of the township has, of course, a strongly accidented surface of *Medina sandstone No. IV*, covered with loose rocks and woods. The other half consists of *Clinton and Onondaga* gray and red shales and soft sandstones, with lime shales, &c. *formation No. V.* Two loops of *Lewistown limestone No. VI*, and two high hill spurs of *Oriskany sandstone No. VII*, one in each loop, project eastward from the end of Warrior's ridge in Barree township.

The *fossil ore crop* which runs in front of Stone mountain to Greenwood furnace there doubles back and runs westward along *Brush ridge*, back of the mines. It then bends north around the base of Broad mountain, and runs north-east to the county line. Returning thence, in a series of long, close zigzags, it follows the south foot of Getty's ridge to Henninger's cross-roads, on Little Laurel run, Laurel run, a mile N. W. of McAlevy's Fort, and Herod's run at Jackson's saw-mill. Two short loops of this outcrop penetrate this township from Barree township at the head of Herod's run; and two more loops, one short and one very long one, follow the head waters of Laurel and Muddy runs between Greenlee and Shaver's mountains.

The following report of the fossil ore outcrops, by Mr. C. E. Billin, relates to Barree as well as Jackson township, and is illustrated by Sheet No. 3.

Ranges of fossil ore through Barree and Jackson townships, by C. E. Billin.

The outcrop of the Clinton (No. V) fossil ore bed forms a sinuous line, 60± miles in length, extending across the head of Stone valley between the ends of the Seven Mountains and Warrior ridge. All the openings, with the exception of those on Brush ridge, were made about the year 1850 and have long since been deserted. At present it is impossible to get any very satisfactory measurements of the thickness of the ore beds in these old openings. Along the streams and hillsides the exposures are so wretchedly poor that not only the beds cannot be measured but it is extremely difficult to follow their outcrop. In fact, it will only be by very careful detailed work that the outcrop of some of the smaller flexures can be absolutely located.

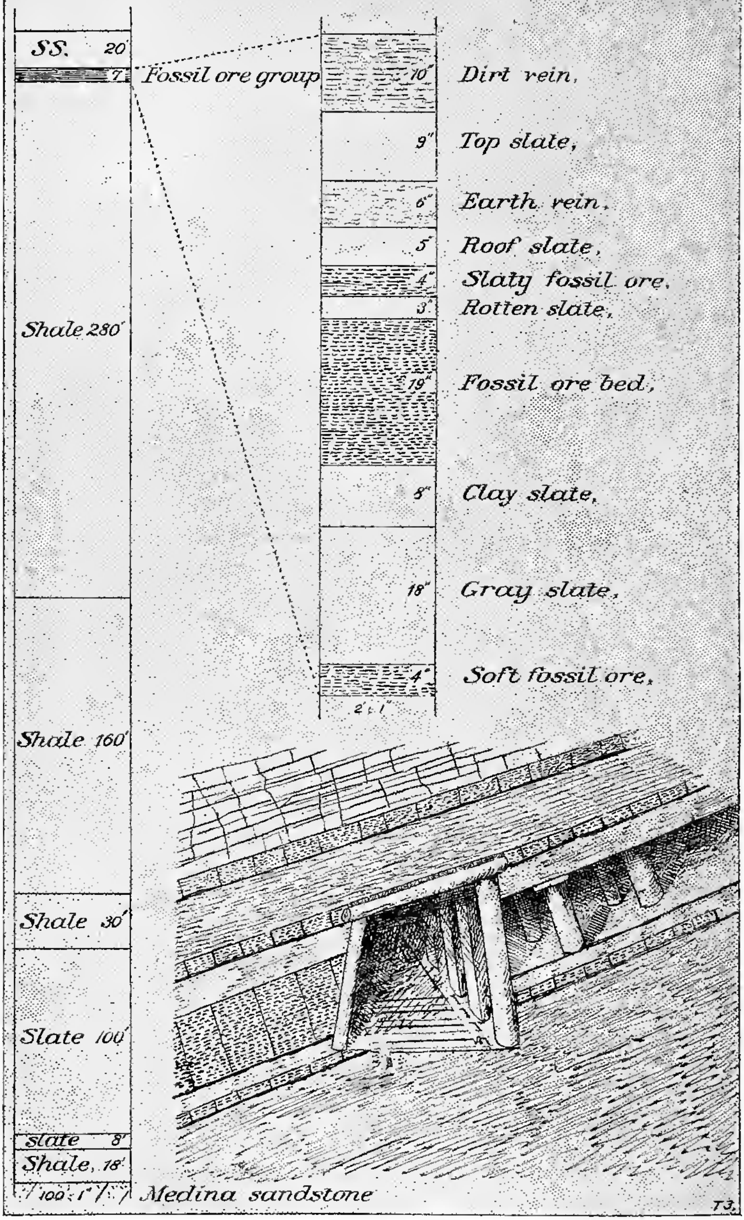
The only fossil ore beds which have been worked in Stone valley occur below the ore sandstone, corresponding to the "Danville ore beds" of the Lewistown valley. (See Report F.)

The following section of the Lower Clinton in Brush ridge shows the character of the associated rocks and the position of the ore beds (See Plate 43, Fig. 1.)

Brush ridge fossil ore section.

Soil containing pieces of sandstone.		
ORE SANDSTONE; bottom layers filled with vertical seams; brown earthy material, frequently resembling lean limonite (brown hematite iron ore); fossils, . say	20'	
DIRT VEIN, (8" to 12"), ... say		10"
TOP SLATE; roof of gangways; gray or yellow slate; compact, (7" to 10"), ... say		9"
EARTH VEIN; generally contains several per cent of iron; sometimes changes to a practical fossil iron ore, (4" to 8"), ... say		6"

Brush Ridge ore at Greenwood Furnace



Slate, yellow, compact, roof of slopes, (4″ to 5″), . say		5″
Slaty *fossil ore*, (1″ to 6″), ... say		4″
Slate, yellow, rotten, ...		3″
Fossil ore bed, (18″ to 20″) . . . . say	1′	7″
Clay slate, (7″ to 8″), ... say		8″
Gray slate, (2′ to 3′) . . . . say	1′	6″
Soft fossil mined in gangway (1″ to 6″) . . . . . say		4′
Shale, more massive, dark gray, with occasional small seams of hard fossiliferous sandstone, fossiliferous limestone, or fossil ore, ... say	280′	
Shale, yellowish, weathering dark-brown, ... say	160′	
Shale, greenish, dark-gray, occasional layers of red or olive, ... say	30′	
Slate, yellowish, gray, sandy, weathering to a reddish brown and breaking up into long fingers, ... say	100′	
Slate, hard, dark-gray, with occasional sandy layers, (5′ to 10′), ... say	8′	
Shale, light yellow, (10′ to 25′), ... say	18′	
MEDINA SANDSTONE, layers of dark and light greenish-gray sandstone, very compact, and filled with yellow ferruginous specks.		
This lies beneath the fossil ore bed, ... say	*600′*	

The bottom layers of the ore sandstone are very siliceous, dark gray or yellowish in color, thinly bedded and brittle. The upper 8 or 10 feet are quite massive, very fossiliferous and of the common dirty yellow or grayish white color. This rock is distinguished by its abundance of fossil *encrini*. Its thickness is not quite as great as in the Lewistown Valley, but fragments of it are more scattered at the outcrop, owing to its inferior hardness. The weathered pieces have a rotten, worm-eaten appearance, and a dirty yellow color. This rock always proves the best guide to the position of the fossil ore.

For convenience of description the line of outcrops of the ore beds has been divided into twenty-two (22) ranges.

Range No. 1. Along Stone mountain.

The absence of the usual ridge, formed by the Ore-sandstone, is due to the steep dip of the rocks which throws the outcrops of the ore beds and the accompanying sandstone high up on the terrace of the mountain. Mining operations have never been prosecuted along this range of outcrop, for there are few ravines which afford good opportunities, and the ore beds where exposed, though containing soft ore, are generally thin.

During the fall of 1873, Mr. Wm. H. Womer, manager of Greenwood furnace, sunk a shaft (No. 30, on map to illustrate Stone Mountain fault) on the outcrop of an ore bed. The ore and rocks exposed show evidence of a "creep," being overturned at the outcrop, gradually coming round to a steep N. E. dip. The ore occurs in three layers, each about 4 inches thick, separated by layers of yellow sandstone 3 inches thick. Its character was very much like that of the "Dirt vein" (see section above) which underlies the ore sandstone in Brush Ridge.

In the synclinal valley which lies between Stone and Broad mountains, the ore bed, after ranging along the foot of Stone mountain, crops out at the stream which comes down from the mountain just S. E. of Greenwood furnace. At this point the outcrop begins to sweep around toward the west, passes a little back of the furnace stacks and enters the S. E. point of Brush ridge.

Range No. 2. Along Brush ridge.

This ridge is formed by the Ore sandstone and Clinton lower shales. Starting from a point about 300 yards west of the Greenwood furnace, its course is about S. 70° W., nearly parallel with Stone mountain three miles; then curving rapidly to the west it sweeps around the sinking Broad mountain anticlinal and ends at a point about 3700 yards west from the furnace.

The detailed topography of this ridge is shown by 20 feet contours in the map to illustrate the Stone Mountain fault (See Sheet 4).

The characteristic and very marked difference in the topographical features of the two slopes of all monoclinal ridges formed by the Ore sandstone and associated rocks is very beautifully illustrated in Brush ridge. While the southern slope, formed by the Ore sandstone, is remarkably regular, the northern slope formed by the basset edges of the Clinton lower shales is cut by a great number of forked and irregular ravines.

The fossil ore beds, passing west from Greenwood furnace, enter the south-east point of Brush ridge just at the breast of the mill-dam. Owing to the flat dip the outcrop rises abruptly along the slope of the ridge to within a short distance of the crest; then turning it follows along the ridge, a few hundred feet south of the crest, to the first ravine which breaks the regularity of the southern slope. The dip of the rocks in this distance is 10° to 15° south.

The line of outcrop at the ravine is suddenly bent down, and, owing to a change in the slope of the ridge and a slight steepening of the dip of the measures, does not rise to the crest again until after passing the next ravine.

West of this the outcrop continues high up on the ridge, soon bending around to the north, when the ore beds begin to fold over the crest of the "Broad Mountain anticlinal."

Messrs. Hall and Rawle, who were proprietors of the Greenwood furnace, seem to have suspected as early as 1835* that there were deposits of iron ore in Stone valley. In August they sunk a shaft for ore, but as far as can be learned without success. Some time in 1839 an outcrop of iron ore was discovered in a coal road on Brush ridge. Mining was commenced by stripping from the top of the ore near the outcrop the covering layers of decomposed earth and slate. The ore was then easily dug with a pick and shovel. This outcrop ore was of a good quality and as rich in iron as the brown hematite which they had been using. Between the years 1839 and 1850 all the ore mined was taken out of open cuts by stripping, the operation being confined to the crest of Brush ridge. About ⅓ fossil ore was used in making up the furnace burden.

It is estimated that about 90,000 tons of fossil ore have been extracted from Brush ridge since operations were first commenced in 1839. This has all been used in the manufacture of charcoal iron.

The principal mining operations have been confined to a comparatively small area in the south-west end of the ridge. All the mines, shafts, slopes, &c., are shown on Sheet 3. There is no reason why the ore beds cannot be opened nearer the furnace, for they remain of nearly the same size throughout the ridge, and will in many places be found to contain

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*See E. Nichol's Mss. Report to Logan I. & S. Co.

soft ore. But future developments should be made with care and judgment.

The general dip of the rocks along the southern slope of the ridge is from 10° to 15° south, which makes the operation of mining more expensive, but the ore is soft and rich.

The ore sandstone is a yellowish, coarse-grained rock, filled with vertical seams, which form channels through which the surface water percolates down to the ore beds. In some small areas on the ridge the character of the sandstone is more compact when the ore below becomes "hard fossil." In Drift No. 31, a very hard quartz rock of a bluish gray color, but showing lines of stratification parallel to the general dip, was encountered. This is a highly modified form of the ore sandstone, and the ore under it will prove hard and calcareous. In a few places the ore beds become "faulty" and change in character. In Drift No. 18, a roll was encountered, which carried them down vertically for 22 feet, when they again assumed a nearly horizontal position. *Faults* or *jumps* of from 6 inches to 4 feet have frequently been met with in mining, and in many of the drifts the rocks are very much *folded* and *rolled*.

Fig. 3 on Plate 43 shows the position of the ore beds in the gangways and the method of working slopes on the main vein. The smaller veins above and below the main seam are only taken out in the gangway.

The following analyses of Brush ridge ore were made by Prof. O. D. Allen for the Logan Iron and Steel Company, and kindly furnished for the use of the Survey by Mr. R. H. Lee, superintendent:

Analysis of fossil ore, (average sample.)

Sesquioxide of iron,	70.09
Sesquioxide of manganese,	.51
Silica,	12.60
Phosphoric acid,	.43
Water,	4.43
Metallic iron,	49.06
Manganese,	.36
Phosphorus,	.189

Analysis of hard and soft fossil ore from same drift in Brush ridge.

	Hard ore.	Soft ore.
Metallic iron, ...	30.60	50.48
Insoluble residue, ...	6.25	21.33
Phosphorus, ...	.527	.177

The hard ore contained much carbonate of lime.

Range No. 3. AlongBroad mountain.

The Broad mountain anticlinal flexure, the axis of which passes through the south-west end of Brush ridge, is *overturned*, and consequently the rocks of the north-west portion of the ridge have a steep southerly dip. The ore outcrop on this dip passes a little south of J. Hagen's and Mrs. Cole's (see plate . . . . .) and crossing the "Broad mountain road" about 3700 yards west of Greenwood furnace, ranges along the terrace of Broad mountain to within a short distance of the Lewistown and Bellefonte turnpike. Along the greater portion of this range the ore sandstone is very hard and compact and the ore is probably worthless.

Range No. 4. The broad and flat anticlinal flexure of Long mountain, in sinking rapidly toward the west resolves itself into three subordinate waves. In the most southeastern of these the ore is first seen in a rocky cliff near J. Zook's sawmill. The dip is to the southeast and changes suddenly from 30° to 85°. Two veins of hard fossil ore, each 10 or 12 inches thick separated by 6 inches of soft porous sandstone, are exposed. The ore sandstone is 30 to 35 feet thick. From this exposure the ore beds continue regularly toward the south-west not however forminga very distinct ridge, to a high and abrupt cliff which is a few rods north of S. Powell's.

This cliff affords a beautiful exposure of an anticlinal arch. The outcrop of the ore sandstone rises from the level of the creek to the top of the cliff with a southerly dip of 50°, then arching over gently it descends with a northerly dip of 45°, sinking under the surface at a point about 1200 feet distant from where it first appears. In this exposure there are two beds of ore lying under the Ore sandstone, one 9 the other 4 inches thick, separated by 3 or 4 inches of soft slaty sandstone.

Range No. 5. The ore beds and accompanying sandstone, on the N. W. dip of 45° crop out for 2½ miles. Throughout a portion of this distance they have been very much eroded and do not afford good opportunities for mining.

Ranges Nos. 6, 7, 8, 9.—Between range No. 5 and the Getty's ridge range No. 10 there are four short ranges (Nos. 6, 7, 8, and 9). The south-eastern one (No. 6), with a dip of 15° to 20° south, forms quite a distinct ridge. On this range, about 1000 feet north-east from Hunter's saw-mill, there are two seams of fossil ore exposed in the side of the road. They occur under the Ore sandstone, and contain both hard and soft ore. The upper bed is 9 inches thick, separated from the lower bed, which is 15 inches thick, by one foot of soft fine-grained sandstone.

The two small anticlinals, situated just north of the saw-mill, give very short ranges of outcrop and form low ridges. Along the road, a short distance west from the saw-mill, the dark blue layers of *Barree limestone* (above the Ore sandstone) have been quarried by Mr. John Barr. They yield, upon burning, a dark, strong lime, which answers very well for agricultural purposes.

The following analysis of specimens from Mr. Barr's quarries was made in the laboratory of the Survey at Harrisburg:

Analysis of John Barr's limestone.

Carbonate of lime,	88.687
Carbonate of magnesia,	1.850
Oxide of iron and alumina,	1.439
Sulphur,	.164
Phosphorus,	.004
Insoluble residue,	8.230

Range No. 10. Past Saulsburg and Manor Hill.

The next range is the longest, and probably the most important, in the valley. The Clinton lower shales and Ore sandstone, which dip S. off the Getty's ridge anticlinal, form a continuous chain of ridges, extending from a point about one mile north-west of John Mash's, in Jackson township, to within a quarter of a mile of Manor Hill, in Barree township. The numerous gaps in the ridge, through which small streams from the mountains find their way out into the valley, afford good opportunities for mining. The general course of the ridge is S. 50° W.; its average elevation 200 feet above the stream level in the gaps. The dip of the rocks changes gradually from 60° S. E. at Mash's to 10° S. E. at Saulsburg. South-west of the latter place, the ore sandstone and accompanying ore beds begin to curve around to the west, and soon fold over the anticlinal. The last place where their outcrop is seen between Saulsburg and Manor Hill is about 234 rods north-east of the latter place.

In this range, which is between 9 and 10 miles long, the ore has only been opened in two places. The position of these old workings, which were open cuts at the outcrop of the ore, is shown on the map (Sheet 3). Both were made by the proprietors of the "Little furnace" who used the ore and "liked it better than Brush ridge ore."

It was impossible to obtain fair average specimens of ore for analysis from this range, as all the openings which have been made are now either fallen in or covered up. A *surface specimen* was taken from the outcrop of the ore beds, on the ridge north-west from John Bair's, and sent to the laboratory of the Survey at Harrisburg, for analysis by Mr. S. S. Hartranft, under the direction of Mr. A. S. McCreath.

Bair's fossil ore. (*M.M.*, *238.*)

Sesquioxide of iron,	71.500 =	50 050 p. c. iron.
Sesquioxide of manganese,	.643 =	.448 p. c. mang.
Alumina,	5.825	
Lime,	1.715	
Magnesia,	1.248	
Sulphuric acid,	.069 =	.028 p. c. sulp.
Phosphoric acid,	1.285 =	.561 p. c. phos.
Water,	4.979	
Insoluble residue,	12.385	
	99.649	

Where Laurel Run has cut its way through the ridge, the ore beds are well exposed. They occur under the Ore sandstone, are two in number, each about one (1) foot thick, and separated by 14 inches of slaty sandstone. The ore is hard at water level, but becomes soft higher up on the ridge. The Ore sandstone is about 35 feet thick. In its lower portion it is thinly bedded, dark gray in color, very siliceous, hard, and brittle. The upper 8 feet is massive, very fossiliferous, and of the common yellow color.

On the crest of the ridge, between Little Laurel run and Big Laurel run gaps, the ore was worked for Little Furnace, by means of open cuts, many years ago. Specimens were collected from the surface at these old workings, and forwarded to the laboratory of the survey for analysis by Mr. A. S. McCreath. (MM, p. 237).

Fossil ore 1 mile west of McAlevy's Fort.

Iron,	46.500
Sulphur,	.025
Phosphorus,	.475
Carb. of lime,	17.550
Carb. of magnesia,	1.551
Insoluble residue,	6.880

North-west from McAlevy's Fort the ore beds are exposed, dipping 38° S. E., where Laurel run washes against the base of the ridge. Above the Ore sandstone is a thinly bedded calcareous shale, interstratified with layers of limestone, which vary in thickness from 2 to 10 inches, the heaviest layer occurring about 40 feet above the ore sandstone. These *Barree limestone* layers are dark or light bluish gray in color, have a conchoidal fracture and "make a strong but dark lime." A few of the layers are very fossiliferous, and contain yellow carbonate of iron, resembling somewhat the hard fossil ore.

Range No. 11. The line of outcrop along the north-west dip of the Getty's ridge anticlinal is easily traced by following the very regular ridge formed by the ore sandstone. The line crosses the road leading to Monroe furnace, just west of Steffy's hotel, and, soon after crossing Laurel run, bends sharply around, in the rapidly rising synclinal between the ridges, to return to the south-west along the south-east dip of Bell's ridge which constitutes

Range No. 12. Along this range the ore beds have been opened in three places. On the crest of the ridge north-west of Steffy's hotel a very small open cut has been made. On both east and west sides of the ravines near N. Rudy's the beds have been opened by short drifts. South-west from N. Rudy's, on the crest of the hill, many tons have been mined by means of open cuts. Nowhere on this range could the dip of the measures or the sizes of the ore beds be positively ascertained, but it is probable that the ore beds do not vary materially in thickness from those in the Getty's ridge range. All of the old workings on this range were made in the interest of Monroe furnace. They are now entirely abandoned, and fallen shut.

A *surface specimen* from the old workings ¼ mile south-west from N. Rudy's and 3 miles west from McAlevy's Fort was sent to the laboratory of the Survey for analysis by Mr. A. S. McCreath.

Fossil ore 3 miles W. of McAlevy's Fort.

Iron,	34.800
Sulphur,	.038
Phosphorus,	.132
Carb., of lime,	none
Carb., of magnesia,	none
Insoluble residue,	40.680

Bell's ridge anticlinal in sinking rapidly toward the south-west carries the ore beds under the surface, on the crest of the anticlinal, about 1 mile southwest of N. Rudy's.

Range No. 13. The range of outcrop which dips north-west from this anticlinal is not more than 1 mile long and does not afford good opportunity for opening the ore beds.

Range No. 14 is about 4½ miles long and throughout has a gentle dip of from 25° to 18° southeast. The ore ridge is high and regular and cut by three or four large gaps.

Range No. 15. The line of outcrop along this range could not be followed continuously. Judging from the topography, and one or two exposures, near W. H. McGinnis', it seems most probable that the anticlinal flexure of Greenlee mountain resolves itself into two flexures, after entering the Clinton shales. One of these flexures, which sinks rapidly near Mr. McGinnis', causes a sharp bend in the outcrop line. It was so poorly exposed and the exact position of the outcrop so uncertain, that the three dips have been included in this one range. At the gap in the ridge, through which the road passes, west from Manor Hill the ore rocks dip 30° N. W. Throughout most of the distance for a mile and a half north-east, from this point the ridge has been so cut down by erosion as to leave very little workable ore.

At the gap in the ridge, near Mr. W. H. McGinnis', the Ore sandstone is exposed dipping 26°S. E.

The ore beds occur under the Ore sandstone, and at water level. Are hard and calcareous. The following is an analysis, by S. S. Hartranft, of a surface specimen of this hard ore:

Fossil ore 2 miles N. W. of Manor Hill.

Iron,	25.075
Sulphur,	.012
Phosphorus,	.223
Carbonate of lime,	54.359
Carbonate of magnesia,	1.112
Unsoluble residue,	5.235

This Range No. 15 is well defined north-east from W. H. McGrum's by a prominent ridge, which is cut by deep gaps at Shaver's creek and Laurel run. On both east and west sides of the Laurel Run gap the ore beds have been worked by means of drifts. Still further east, on the crest of the ridge, are extensive open-cut workings. All these openings were made to obtain ore for the Monroe furnace. Judging from the size of the dumps at the drifts and the depths of the open-cuts, I should say that many hundred tons of ore must have been mined. "The ore was soft, rich, brown in color, and yielded well in the furnace."

This range was followed out to its north-eastern end but could not be definitely located. It extends about one mile further north-east than is shown on the map.

Ranges Nos. 16 and 17 form an anticlinal ridge, on the crest of which some mining has been done by means of open cuts. In the gap, through which passes the road leading to Monroe furnace, the ore beds have been proven by means of short drifts on both the south-east and north-west dips of this anticlinal.

Range No. 18. Where this range crosses the road leading to Monroe furnace the ore-beds dip 85° south-east. This dip flattens slightly as we proceed south-west, becoming 60° near A. Aak's. The steepness of the dip will probably produce soft ore on this range.

Range No. 19 has been worked near Amos Aak's, where a drift was driven for about 100 feet to the north-east. At Shavers' creek the ore-ridge has been very much cut down.

Ranges Nos. 20, 21.—The outcrop of these ranges could not be followed with much certainty. The curve shown in the line of the outcrop as given on the map, represents an anticlinal just south-east of Monroe furnace. This is entirely hypothetical, though the anticlinal flexure of Shavers' creek ridge (see Section C. D.,) makes this form for the outcrop the most probable.

Range No. 22.—The north-eastern part of this range has suffered very much from erosion. Along the foot of Tussey mountain, south-west from Monroe furnace, the ore beds dip from 30° to 35° south-east.

Back of R. J. Massey's an ore bed, occurring 5′ below the Ore sandstone, has a thickness of 8 inches, and no other seams could be found. The ore is hard at water level. S. S. Hartranft's analysis of a specimen from this locality yielded as follows:—

Fossil ore 4 miles N. W. of Manor Hill.

Iron,	11.825
Sulphur,	.019
Phosphorus,	.255
Carbonate of lime,	71.518
Carbonate of magnesia,	2.792
Insoluble residue,	5.800

Greenwood Furnace.—This is the only one of several charcoal furnaces once at work in Stone valley which still remains in blast. The facts, for the following description of the early history of Greenwood furnace, were taken from a MSS. report made by Mr. Edward Nichols to the Logan Iron and Steel Company.

When the furnace was started in 1834, the ores used were exclusively brown hematites from the Kishicoquillas valley.* This ore was of an excellent quality, but owing to the necessity of bringing it across Stone mountain in wagons, its cost at the furnace was considerable.

The first proprietors of this furnace seem to have been laboring under the same disadvantages as the proprietors of the old Brookline furnace, which was located about half a mile north from McVeytown, though the latter furnace stood within a stone's throw of what is now the Ross ore bank, which has yielded large quantities of very good ore.† It was abandoned on account of the great expense incurred by obtaining ores from the Kishicoquillas valley.

The following dimensions of the Greenwood furnace stacks and notes in regard to working have been kindly furnished by Mr. R. H. Lee, general superintendent of the Logan Iron and Steel Co.:

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*The principal ore-bank in the Kishicoquillas valley is the old "Greenwood Bank," situated about one mile southwest from Belleville. The ore deposit occurs in fissures of the limestone (Calciferous?) on the crest of an anticlinal. The deposit has been worked entirely by open cuts, which have been carried to a depth of over 80 feet in the principal workings. "The surface workings produced hard, compact hematite. Pipe ore, of a distinct stalactitic formation, was not met with until the workings had reached a depth of 50 feet. At this depth, associated with the ore and bowlders, were irregular beds of pure white sand from 18 inches to 3 feet thick. After removing this, yellow limestone clay associated with ore was met with."

The following is an analysis of limonite from the "Greenwood ore-bank," made for the Logan Iron and Steel Company, by Prof. O. D. Allen:

Analysis of Greenwood pipe-ore.

Sesquioxide of iron,	67.63
Sesquioxide of manganese,	.34
Cobalt,	Trace.
Silica,	17.61
Phosphoric acid,	.236
Water,	9.64
	95.456
Metallic iron,	47.34
Manganese,	.23
Phosphorus,	.107

Phosphorus to iron as .226 to 100.

† See Report F, p. 93.

There are two stacks, each about 32 feet high and 8½ feet diameter at bosh. One stack was put in blast in 1834 and the other built in 1864.

The charge of ore varies from 550 to 600 pounds, according to the kind of iron desired, being lighter for No. 1 than for higher grades; for forge iron. a mixture of ⅓ to ½ of pipe ore and ⅔ to ½ of fossil ore is used; for foundry iron, the fossil ore is used exclusively. About 1½ tons of charcoal and 2½ tons of fossil ore are used per ton of foundry iron. The make of the furnaces is strictly cold blast at present. The yield of the one stack which is in blast is about 34 tons per week of No. 1 foundry iron.

The following analysis was made for the Logan Iron and Steel Co. by Prof. O. D. Allen:

Analysis cold-blast charcoal pig-iron, made from Brush Ridge fossil ore.

Graphitic carbon, } Combined carbon, }	3.64
Silicon,	2.69
Sulphur,	0.09
Phosphorus,	0.39
Manganese,	0.51
Cobalt	Trace.
Copper,	"

Little Furnace.—This furnace was situated on Stone creek about three quarters of a mile above McAlvey's Fort. It was built by Messrs. Mitchell Bros. in 1841, and was at first known as Barree furnace.

Information for the following brief account was obtained from Mr. Mitchell, one of the original proprietors. During 1842 the furnace was in blast for 9 months, and after that ran irregularly until 1848. The stack was 33 feet high, but too narrow at the bosh. On this account it consumed too much charcoal per ton of iron to allow of its being worked profitably. The yield of the furnace was from 2 to 4 tons per day; two casts being made in every 24 hours. Cold blast was used entirely, power for forcing it being obtained from Stone creek.

Fossil ore was used exclusively; some being brought from Brush ridge, others mined from the outcrop of Range

No. 10, and a few tons taken from Range No. 12 N. W. from Sheffy's Hotel. This latter is said to have been "dirty in the vein."

Rebecca Furnace.—A few miles south of the Little furnace and about half a mile from Ennisville, there formerly stood iron works known as the Rebecca furnace and forge. Both were operated by water-power derived from Stone creek.

Rebecca Forge was built in 1827. Bar iron was manufactured, to supply the local market, from Marion Furnace pig-iron. The pig had to be transported in wagons, over rough mountain roads, from *Marion furnace*, which was located near Milroy ; the distance being about 17 miles.

Rebecca Furnace was built in 1843 and made its last blow in 1847. The stack was somewhat smaller than the Greenwood furnace stack. Its yield was about 25 tons per week of "charcoal, cold-blast iron." This furnace was built to utilize a deposit of ore occurring in the Waterlime, at the north-east base of Warrior's ridge, and locally known as the Magill hematite. It was a brown slaty ore and proved of very inferior quality.

Monroe Furnace.—This furnace was erected in 1846, by Messrs. Birchfield and Irvin. The stack was built of stone, 35 feet square at the base, inside height 32 feet, and diameter at bosh 8½ feet. Water-power for the cold-blast was obtained from a small mountain stream.

The furnace was built to utilize the brown hematite ores ("pipe ore") occurring in the limestones of II along the N. W. base of Tussey mountain. At first these ores were used exclusively, but, after running for 3 or 4 years, fossil ore was introduced and used quite extensively. In connection with the fossil ore, 200 or 300 tons of the "Red rock" from Robert Fleming's property was used.

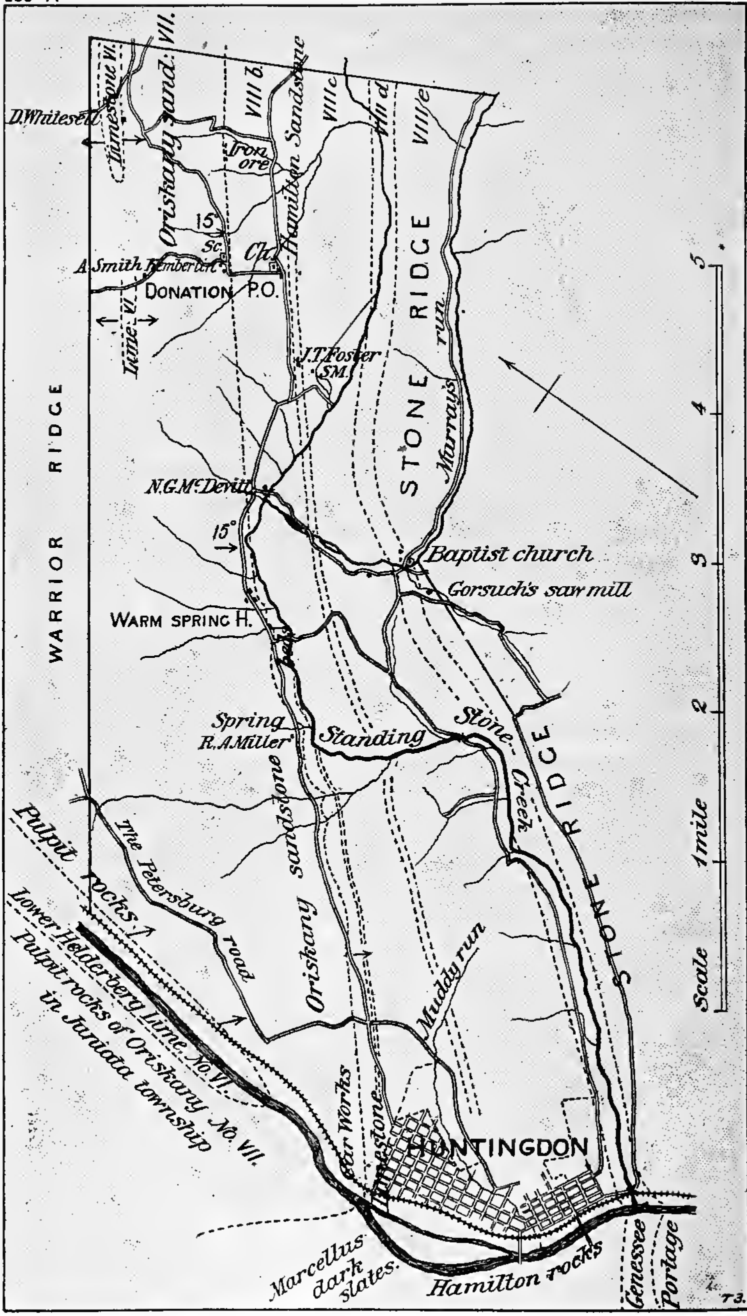
In 1863, the Logan Iron and Steel Co. bought the property, since which time it has been standing idle.

[*Note.*—In the foregoing pages, from page 239, Mr. Billin has described the zigzag course of the fossil ore outcrop through Jackson and Barree townships, and indicated the character and altitude of the bed at various places. Minuter variations of the outcrop from a straight line, produced by the irregular erosion of the overlying and underlying rocks, are exhibited on Plate LX, page 328.

This plate is made from a part of Mr. Billin's enlarged colored "Geological map to illustrate the Stone Mountain Fault," on which the topography of the surface is expressed in 20′ contour curves, on a horizontal scale of 1600′ : 1″

Stone creek at Greenwood furnace is 980′ A. T. and descends westward to 920′ the first mile, and to 860′ the second mile. Eastward its bed rises rapidly to 1150′ the first mile, and 1400′ the second mile. Here the basin of Medina sandstone is only a mile wide from the crest of Stone mountain (2020′ A. T.) on the south-east, to the top of Broad mountain on the north-west. A notch in Stone mountain, a little less than two miles east of the Furnace, lowers its crest 300 feet to 1735′ A. T. and is a very interesting feature because of its resemblance to the celebrated Wind Gap of Eastern Pennsylvania on the Monroe-Northampton county line. A road crosses Stone mountain here. A mile south-west of the notch the crest again reaches 2020′ A. T. and then falls off gradually into the gap made by the fault.

A description of this typical example of a downthrow fault will be found on pages 329, &c., with the map and four sections.—J. P. L.]


D. Whiteseed
Limestone VI.
Oriskany sand. VII.
VIII b
Iron ore
Hamilton Sandstone
VIII c
VIII d
VIII e
15°
Sc.
Ch.
A. Smith
Kemberlin
DONATION P.O.
Lime. VI.
J.T. Foster S.M.
STONE RIDGE
Murrays run.
WARRIOR RIDGE
N.G.McDevitt
15°
Baptist church
Gorsuch's saw mill
WARM SPRING H.
Spring
R.A.Miller
Standing Stone Creek
STONE RIDGE
Oriskany sandstone
Pulpit rocks
The Petersburg road
Muddy run
Lower Helderberg Lime. No. VI.
Pulpit rocks of Oriskany No. VII.
in Juniata township
Gas Works
Limestone
HUNTINGDON
Marcellus dark slates.
Hamilton rocks
Genessee
Portage
Scale 1 mile 2 3 4 5
T3.

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10. *Oneida.*

This long, narrow township, bordering the Juniata river, covers nine miles of the valley of Standing Stone creek, and the south-east slope of Warrior's ridge. The valley is excavated in the soft Hamilton rocks (*Genessee*, *Hamilton* and *Marcellus*), and is *bordered on the east* by Stone ridge, an outcrop of the *Portage* formation. All the formations dip south-eastward into the great basin, at gentle angles, from 5° to 15°; and they are well exposed along the river at and below Huntingdon.

Huntingdon borough section.

1. Portage flags.	
2. Genessee, ... largely concealed but probably	200′
3. *Hamilton shales* and *sandstones* underlying a large portion of Huntingdon, and extending along the railroad from the 202nd to the 203rd mile-post, which with a varying dip of 5°-10° would give a thickness of, say, .	600′
4. *Marcellus shale*, extending from the 203rd mile-post to the upper end of the Car works, 3450 feet, . say	700′
5. *Oriskany sandstone*, a massive, hard, white sandstone, rising in cliffs along the railroad above the Huntingdon car works, and forming the surface rock along Warrior ridge at the northern line of this township,	75′
6. *Stormville shales*, exposed in a few localities along the railroad north from the Huntingdon car works, . . .	225′
Total length of section, ...	1800′

The Portage beds begin at Stone creek and extend down the river in Henderson township, making the high cliffs of flaggy sandstone overhanging the railroad and canal just below Huntingdon.

The *Genesee beds* are almost entirely concealed beneath the valley of Stone creek, but the horizontal interval they cover with the prevailing rate of dip, 10° to 15°, would give them a thickness of about 200′.

The Hamilton rocks, proper, are finely exposed along the road which passes through the back part of Huntingdon; and some of the beds, especially in the upper portion, are quite *fossiliferous;* and from this locality were obtained a large number of the fossils named on page 111 above. The high hill just back of the town, on which the cemetery is located, is composed of *Hamilton beds*, and many beautiful fossils are frequently thrown out in excavating graves and vaults. The bottom beds are exposed along the road which leads past Mr. Goodman's, just back of town. Here they pass down into the *Marcellus*, and hold many specimens of a small disc-shaped *Bryozoan*, together with *Spirifera medialis*, *S. granulifera*, *Athyris spiriferoides*, *Orthis vanuxemi*, and several other forms.

The *Marcellus beds*, (No. 4 of the section.) make the valley along Muddy run and underlie nearly all of West Huntingdon. At top they consist of a series of gray or pale ashen-colored shales, which in the uppermost portion are crowded with *fossils*, among which *Leiorhynchus limitare* is most abundant. The thickness of these ashen-gray beds is not far from 250′. Under them lie the *black slates*, which are exposed in excavations made in West Huntingdon; notably one east from the Normal School, on the outskirts of the town, where these beds have been quarried for road material. As exposed here the slate is very *bituminous*, some of it being so indurated and compacted by pressure as to possess an appearance resembling impure anthracite. The thickness of this portion of the *Marcellus* is not far from 350 feet. Under this great mass of *black slate* lie several layers of a greenish, hard, gray *limestone*, breaking with dull angular fracture. Under these lie more *blaek slates*, and then another *limestone series* very much like the one above, but with partings of *black slate;* the whole being *fossiliferous*. See page 113 above.

The Marcellus iron ore of the Aughwick creek country which overlies this limestone series is not seen in this section, and is apparently absent entirely. But at the very base of the *Marcellus* formation in the clayey shales which there repose directly on the *Oriskany sandstone*, just back of the Huntingdon car works, are a few thin layers of *lean carbonate ore.*

Here the shales at the base of the *Marcellus* are disintegrated into clay, of which a large bed was found in excavating for the foundation of the new building.

The Oriskany sandstone rises above the railroad just at the car works, about one mile above Huntingdon station, and soon makes a great cliff with bold and fantastic ledges, rising to the crown of Warrior ridge at an angle of 5° to 10°. The upper portion is yellowish white and contains many casts of fossils; *Spirifera arenosa, S. cumberlandiæ, Rensselaeria ovalis* and *Platyceras sp?* being especially numerous. The lower half is a white, fine-grained sandstone, rarely containing any fossils, and excessively hard. It is quarried extensively for ballast a short distance above the car works.

As we pass up the Juniata river from the ballast quarry, the rocks continue rising slowly until all of the *Stormville shales* have appeared above water-level, and the uppermost beds of the *Lower Helderberg limestone* make their appearance, and continue along the railroad; sometimes dipping in one direction, and again in the opposite; keeping the base of the *Oriskany sandstone* 300′ or 400′ above the river. Finally, at the west township line, the purer layers of No. VI begin to come up.

Near Huntingdon the Warrior ridge plateau, faced above with *Oriskany sandstone*, is traversed by gentle rock waves scarcely strong enough to reverse the dip, the only effect being to broaden the ridge, and hold the underground drainage; but further east these waves become more decided anticlinals, and one of them brings to the surface the Lower Helderberg (No. VI) limestones, along the north county line. One outcrop of the sandstone crosses the road from West Huntingdon to Warm Springs, about 100 rods north-east from the crossing of the Petersburg road; and from this point for nearly a mile and a half this outcrop keeps along at the distance of 3 or 4 rods south of the road. At R. A. Miller's it runs for a short distance north of the road, and the *Marcellus limestones* coming into the road; 10′ or 15′ of greenish gray *limestone* being visible, overlying 10′ of gray shales, which lie upon the *sandstone*. Near Huntingdon the *Marcellus limestones* are seen in the road 5 rods east from where the old Petersburg road crosses the Warm Springs road, and again where these beds recross the Warm Springs road 100 rods east

Warm Springs is four miles from Huntingdon up Stone creek. Here a spring of water (not by any means *warm*) issues from the *Oriskany sandstone.* It is said to possess medicinal qualities; but I could discover nothing unusual in its taste. A large hotel was once erected here, with baths, &c. for entertaining summer visitors, but the property has been unoccupied for several years and is falling into decay.

The Oriskany sandstone is exposed along the north bank of Stone creek one half mile above the Warm Springs property; here its top is filled with casts of fossil shells. It dips into the water 15° (S. 40° E.)

Where the road turns south-eastward near N. G. McDevitt's, the *Oriskany sandstone* outcrop gets north of the Stone creek road again, and keeps about 100 rods north of it from here to the Porter township line.

The Hamilton lower sandstone crosses the road above McDevitt's and makes a low ridge until we come to Donation P. O. where the road crosses it to the north.

On the Donation road across Warrior's ridge the *Marcellus black slates* are pretty well exposed north-west of Donation. They begin about 10 rods from the forks of the road. The *Oriskany sandstone* comes up at the sharp turn in the road near G. W. Kemberlin's. This makes the *black slates* and thin bottom *limestones* together 385′ thick, calculated on a dip of 15° S. 45° E.

At the northern corner of the township a low anticlinal enters it from Porter township, and the *Lower Helderberg limestone No. VI* crops out at the surface at several places on the back of the roll.

It has been quarried and burned on the land of Mr. Andrew Smith, and also on the land of Wm. Whitesel.

Large nuggets of *brown hematite* iron ore are found in Mr. Whitesel's fields, at the top of the limestone, where it is under the *Stormville shales.*

Stone ridge.—The Portage beds make a high ridge, with a precipitous north-west slope all along the eastern line of the township, from the Juniata 4½ miles to the Baptist church. From this onward for 3½ miles *Murray's run* makes the township line, and the Stone ridge runs between it and Stone creek. At the church, *Murray's run* cuts through the bottom beds of the Portage formation, and then, turning at a right angle, flows north across the outcrops of the Genessee, Hamilton, and Marcellus beds to join Stone creek at McDivitt's. These beds are well exposed along the road which follows *Murray's run* across the valley, a distance of 335 rods; which on a dip of 15° would make about 1425′ of measures—about the same as in the townships south of the river.

The top of the Marcellus beds is well exposed where the road crosses Murray's run, just west from A. P. White's. Here are the same kind of layers of hard, sandy, calcareous rock which occur at the top of the *Marcellus* along the railroad in West Huntingdon; and also further south in Walker township. There are two of these beds on Murray's run, each 6″ to 10″ thick, separated by 4′ or 5′ of shale.

The highly fossiliferous shale seen at Huntingdon, McConnellstown, and elsewhere is seen also here, 6′ or 8′ underneath the lower of the two calcareous beds, containing vast numbers of the same fossils: *Leiorhynchus limitare*, *Ambocœlia umbonata*, and other forms.

Near the middle of the *Hamilton beds*, on Murray's run, are seen *Tropidoleptus carinatus*, *Spirifera mucronata*, *S. granulifera*, *Athyris spiriferoides* and *Orthis penelope.*

The Genesee black beds are exposed for a short distance along the road which passes up the south fork of Murray's run past S. Gorsuch's saw-mill. The exposure is about half-way between the saw-mill and the Huntingdon road which passes down Stone creek.

Stone creek flows in the *Genesee slate* for the last three miles of its course; but it occasionally encroaches on the *Portage*, or cuts into the edge of the *Hamilton proper.*

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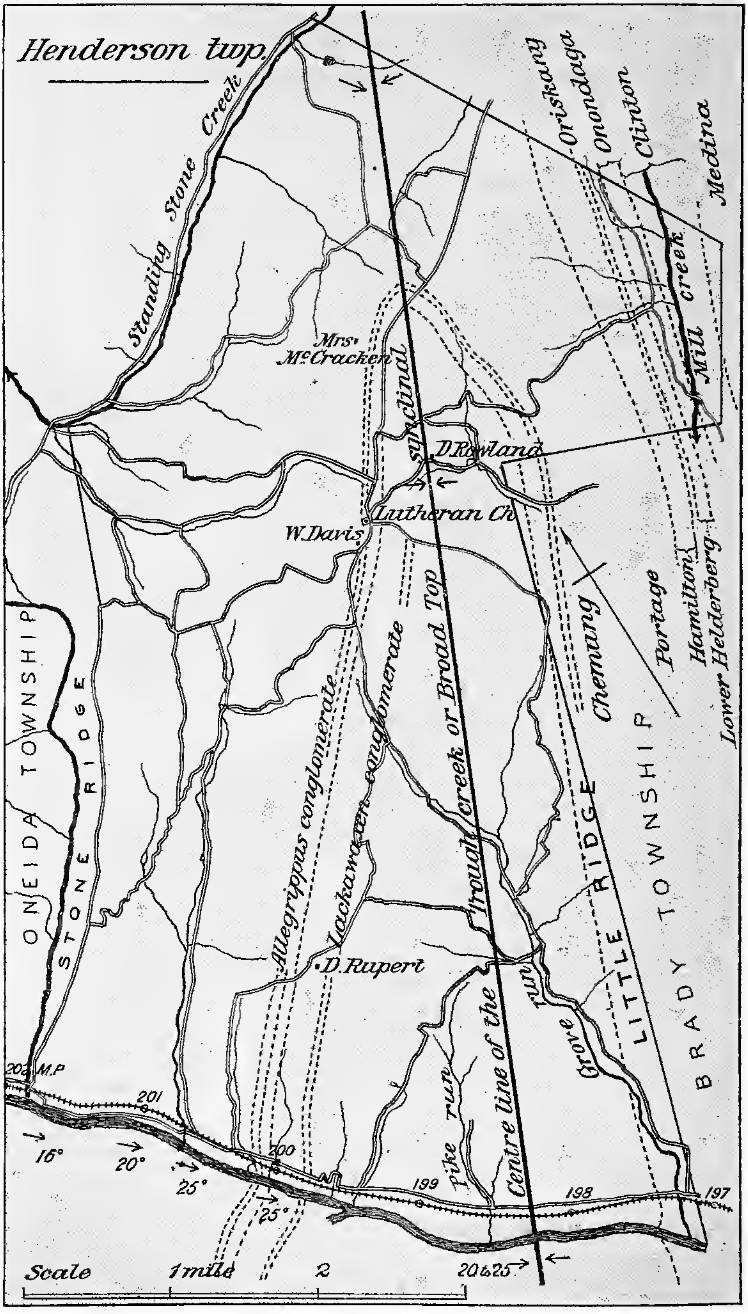
11. *Henderson*

This township lies along the Juniata river for 4½ miles, *Stone ridge* is the west line for 4½ miles, and *Murray's run* for 3⅓ miles further, to the Barree line. Its east line follows


Henderson twp.
Standing Stone Creek
Oriskany
Onondaga
Clinton
Medina
Mill creek
Mrs. McCracken
synclinal
D. Rowland
Lutheran Ch.
W. Davis
Chemung
Portage
Hamilton
Lower Helderberg
ONEIDA TOWNSHIP
STONE RIDGE
Allegrippus conglomerate
Lackawaxen conglomerate
Trough creek or Broad Top
Centre line of the
LITTLE RIDGE
BRADY TOWNSHIP
D. Rupert
Grove run
Pike run
202 M.P.
201
200
199
198
197
16°
20°
25°
25°
20 to 25°
Scale
1 mile
2

Little ridge from the river northward for 5 miles, and then runs east 1½ miles across Mill creek to the foot of Stone mountain, along which it continues 1¼ miles to the Barree corner.

The axis, or central line of the great basin, crosses the Juniata river half-way between the 198th railroad mile-post and the mouth of Pike run, or about one mile and a quarter below the mouth of the Raystown branch.

The following section of south-east dipping measures was made from the railroad cuts and natural exposures along the river: (See Sheet 2, Fig. 12.)

Pennsylvania railroad section.

1. Concealed from 1500′ north-west of the 198th mile-post to mouth of Pike run; mostly *red shale;* dip 20° to 25°, distance 1500′, ... about	575′
2. *Red shale* to 199th mile-post, dip 25°; distance 2280′, .	960′
3. Concealed to opposite mouth of Raystown branch Juniata river, dip 25°; distance 570′, ...	240′
4. Olive shales, ...	20′
5. Sandstone, greenish-gray, ...	5′
6. *Red shales*, ...	5′
7. Olive, and greenish shales; with a streak of *fossiliferous impure limestone* (breccia) near center; shells too badly preserved for identification, ...	40′
8. Sandstone, massive, greenish-gray, *fossiliferous*, containing *Spirifers* and *crinoidal fragments*, ...	20′
9. Hard greenish sandy beds with two or three layers containing *crinoidal fragments*, dip 25°; distance 150′, .	63
10. Concealed for 90′, ...	38′
11. Olive, yellowish shale, ...	7′
12. Hard, green sandstone, dip 25°, ...	20′
13. *Red and gray shales*, ...	5′
14. *Red shale*, ...	5′
15. *Calcareous breccia*, (cornstone), ...	2′
16. Sandy shales and greenish-gray sandstones, dip 25°; distance 280′, ...	118′
17. *Red shale* with some green near middle, ...	15′
18. Hard, greenish-gray sandstone, dip 25°; distance 150′,	63′
19. *Red shale*, ...	4′
20. Sandstone, greenish-gray, quite hard, passing down into green shales below, *spirifers* sparingly seen at top,	60′
21. Mostly concealed, but showing some greenish-gray, sandy beds to 200th mile-post, dip 25°; 570′, . . .	240′
22. Greenish-gray sandstone and concealed, dip 25°, ...	115′
23. Olive and yellowish, sandy shales, dip 25°, ...	10′
24. Concealed to Ardenheim Station, dip 25°; 420′, ...	175′

25. Concealed to crossing of road below old Pottery, dip 25°; 1650′, ... 695′
26. Mostly concealed, but containing surface blocks of dark, reddish, and olive, sandy material, dip 25°; 450′, 190
27. Sandy shales, containing *fossil shells* in fragmentary conditon, ... 50
28. Sandstone, gray, hard, and massive, dip 25°, ... 15′
29. Olive shales, ... 16′
30. Sandstone, massive, greenish-gray, ... 4′
31. Shales, olive and green, ... 25′
32. Massive, greenish-gray sandstone, ... 15′
33. Olive, sandy shales, dip 25°, ... 25′
34. Sandstone, hard, thin layers, ... 15′
35. Olive, and yellowish sandy shales, dip 25°; 300′, . . 125′
36. Concealed to road-crossing near canal lock, dip 25°; 180′, 75′
37. Concealed to Snyder's run, dip 25°; 450′, ... 190′
38. Concealed 60′, ... 25′
39. Olive shales, dip 25°; 420′, ... 175′
40. Yellowish olive shales, ... 30′
41. Olive shales containing *fucoids*, ... 15′
42. Hard, greenish-gray sandstone, containing many *Crinoidal columns and joints*, ... 10′
43. Olive sandstones and shales, ... 20′
44. Sandy shales, olive, *fossiliferous*, containing *Pteronites chemungensis*, *Chonetes setigerus*, a large *Spirifer* and other forms, ... 20′
45. Olive shales, fossiliferous containing *Chonetes setigerus*, *Spirifera mesocostalis*, *Pteronites chemungensis*, *Eodon bellistriata*, *Bellerophon sp?* *Nucula sp?* and many other forms, ... 15′
46. Yellowish olive shales, ... 30′
47. Hard sandstone in thin layers, interstratified with olive shales, ... 25′
48. Olive shales interstratified with hard, thin, sandy layers, 45′
49. Hard sandstone layers with some greenish-gray shales, 10′
50. Soft, olive shales, with a few hard, sandy layers, . . 35′
51. Sandstone, flaggy, ... 5′
52. Olive shales to 201st mile-post; dip here 20° to 22°, . . 15′
53. Shaly sandstone and shales, ... 105′
54. Hard sandstone, in layers 2′ to 3′ thick,. . . 37′
55. Shales, bluish-gray, containing a few thin sandstones, same iron nodules and sparingly the remains of *Spirifera* and *Productella*, ... 165′
56. Concealed, dip 20′, ... 135′
57. Sandy and flaggy, olive micaceous beds, . . . 95′
58. Sandy shales containing *Fucoides graphica* or a closely allied form,. . . . . 90′
59. Concealed, ... 40′
60. Sandy shales, ... 30′
61. Hard sandstone, interstratified with shales,. . . . . 12′
62. Bluish-green, sandy shales with a few flaggy sandstones, 80′

63.	Very hard, bluish-gray, micaceous, sandy beds, once quarried extensively for building a wall along canal; sandstone layers 1′ or 1¼′ thick, separated by thin shales, *Fucoides graphica*, and "casts of flowing mud" seen on some of the layers; dip (S. 40° E.) 16°,	75′
64.	Hard flags and sandy shales, ...	33′
65.	Bluish-gray, sandy shales, ...	9′
66.	Very hard, calcareo-siliceous rock, ...	3
67.	Bluish fossil shales with some sandy beds, ...	30′
68.	Very hard, bluish-gray limy beds, ...	3′
69.	Flaggy sandstone and sandy shales, ...	13′
70.	Bluish-gray, sandy shales, ...	7′
71.	Hard, bluish, limy (slightly) bed, ...	4′
72.	Gray, flaggy sandstone and shales; dip 16°, ...	25′
73.	Concealed to base of *Portage flags* or top of *Genesee*, 1200′ below the 202d mile-post, and about 800′ below where the railroad crosses Stone creek, ...	125′

Summary.

IX. *Catskill beds*, (Nos. 1-23), ...		2620′	5836′
Catskill-Chemung, (Nos. 24, 25, with 515′ of No. 26)		700′	
VIII. *Chemung beds*, (180′ of 26 and No. 49,)	1335′	2516′	
VIII. *Portage*, (Nos. 50-74,)	1181′		

This section begins just opposite the synclinal end of Terrace mountain; and there are about 1000′ more of *Catskill beds* above the top of the section, up to the base of the *Pocono* formation in Terrace mountain; which increases No. IX to 3620′. *The Lackawaxen and Allegrippus conglomerates* are not marked in the section, but their fragments were seen on the surface. Hence the subdivisions above given were made by allowing for the *Chemung* and *Portage rocks* 2500′, and for the transition (VIII-IX) series 700′; and giving the remainder to the *Catskill.*

The distinction of *Portage* and *Chemung* is mainly lithological; but account is taken of the absence of *Chemung fossils* in the lower division. These fossils make their appearance in considerable numbers a short distance above the bottom beds of what I have called *Chemung.*

The Allegrippus (*lower*) *conglomerate* crosses the section in the concealed interval just above the top of No. 27; in a high ridge on both sides of the river. Its fragments, full of white quartz pebbles, are scattered over the surface all along the small run which comes into the river past the Ardenheim school-house. Its place is thus fixed with a possible error of 50′ or 100′.

The rocks which I have placed in the *Portage series* are quite sandy in this section, especially in the lower portion, making high cliffs along the river, closing it in on both sides so as to make "narrows," along which the passage-way both for the canal and railroad had to be blasted out of the solid rock.

The Genesee beds make the valley of Stone creek, west of the Portage bluffs, and there is only room for 200′ of them before we get down to the *Hamilton upper shales*.

The *Catskill red shales* begin about 150′ above the base of No. 2. This 150′ is olive shale, with a few thin *red beds*, and greenish-gray sandstone.

The *synclinal* spoons up north-eastward. At the river it holds 2500′ of Catskill strata; but it loses the last and lowest of these beds only 5 or six miles north of the river, east from the Lutheran church, on hills 400′ higher than the level of the river. The rate of rise along the axis of the synclinal must therefore be about 600′ per mile.

The *synclinal axis* crosses the road which runs east from the Lutheran church at the sharp bend of the road at Mr. D. Rowland's. It crosses the road which goes south-east from the church, half way between the church and the township line.

The Allegrippus conglomerate crops out in the road just south of the church, near Wm. Davis'; dipping 25° to 3° S. E. as a ridge covered with its *conglomerate fragments*.

The *Lackawaxen conglomerate* may perhaps be recognized in a conglomerate which crosses the road near D. Rupert's house, 1½ miles from the river, or rather just south-east of there. To the south-west this conglomerate makes a ridge covered with conglomerate fragments.

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12. *Brady.*

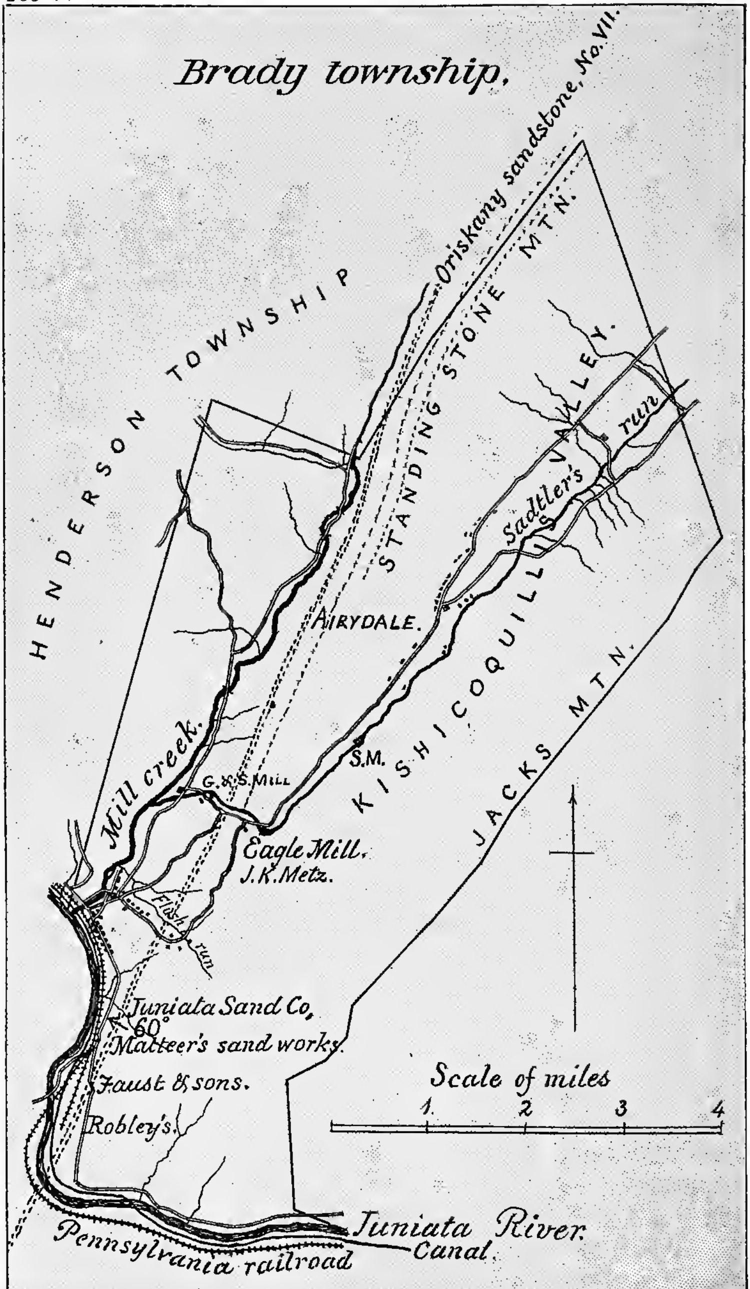
This township borders Henderson on the east, and extends from Jack's narrows northward 12 miles along Stone mountain and 9½ miles along Jack's mountain. These are 4 miles apart along the Mifflin county line, crossing Kishicoquillis valley; the south end of which lies in this township; drained by Saddler's run through Eagle mill (or Matteer's) gap into Mill creek, which follows the west foot of Stone mountain south to the river at Mill Creek P. O.

The geological structure in this township is exactly the reverse of that found in Henderson. There, we have a *synclinal axis* passing through the center of that township, making it a great trough. Here, through the center of Brady passes the anticlinal arch of Jack's mountain, bringing up the limestones of No. II. The axis of this anticlinal crosses the river at the aqueduct, where 200′ to 250′ of the *Hudson River shales* appear beneath a beautiful unbroken arch of *Oneida conglomerate.* The arch of overlying *Medina white sandstone* is worn off at the top, with two outcrops, making the crests of Jack's and Stone mountains, which diverge northward (as the arch rises) and enclose Kishicoquillis valley.

The west dip in Stone mountain is very steep, 50°, varying to nearly 90°, but growing less in the upper Chemung beds on the west township line.

The Oriskany sandstone makes a great show at the bend of the river and along the railroad north of the bridge, dipping 65° to 70′, in a solid wall, which runs along the east side of Mill creek as a sharp ridge, from which glass sand is quarried.

The *Juniata Sand Company* have a fine quarry in the bottom beds of the *Oriskany*, about ¾ mile below Mill Creek village. A steam crusher and washer prepares 35 tons of sand daily for shipment to Pittsburgh, Wheeling, Bellaire, &c. *The sand* produced is called "*second class*," and is used for making bottles, fruit jars, and certain grades of window glass. The sand rock is 125′ thick and makes a line of cliffs on each side of the little stream which breaks through the ridge and supplies plenty of water for washing and transporting the clean sand down the small flume to the shipping point on the railroad. Only the lowest 30′ of the sandstone is now used, these being the purest and softest beds of the series. The following section was got in the ravine: (See Plate XXIV, Fig. 2.)


Brady township.
Oriskany sandstone, No. VII.
HENDERSON TOWNSHIP
STANDING STONE MTN.
KISHICOQUILLIS VALLEY.
Sadtler's run
JACKS MTN.
AIRYDALE.
Mill creek.
G. & S. MILL
S.M.
Eagle Mill.
J.K. Metz.
Flush run
Juniata Sand Co,
60°
Matteer's sand works.
Faust & sons.
Robley's.
Scale of miles
1
2
3
4
Juniata River.
Canal.
Pennsylvania railroad
T3.

Juniata Sand Co's. Section.

1.	*Oriskany sandstone*, very massive, lower portion alone quarried,	125′
2.	*Stormville shales*,	125′
3.	Limestone flaggy,	10′
4.	*Stromatopora bed*, massive,	8′
5.	Impure, slaty limestone, visible,	25′

The dip is 60°, westward.

The *Stormville shales* are here decomposed at top into a bluish-white clay; and the bottom beds of the *Oriskany* have had their *lime* removed and the sand left in a condition to be easily crushed.

The limestone bed, No. 3, of the section, was once quarried and burned by Mr. Irwin, on the land of Mr. Thompson, as flux for the *glass sand*; but it was too impure; as is the case with this part of No. VI everywhere.

The Stromatopora bed, No. 4, is quite well developed here and makes a cliff of massive, impure limestone along the hill, from which *Stromatoporæ* in irregularly weathered patches protrude in vast numbers, including some specimens of *Favosites helderbergiæ*, *Zaphrentis* and other *coralline forms.*

The *Stormville shales* are 75′ to 100′ thinner here than along the base of Tussey mountain; but on the other hand the *Oriskany sandstone* is 75′ thicker; so that taking the two together the total of 250′ does not differ.

The *Lower Helderberg*, *Salina* and *Clinton measures* crop out in succession between the *Sand ridge and the slope of* Stone mountain along a belt only about 1200′ wide; which at 60° would make them together only 1000′ thick; whereas each of them exceeds that thickness along Tussey mountain.

A *fault* may run along at the foot of Stone mountain.

J. W. Mattern's glass sand works are about 150 rods south of the Juniata Co's. works, where another little stream breaks through the *Sand* ridge, but without furnishing enough water to wash the sand. Water is pumped from the canal. The sand (of about the same quality as that turned out by the Juniata Co.) is made from the lower beds of the Oriskany, because they are softer. These works have a capacity of 30 to 35 tons daily, and the sand is shipped mostly to the Pittsburgh glass factories.

B. F. Faust & Son have the next sand works now in operation, two thirds of a mile below Mr. Mattern's. Here there is no break in the sand ridge, but a nearly vertical wall 150 feet high, and the stone is quarried from the *upper* face; being first burned, and then crushed dry with a stamp machine; so that very little water is used, the only portion of the sand washed being the refuse material.

Below this last and near the lock on the canal, a sand quarry was once worked, but disused for several years, the rock being rather hard.

Long curved shells (*Platyceras*) called "cows' horns" by the quarrymen are abundant at all of these quarries, being especially numerous at Foust's where in some layers the rock is honey-combed with their casts. None of the original substance of the shell remains, the lime having all been removed, leaving nothing but a cast of sand.

The *Oriskany sandstone* is exposed through this township for a distance of six miles, and there are doubtless many other localities at which just as good sand could be obtained as at those now in operation, since it is not necessary as formerly supposed that a sand quarry should be located where a stream breaks through the ridge in order to find rock soft enough to crush; because, after the top coating is removed, *soft sand* may be found almost anywhere, though of course there are many localities where it will be too hard, because the lime has not been removed.

Four miles north of Mill creek station, where Mill creek turns abruptly south, the following section was made: (See Sheet 2, Fig. 14.)

Decker's saw-mill section.

1. *Allegrippus conglomerate*, quite pebbly and coarse; makes ridge; thickness, 5' to 8'.		
2. *Chemung shales* and sandstones; dip 30° at top, 45° at base; horizontal distance 2000', ...	1200'	2425'
3. *Portage beds*; dip 45°, distance 1750', . .	1225'	
4. *Genessee, Hamilton* and *Marcellus*; dip 60°-65°; distance 1400', ...		1260'
5. *Oriskany sandstone.*		

The Genesee, Hamilton, and *Marcellus* beds are not so thick here by 200′ as elsewhere in the county; but there may be dips steeper than the 60° or 65°, which I observed. As the *Chemung beds* get steeper from the top downward, and the steepening is increased into the *Genesee*, the dips in the *Hamilton* and *Marcellus* ought to be still steeper, possibly vertical.

The Oriskany sandstone forms a high cliff just east from Decker's saw-mill, and fragments of it are scattered over the ground.

The Lackawaxen conglomerate makes a ridge along the west township line for some distance south of Mill creek.

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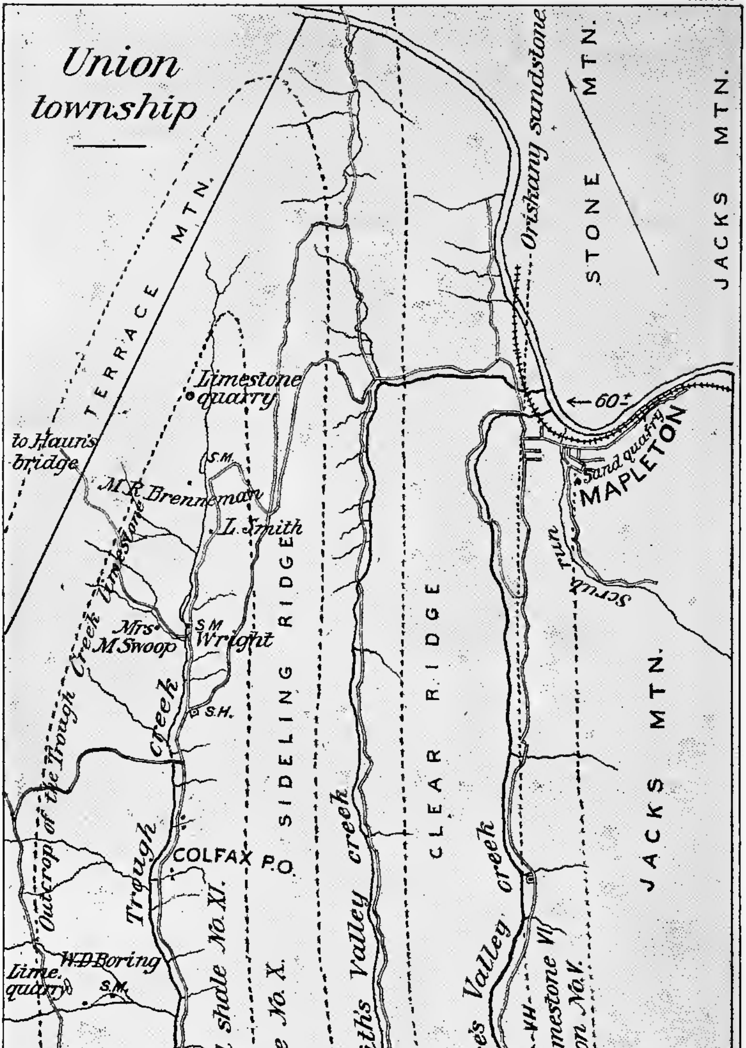
13. Union.

This township covers *Trough Creek valley*, between Terrace mountain and Sideling hill; *Smith's valley*, between Sidling hill and Clear ridge; and *Hare's valley* between Clear ridge and Jack's mountain. The east township line runs 5 miles along the top of Jack's mountain to Singers's Gap creek. The west township line runs 9 miles S. 50° W. along the crest of Tussey mountain, and then another mile S. 80° W. to the Cass township corner. From Tussey crest to Sideling hill crest along the Cass township line, Trough creek valley is five miles broad; but of this only two miles is occupied by the Mauch Chunk red shale formation No. XI; and this width is maintained for 3½ miles north to Colfax. 3 miles further the area of No. XI comes to a point at the head of the valley behind the high knob of Pocono sandstone No. X, which overlooks the river. Smith's valley is Catskill No. IX, ⅝ mile wide.

Clear ridge is Chemung, Genesee, and Hamilton.

Hare's valley creek flows along the Marcellus outcrop. East of it runs the Oriskany ridge with the Stormville shales and the Lewistown (Lower Helderberg) limestones of No. VI. The little valley of Lamb run at Mapleton is excavated in Onondaga (*Salina*) and Clinton shales No. V, which also occupy the flank of Jack's mountain; its crest being an arch of Medina sandstone No. IV.


Union township
TERRACE MTN.
Limestone quarry
to Haun's bridge
M. R. Brenneman
L. Smith
S.M.
Mrs M. Swoop
Wright
S.H.
Outcrop of the Trough Creek limestone
Trough creek
COLFAX P.O.
W. D. Boring
Lime quarry
D. Baumgardner
CALVIN P.O.
Jas. Brown Grist mill
Mauch Chunk red shale No. XI.
Pocono sandstone No. X.
SIDELING RIDGE
Smith's Valley creek
Catskill
No. IX.
CLEAR RIDGE
Chemung No. VIII.
Portage
Hamilton
Hare's Valley creek
Oriskany sandstone
Oriskany sandstone VIII
Lewistown limestone VI
Lower Helderberg limestone VI
Lower Helder and Clinton No. V.
Onondaga
Medina No. IV.
STONE MTN.
JACKS MTN.
MAPLETON
Sand quarry
Scrub run
60°

Where the railroad crosses the Juniata above Mapleton, the *Genesee shales* and upper *Hamilton* are completely exposed. The section has been already given on page 107. (See Plate XXI.)

Mapleton section.

1.	Portage flags,	
2.	Bluish-black shales with thin, interstratified limestones filled with *Goniatites, sp? Lingula, Avicula* and other forms,	45
3.	Black fissile slate,	100′
4.	*Tully?* limestone, impure fossiliferous, containing *Ambocœlia umbonata*,	5
5.	Sandy shales containing *Homalonotus, dekayi, Heliophyllum halli, Spirifera* and *Stictopora*,	70′
6.	Sandy flags containing *crinoidal* remains,	25′
7.	Sandy shales,	25′
8.	*Coral bed*, a mass of *Heliophyllum*, and *Cystophyllum*, from 4 to 6 inches thick, very much like the coral bed at the bottom of the Genessee in Pike and Monroe counties.	
9.	Shales, dark-brown, and blackish, quite *fossiliferous* near base,	85′
10.	Shales, sparingly *fossiliferous*,	50
11.	*Hamilton upper sandstone*, flaggy at top but massive below; *Spirophyton* observed in the upper portion along with *Spirifers* and *crinoidal fragments*; Bottom part very fossiliferous. (See list of species on page 110.)	45′
12.	Shales; and concealed by the river channel; distance 1175 ; dip 60° to 65° ; observed at both sides,	1000′
13.	*Oriskany sandstone* at Faust's quarry,	

The measurements were made with great care, tally well with those made in Hopewell, Lincoln, and Penn townships, and therefore make it probable that the *Hamilton* on Mill creek in Brady township is usually thicker than the section at Decker's saw-mill, on page 270, makes it.

The limestone layers scattered through the *Genessee* come in and go out again quite suddenly, and in some places inclose many specimens of *Goniatites patersoni*.

The Oriskany sandstone south from Mapleton makes a high, steep ridge, from which good glass-sand is extensively quarried by the Mapleton Sand Company, of which Messrs. Hatfield and Philips are the principal stockholders. There are two quarries and washing works, each having a capacity of forty tons a day. The first quarry is just west of the village, about one fourth mile from the Mapleton depot; on the eastern face of Sand ridge; consequently in the lower beds.

In the middle beds of the *Oriskany* are here seen vast numbers of *Platyceras* (several species,) *Rensselæria ovoides*, *Grammysia*, *spec.* *Spirifera arrecta*, and many other forms, projecting from the layers of sandstone in countless numbers. A full list is given on page 119 above.

The other quarry is a furlong southwest of the first one and has only recently been opened. The lower portion of the *Oriskany* is quarried here; reached by a tunnel driven through the upper *Stormville shales*, *showing finely the plane of contact of the overlying Oriskany and underlying shales;* the change being *immediate* from fine, clayey shales to coarse sand rock; and the shales being partially disintegrated into *clay* for several feet from the plane of contact.

In the valley of Trough creek are some of the finest farms in the country, of rolling, red shale land; the rocks dipping towards the creek 8° or 10° from the northwest, and somewhat steeper from the east. The red shale points out at the forks of the creek, one mile north of Mr. Brenneman's house.

The limestone, at the base of the red shale series, has been described on pages 75 to 77. It is of the greatest importance to the agricultural interests of the valley; for, by a liberal use of it on the fields, they may easily be brought into a high state of fertility; whereas if no lime is applied the soil grows gradually poorer and poorer, until the return is so small that farming is unprofitable. The limestone beds could be opened upon at least 20 farms in this township; and yet there are at present only two farms on which it is quarried. It can be easily found at the edge of the *red* land on the slope of Terrace mountain, where the gray rocks come up. At many points, however, the outcrop is covered by clays, &c. which have been made by the decomposition of the limestone; but the unchanged limestone beds will be found underneath. They were once quarried by Mr. Brenneman half a mile or more north-east from his house, and 2,000 or 3,000 bushels of lime burned, but the quarry is not now used.

They are quarried now on the land of Mrs. M. Swope, along the road which leads north over Terrace mountain to Haun's bridge. Here 3½′ of limestone rest directly on *sandstone.* The lowermost layer of the limestone, being quite sandy, is often rejected. The whole is, however, somewhat siliceous, and has a bluish-gray or greenish cast, *non-fossiliferous*, leaving a blackish, unctuous clay on decomposed surfaces. The stone is hauled from Mrs. Swope's quarry to many farms in the township, the farmers prefering to burn it themselves on their own premises.

The only other quarry is on the land of Michael and W. D. Boring, 2½ miles southwest from Mrs. Swope's, where the following beds may be seen:

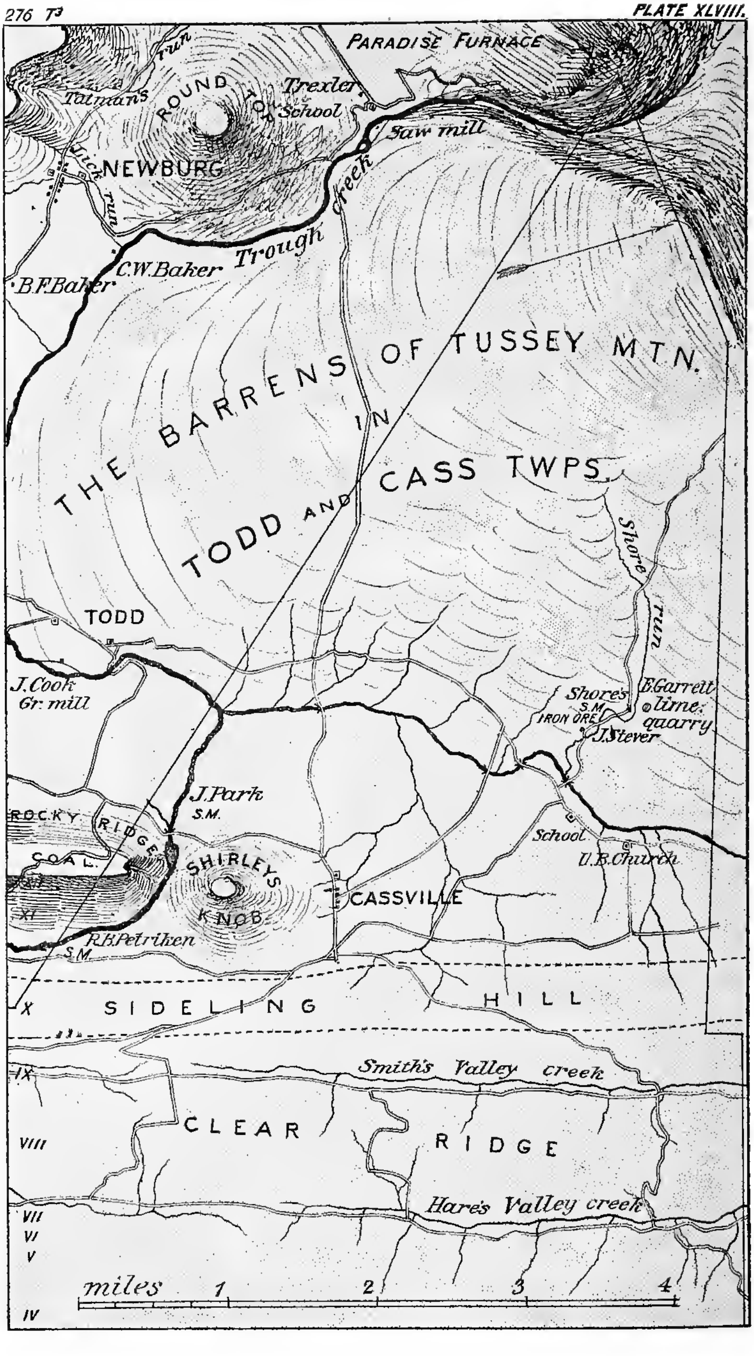
Boring's limestone quarry.

1. Soil and *red shale*,	5′ 0″
2. Red, sandy, limy beds,	4′ 0″
3. *Greenish limestone*,	3′ to 3′ 6″
4. Black clay, (decomposed limestone),	3″
5. *Limestone*, upper half good, lower half too sandy for burning,	1′ 6″

The limestone is quarried, after stripping off some overlying shales, along the slope of the hill for several hundred feet. The amount of limestone available here before the stripping becomes too heavy is not large; but there are several other places on the same property where it can be easily worked; one of them in the orchard just east from Michael Boring's house; where it crops out in the road for several yards, and the siliceous portion is seen with its blackened fragments along the ground for a much greater distance. It could also be reached by removing some soil and *red shale* just northeast from the present quarry.

Mr. McCreath's analysis shows that Boring's limestone consists of 86.607 per cent of carbonate of lime; 1.574, carbonate magnesia; 1.520, oxide iron and alumina; 0.011 phosphorus; a strong trace of manganese; and 9.530 of siliceous matter.

It was once opened and burned on the land of Henry


PARADISE FURNACE
Tatman's run
ROUND TOP
Trexler School
Saw mill
NEWBURG
Lick run
Trough Creek
C.W.Baker
B.F.Baker
THE BARRENS OF TUSSEY MTN.
IN
TODD AND CASS TWPS.
Shore run
TODD
J.Cook Gr: mill
Shore's S.M.
IRON ORE
E.Garrett lime: quarry
J.Stever
J.Park S.M.
ROCKY RIDGE
COAL
SHIRLEYS KNOB
CASSVILLE
School
U.B.Church
XI
R.B.Petriken S.M.
X
SIDELING HILL
IX
Smith's Valley creek
VIII
CLEAR RIDGE
VII
VI
V
Hare's Valley creek
miles 1 2 3 4
IV

Baumgardner, 1 mile south-west from Boring's quarry, but nothing has been done there for many years.

On the east side of the valley, the outcrop of limestone seems to be much more siliceous, and no one in this township has succeeded in burning it. Mr. Lewis Smith made the attempt, but the rock was merely a limy sandstone and choked up the kiln with slag.

Brown hematite iron ore-bearing clays have been deposited at various places along the outcrops of the *Trough creek limestone beds*, the result of their dissolution ; as on the land of Mr. Levi Pheasant, whence about 100 tons were wagoned to the Rock Hill furnace, at Orbisonia, and report says successfully mixed with other ores. The long and difficult transportation prevents any development of these ores, and the old drifts are fallen shut, so that no accurate information can be got from them. But I learned from one who had seen the ore in place, that the deposit occurs in irregular pots and nuggets along with a great quantity of wash ore.

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14. *Cass.*

This township, lying south of Union, also crosses Trough creek valley from mountain to mountain (12 miles), Smith's valley, Clear ridge, Hare's valley, Stone ridge, and the west slope of Jack's mountain to its summit. The north and south branches of Trough creek meet at the Cass township line, flow around through Todd township, and cut the gap through Tussey mountain at the western township corner.

The Trough creek basin, which is single in Union township, becomes double in Cass township, being subdivided by an anticlinal roll running west of Cassville. The eastern sub-basin is deeper and more tightly compressed than the western, and preserves the *Pottsville conglomerate No. XII* in Shirley's knob, and in Rocky ridge, the north end of which comes to the south township line. A patch of coal measure rocks remains on Shirley's knob. Rocky ridge belongs to Todd township. The breadth of red shale across both sub-basins at Cassville is 2¼ miles. Its western edge runs ⅓ mile west of the creek. From the west edge of the red shale there is a long mountain slope of Pocono sandstone (produced the broad gentle northward rising Broad Top City anticlinal) called the Barrens, for 3 miles up to the crest of Terrace mountain.

The Trough creek red shale valley of Union township is therefore the northward continuation of the East Broad Top coal basin; whereas the Shoup run coal basin points toward the Cass township corner.

Shirley's knob, on the summit, at 1900′ A. T. (by barometer) the Cook bed, as I understand it, was opened in 1881, (before which date the knob was supposed to be capped merely with conglomerate,) Mr. Sleeman sinking several pits 5′ to 25′ deep and finding the coal in nearly all of them, but broken into very small lumps, several hundred bushels of which were sold. The bed is 5′ or 6′ thick, and only 10′ above No. XII. The abundance of *fossil plants* in the roof shales indicates the Cook bed; the following species being recognized: *Neuropteris hirsuta*, *N. clarksoni*, *N. flexuosa*, *Pecopteris nervosa*, besides a *Cardiocarpon* and a *Cordaites*.

The Conglomerate (XII) makes a cliff 30′ high on the south edge of the summit; very hard, rather coarse, grayish-white sandstone. The area underlaid by the coal (say 10 acres,) is on the slope west of the crest of the knob. The west outcrop of No. XII is broken up into masses of rock from one to five feet across, scattered over the entire west slope of the knob.

The Trough creek limestone (at the bottom of XI) is extensively quarried on the land of Mrs. Ellen Garrett, 2½ miles N. N. W. of Cassville, where Shore's run descends from the Barrens and enters the red shale. (See Plate XIII.)

Mrs. Garret's quarry.

Red shale and green sandy beds,	4′
Limestone, good,	2′ 6″
Clay,	3″
Limestone,	1′
Pocono sandstone No. X, [Ashburner's lower XI.]	

The upper bench is quarried most; is sometimes 3′ thick, and always exhibits ferruginous particles on its weathered surface. *The clay streak* between the two benches is a decomposed parting of *argillaceous limestone.* The lower bench is sometimes so sandy as to be rejected. It weathers rapidly and leaves a dark, ferruginous substance on the subject which, when wet, is soft and unctuous. The limestone is quarried by stripping, only from 2′ to 4′; and several acres of *this limestone* are still accessible before the stripping gets to be expensive.

The Pocono sandstone No. X begins to rise from Shore's run where the road at J. Stever's crosses it.

The *iron ore* seen at the roadside, just below Shore's saw-mill, lying directly on top of the *Pocono sandstone.* It was once mined by drift on the land of Clayton Greenland, and 75 or 100 tons of it hauled to Orbisonia; but it is rather siliceous, and contains a considerable quantity of *manganese.*

A bed of *red limestone* is sometimes seen in this township overlying by several feet the bluish-green limestones which rest on the *Pocono sandstone.* One such was once quarried near Mr. Stever's, on Shore's run, and report says made excellent farm lime.

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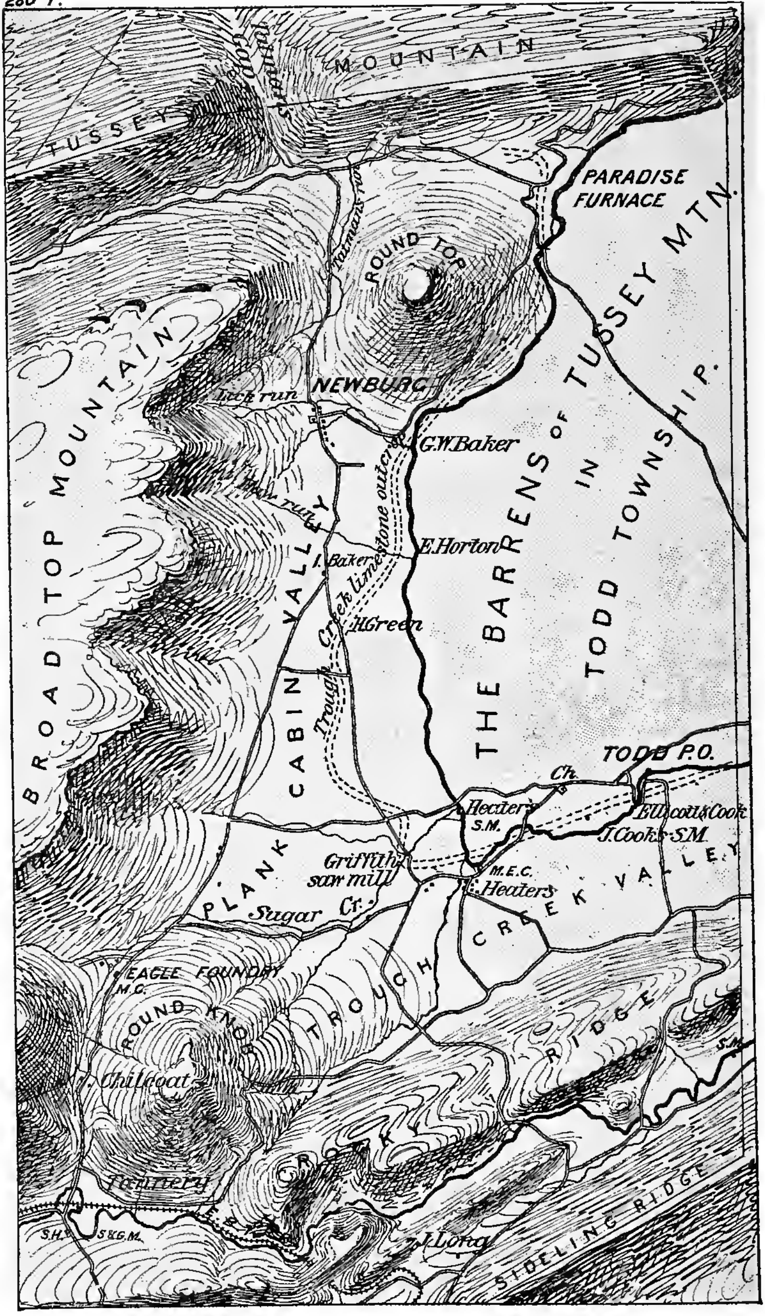
15. *Todd.*

This township adjoins Cass on the south; stretches across from Terrace mountain to Sideling hill; covers part of the Barrens, the red shale valley of Newburg, and the northern portion of the Broad Top mountain, together with Rocky ridge, Chilcote's Knob, Round Knob, and the north end of Wray's hill.

The course of Trough creek around the edge of the Barrens—first from Todd P. O. south 1½ miles to the Methodist church; then north-west 3 miles to the bend at Newburg; then north 2 miles to Trexler & Co.'s saw-mill and Paradise furnace—is very instructive, for it defines the shape and character of the wide Broad Top City anticlinal, with


TUSSEY MOUNTAIN
PARADISE FURNACE
ROUND TOP
TUSSEY MTN.
BROAD TOP MOUNTAIN
NEWBURG
Lick run
G.W.Baker
THE BARRENS OF TUSSEY IN TODD TOWNSHIP.
E.Horton
I. Baker
Trough Creek limestone outcrop
H.Green
CABIN VALLEY
TODD P.O.
Ch.
Heaters S.M.
Ellcott & Cook
J. Cook S.M.
Griffith saw mill
M.E.C.
Heaters
PLANK
Sugar Cr.
CREEK VALLEY
EAGLE FOUNDRY
M.C.
ROUND KNOB
TROUGH
RIDGE
Chilcoat
ROCK
S.H.
S&G.M.
J. Long
SIDELING RIDGE

its gently waving west, and steeper dipping east, sides. The long slope of the Barrens, with this semicircular line of the creek at its foot, shows how the great arch sinks southward; how the erosion has gradually removed all the red shale from the slope and left it in the valley; and what an important *rôle* the limestones at the base of the red shales have played in the process; for, the outcrop of the limestones follows the line of the creek all round the foot-edge of the Barrens; and in like manner the line of the south branch of Tatman's run along the foot of Terrace mountain, from the Carbon township line to Tatman's gap.

Much of the Barrens is primitive forest, and a large amount of excellent pine timber is standing on it, still sheltering deer, wild turkey, and other game.

The surface rocks are yellowish, sandy shales, and flaggy sandstones, in parts well suited for farming, but with a soil generally poor and thin.* The sandstones appear in the creek at the Cass township line, the *limestone* outcrop running a short distance east of the creek. A little further south the limestone crosses to the west side of the creek; but at the Todd or brick mills, near Todd P. O., it is quarried in a cliff along the east bank of the creek, on Jackson Miller's land, where the following beds show:

Jackson Miller's quarry.

Red, limy beds,	10′	15½′
Limestone, greenish, impure,	½′	
Limestone (*quarried*), greenish-gray, ... visible,	3′	
Limestone, reported (quarried at low water),	2′	

A good deal of stone has been hauled from here by the farmers. The quarry bed underlies the bed of the creek above and below the quarry.

A bed of *red limestone* lying a few feet above the red limy beds is not quarried here. *The underlying sandstone* is seen coming out of the creek on the west bank.

Below Todd's mills nothing is seen of the *limestone* until

[*These shales and sandstones have been included in the Mauch Chunk red shale formation No. XI in the sections given in Report F on the Sideling hill side of the Trough.]

we come to Taylor's road crossing. Taylor's is a mile below the mill. Here on the east bank is a large limestone quarry owned by F. M. Taylor, Jno. Whiting and Eli Keith, where the following beds show: (See Plate XIII, Fig. 2.)

Taylor's quarry.

1. *Red shales.*		
2. *Red limestone,*	4′	30′
3. *Red shales,* limy,	16	
4. Gray limestone,	2 6	
5. *Red slates,*	3	
6. Limestone, greenish-gray,	4	
7. *Pocono sandstone.*		

The *red limestone* (No. 2) is mined here and highly prized by the farmers. Nos. 4 and 6 are both good limestone and are taken out entirely down to the *sandstone* which forms a platform for it as smooth and level as a floor.

Half a mile further down the creek, just below the Methodist church, we see the limestone with the accompanying shales make a vertical cliff 30′ to 40′ high, just below the mouth of a small stream which puts into the creek from the south. Here the beds are: (See Plate XIII, Fig. 3.)

Heater's quarry.

1. *Red limy shale,*	20	36′
2. Gray limestone,	1	
3. *Red limy shales,*	5	
4. Gray limestone,	3	
5. *Red limy shales,*	4	
6. Sandy, greenish-gray limestone,	3	
7. *Pocono sandstone,*	visible, 5	

A large amount of limestone has been quarried here for farm use; bed No. 3 being that on which the most quarrying has been done, it having been mined back under the overhanging cliffs. The *red limestone* of Taylor's section probably overlies No. 1. The sandstone (No. 7) just below the quarry, makes a range of cliffs along the stream.

Trough creek turns at a right angle to the northwest just above Heater's quarry, and keeps on past Paradise furnace to the gap in Terrace mountain; but in doing this it cuts off a strip of the Barrens, leaving the upper Pocono beds on the south side of the creek. This is shown by the fact that the limestone beds cross Sugar creek half a mile above its mouth, at Griffith's saw-mill, where the road to Newburg crosses. An abandoned quarry here shows: (See Plate XIII.)

Old Sugar creek quarry.

1. *Red limy shales,*	10	48′
2. Reddish-gray limestone,	2	
3. *Red limy,* shaly beds,	20	
4. Gray limestone, (*once quarried*),	1	
5 *Red beds,*	5	
6. Gray limestone, good, (*once quarried*),	3	
7. Concealed,	7	
8. Pocono gray sandstone, massive.		

For two miles towards T. Baker's road-forks sandstone beds are seen cropping out along the road to Newburg.

At Baker's a low ridge of red shale crosses the road and runs northward for several hundred yards.

The Trough creek limestone is quarried on the land of Mr. G. W. Baker, at the mouth of Lick run, ¾ mile east of Newburg. (See Plate XIII, Fig. 5.)

Baker's quarry.

1. *Red shales,*		
2. *Red brecciated limestone (fossiliferous),*	5	33
3. *Red shales* and limy beds,	12	
4. Limestone, gray,	3½	
5. *Red shales* and limy beds,	10	
6. Gray limestone,	2½	
7. *Pocono sandstone,* massive, gray,		20

Some fossil fragments were seen in the top limestone here among which were specimens of a *Straparollus.* This *reddish limestone* is brecciated, and looks as though it had been crushed to pieces and recemented. Beds Nos. 4 and 6 are alone quarried. They have a greenish gray color, and break with sharp, angular fracture; but are somewhat siliceous, as these lower beds always are.

Two miles below the mouth of Lick run on Trough creek we reach the Paradise furnace property, owned by the Patterson estate. Here, a furnace was built in 1832, by Messrs. Trexler and Lesher, to smelt the ores of the neighborhood. It was operated to a small extent for several years, the product being largely manufactured into stoves and other domestic utensils directly from the furnace. It soon went out of blast and remained so until 1865, when it was repaired by the Trexler heirs and run for 3 years, principally on *fossil ore* from Tussey mountain.

The old furnace ore bank is half a mile northwest of the furnace, on the foot slope of Terrace mountain. The limestones and limy shales at the bottom of XI have been dissolved into deposits of *manganiferous iron ore*, in nodules and balls measuring from an inch to a foot in diameter, scattered through the soil and red *débris*, over a wide strip of ground. The ore was mined by stripping, and a large quantity of ore yet remains along the line of contact. Some of the balls contain so much manganese that if a sufficient quantity could be collected they would be valuable for that alone.

Mr. John A. Patterson collected 110 small pieces of this *manganiferous iron ore*, which when analyzed by Mr. McCreath was found to contain:

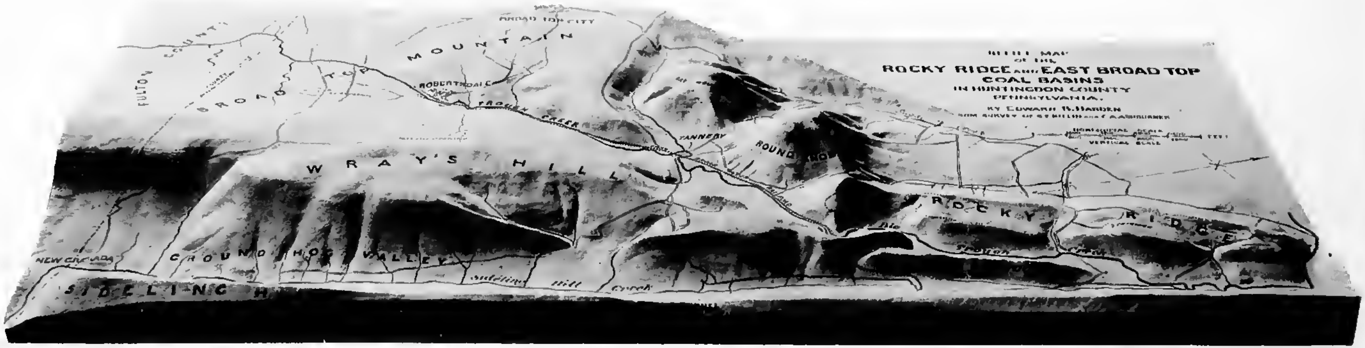
Metallic iron,	23.650
Metallic manganese,	19.676
Phosphorus,	.458
Siliceous matter,	18.640

Of course not all of the ore gave so high a percentage of *manganese*, but it permeates the whole to a considerable extent, and were it not for the high per cent of *phosphorus* might be used in the manufacture of spiegeleisen; and some of the old metal made from this ore looks very much like spiegel.

Just above the bridge across Trough creek, near Paradise furnace, the lower part of the *limestone* is well exposed along the west bank of the creek, viz:

Gray limestone,	3
Red limy and sandy beds,	7
Pocono sandstone, massive.	

all dipping gently east, and for 200 yards further (south) up the stream, where the *gray limestone* goes under water-level. This is on the bottom line of the Coalmont trough; for, going further up the stream, the gray limestone begins to rise to the east and soon gets several feet above the creek.



HELIOTYPE PRINTING CO. BOSTON.

EAST BROAD TOP MOUNTAIN AS SEEN FROM THE SOUTH EAST.

VERTICAL SCALE OF MODEL 800; HORIZONTAL SCALE 1600 FEET TO AN INCH.

Round Top, an isolated mountain rising 950′ above Trough creek, about ¾ mile south of the furnace, lies in the axis of the trough. It is a mound of red shale No. XI, capped with the bottom layers of the *Conglomerate No. XII;* about 10 acres; with an edge of cliff all round. The following section was made from the summit straight down to Trough creek, ¼ mile above the furnace: (See Plate XII, Fig. 1.)

Paradise furnace Round Top section.

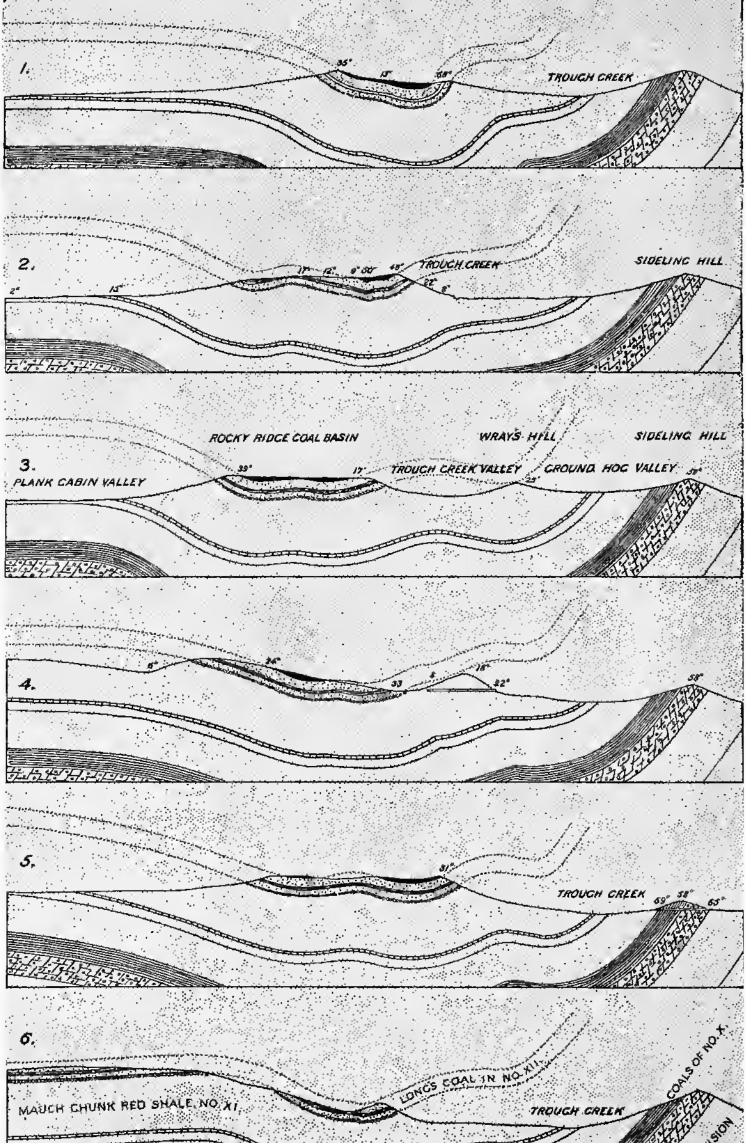
1.	Bottom rocks of No. XII, massive grayish white sandstone,		15′
2.	Concealed,		10′
3.	*Iron ore* of No. XI; pieces scattered over the ground; trial holes along the outcrop,		?
4.	*Red shales* and green sandstones,		500′
5.	*Brecciated limestones*, reddish, impure; visible,		2′
6.	*Red shales;* by barometer 450′ thick; add for south-west dip say 50′: making say		500′
7.	*Limestone, red* and mottled, massive, impure,	25	39
8.	*Limestone, red*, shaly,	4	
9.	*Limestone* gray,	3	
10.	Limy beds, red,	7	
11.	Sandstone at level of Trough creek (900′ A. T.)		
	Total thickness of No. XI,		1051′

No fossils were seen in limestone bed No. 5; but it may be taken to represent the limestone series between the upper and lower red shales in the gaps of Westmoreland and Fayette counties and West Virginia, described in Reports K[2] and K[3].

The lower siliceous limestone at the bottom of No. XI crops out in the cliffs which border the creek above the furnace. The upper red beds (No. 7) are especially massive; they have been quarried and burned by Mr. Patterson. An analysis by Mr. McCreath shows:

Carbonate of lime,	51.785
Carbonate of magnesia,	1.188
Oxide of iron and alumina,	3.380
Manganese, strong trace.	——
Siliceous matter,	42.510
	98.863

The gray limestone, No. 9, was used as a flux at the old Paradise furnace. An analysis by Mr. McCreath showed:



Sections across Rocky Ridge coal basin.

1. Through Savage coal bank. 2. Through Taylor coal bank. 3. Through Dougherty's bank. 4. Through Wray's hill tunnel. 5. Through Sideling hill tunnel. 6. Through Deever place.

Carbonate of lime,	90.992
Carbonate of magnesia,	1 059
Oxide of iron and alumina,	0.940
Phosphorus,	0.013
Manganese, strong trace.	——
Siliceous matter,	6 091
Total,	99.094

Just below Paradise furnace Trough creek begins its gorge-like passage through the *Pocono sandstone beds* of Terrace mountain; following the axis of the trough northward, and frequently descending in rapids. The gray sandstone cliffs between which it flows have in some places a perpendicular height of two or three hundred feet.

*The copperas rocks** are about a mile below Paradise furnace. Here two thin seams of *coal* are visible in the *sandstone beds;* and one occurs in the blue shale under a bed of sandstone. They vary in thickness from two to six inches; and must lie about 200′ beneath the red shale; the Pocono sandstone cliff rising that high above them.

A small bed of coal (8″ to 10″ thick) was found in excavating for the foundation of the grist mill just below Paradise furnace, near the top of the *Pocono series.*

For a description of the rock through the gap, see under the head of Penn township, on page 175 above.

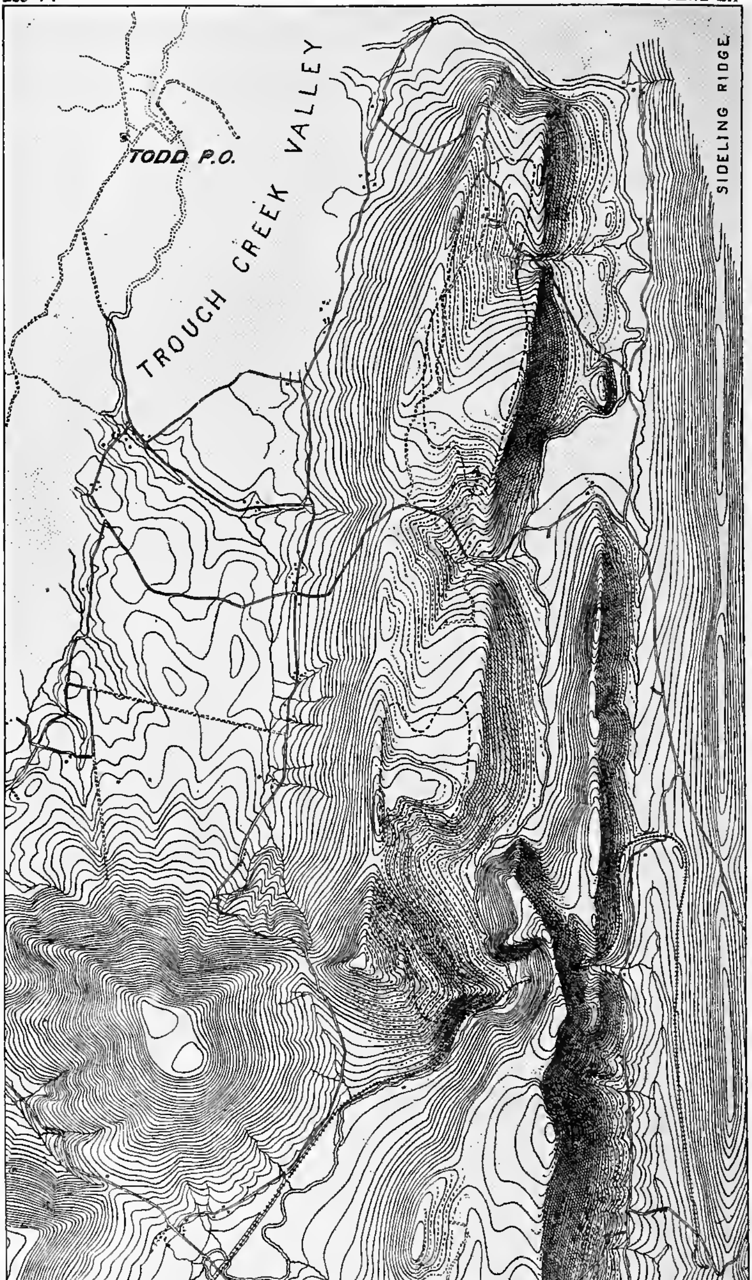
Tatman's creek cuts a separate gap through Terrace mountain two miles south of Paradise furnace, exposing the *Pocono sandstone* in a series of great cliffs.

The brecciated limestone, seen half way up the slope of Round Top, here shows itself along the road which leads from Newburg down Tatman's run. It is 2 or 3 feet thick, and would burn into good lime for farm use.

In this narrow valley of red shale are indications of *iron ore* at several points.

The conglomerate No. XII, which faces the high mountain plateau, looking down westward into the little valley, and northward and eastward into Trough creek valley, has only preserved in this township its lower massive beds. Its

*Exudations of *copperas* on the cliffs above the *coal beds*, and from the shale in which they occur have given name to the locality.


TODD P.O.
TROUGH CREEK VALLEY
SIDELING RIDGE

northern point represents the deep Coalmont basin; its spurs, overlooking Newburg and Eagle forge, represent the rolls which carry the coal beds up and down on Shoup's run. Rocky ridge, with its patches of coal measures, has been preserved along the center line of the East Broad-top basin.

Rocky ridge and Wray's hill.

[The description which follows will be understood by reference to Plates L, LI, LII, reduced from Messrs. Ashburner and Billin's topographical map and sections, made in the survey of 1875, and not before published.

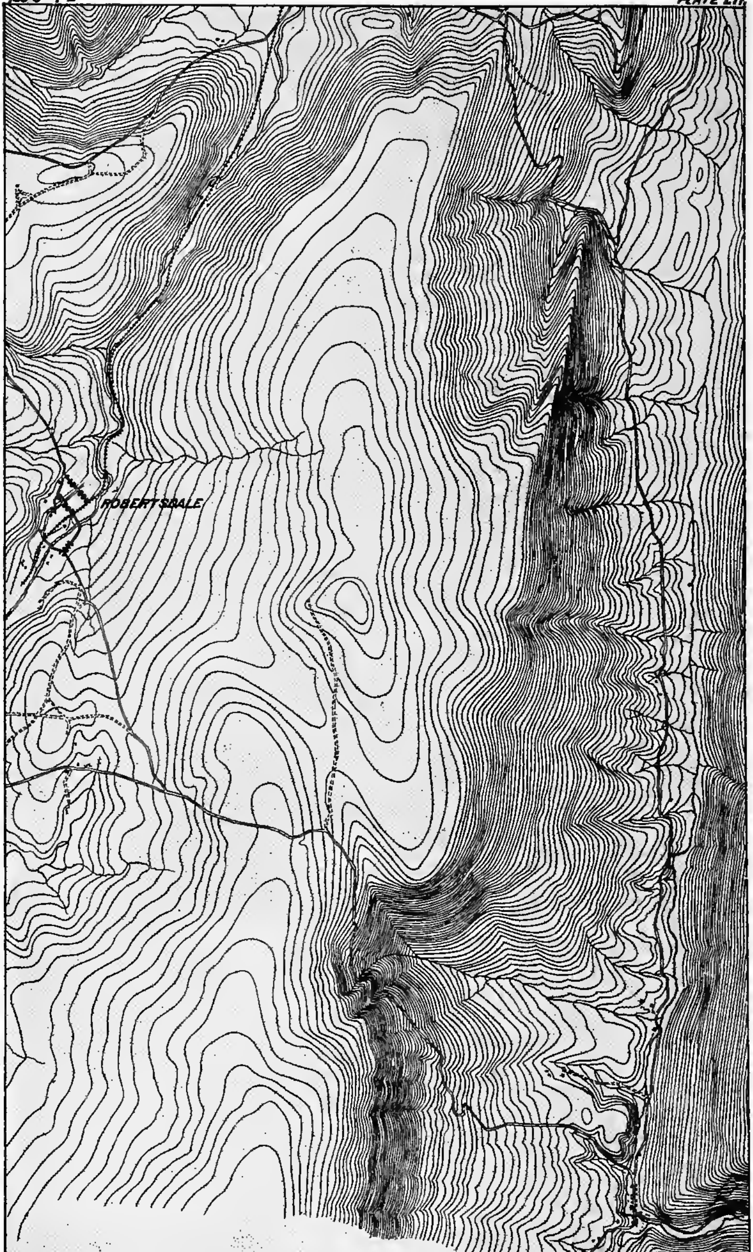
Plate L shows the structure of Rocky ridge and its enclosing valleys, by means of six cross sections; No. 1 through the old Savage bank, at the north; No. 2, through the Taylor bank; No. 3, through Dougherty's bank; No. 4, through Wray's hill tunnel; No. 5, through the Sideling hill tunnel; and No. 6, across Wray's hill somewhat further south.

Plate LI shows the topographical features of *Rocky ridge*, Long's ridge, the long north prong of Wray's hill, the curious spur at the tunnel and the beginning of the exposure of Wray's hill southwards, as far as the tannery.

Plate LII shows Wray's hill expanding into a high plateau, holding the wide and shallow East Broad Top coal basin, with the Robertsdale mines, and Broad Top City on the west.]

The coal measures of Rocky ridge remain as three patches, the largest of which is at its northern end. Here coal had been mined for many years by short drifts, before Mr. G. S. Sleeman, in 1882, undertook more serious mining operations.

The coal measures here, lie in a fold on the east slope of the ridge, so that mining operations on a small scale are difficult, because the rapid dip into the ridge makes drainage difficult, and to get much coal on the west side of the sharp syncline requires a long tunnel. Mr. Sleeman first sunk a slope on the bed, at an angle of 20°, to a depth of 100 feet; and then drove a gangway north for 400′ or 500′, removing


ROBERTSDALE

the water from the mine with a siphon. Failing to get across the basin in this direction, he tunneled from the gangway directly across, 60 feet, to the coal on its west rise, thus getting a large area of available coal.

Sleeman's mine section. (*Plate LIII, Fig. 1.*)

Sandstones and shales.			
Coal, Barnet,	Coal,	1½′	6½′
	Rock,	1′	
	Coal,	4′	
Sandstone, and shales,*			63′
Coal, Cook,	Coal,	4′ 5″	7′
	Slate,	1′ 0″	
	Coal,	1′ 6″	
Shales (overlying Conglomerate No. XII),			15′

This would agree with the Barnett and Cook sections on Shoup's run.

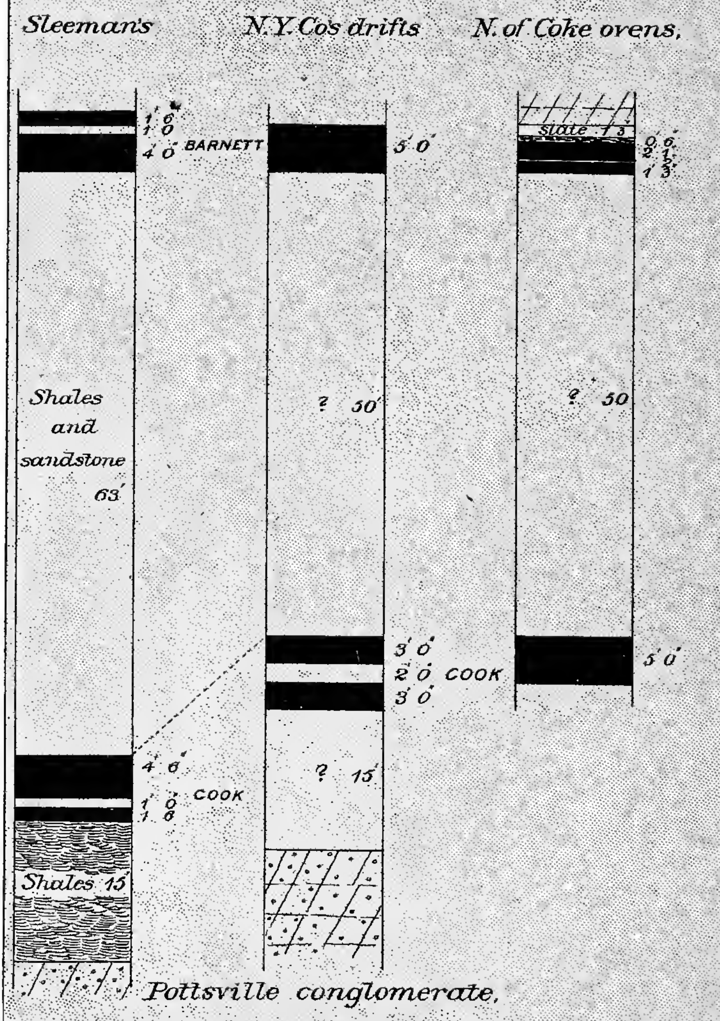
The *Cook vein* is the one mined by Mr. Sleeman. The upper bench is never less than 4′ thick, and more frequently 4½′ to 5′. It is a lustrous, clean coal which comes out in large blocks, and is very free from slate and other impurities, except occasional large "sulphur binders" which are easily removed.

The lower bench has an average thickness of 1½′ and is separated from the upper bench by a dark gray slate which is seldom less than one foot thick, and sometimes 1½′. This portion of the vein is not now mined; for, although the coal is good, the cost of taking up the hard slate above it is so great that when a thickness of 4½′ of coal can be obtained from the upper bench alone, the extra expense would be unwarranted. The coal from this opening is hauled for a long distance into the surrounding country, this being the nearest source of supply for a considerable district east, north, and west.

The Barnet bed was once exploited by a tunnel near Mr. Sleeman's opening, and found as in the section above. The opening had fallen in when I visited the locality and only the blossom could be seen. The parting rock between the two benches of this coal is visible however cropping out on

*This interval of "63" I give on the authority of Mr. Sleeman.

BARNETT and COOK beds on Shoup's run,



the surface where it appears as a very siliceous rock, nearly as hard as granite and one foot thick.

The length of this coal field is 1⅛ miles, by 1000′ in breadth.

The Petriken (Taylor) coal mine is at its south end. Stapleton's road from Roberts' house on the creek to J. Taylor's school-house crosses west over the ridge between the northern and middle coal patch. The middle patch is about half a mile long and subdivided into two little basins. Its north end is a mile south of Petriken's mine. The third patch is only a third of a mile long and half a mile south of the middle patch. The deep gorge of Trough creek (south branch) here separates the south end of Rocky ridge from the north end of Wray's hill on one side (east,) and a notch separates Rocky ridge from Round knob on the other side (west,) on the top of which remains a little conglomerate. The road from Cook's tannery and grist mill north to J. Taylor's school-house goes through this notch.

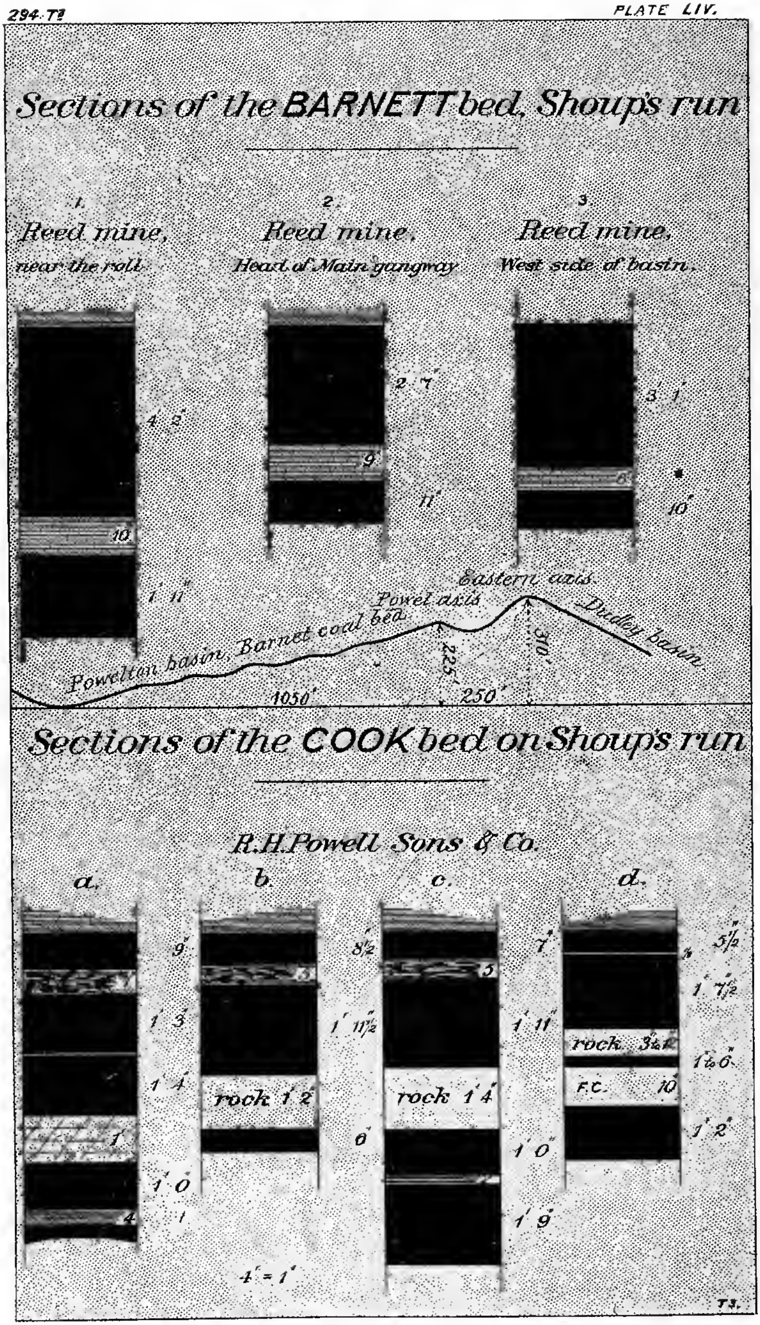
Petriken's coal (A), Curfman's (Savage) coal (B), and Dougherty's coal (C), were analyzed by Mr. McCreath and showed the following constituents: (See F. p. 190.)

	(A.)	(B.)	(C.)
Carbon fixed,	75.421	74.623	67.154
Volatile matter,	18.165	17.840	17.540
Ash,	5.030	5.720	13.600
Sulphur,	.994	.797	1.496
Water,	.390	1.020	.210

Long's ridge is a narrow remnant of Conglomerate No. XII between Rocky ridge and Sideling hill, east of Trough creek, and exactly opposite the middle coal patch on Rocky ridge. It is about ¾ mile long along its rocky crest. *Long's coal bed* (2′ thick,) lies *under* 160′ of conglomerate rocks, and *over* 80′ more of conglomerate rocks, these last resting on the red shale of No. XI. It is opened at the north end of the little ridge.

Wray's hill projects two miles into this township and is capped by No. XII, with no coal except the Long coal bed which lies in the conglomerate.

The Yellow branch of Trough creek flows east along and


Sections of the BARNETT bed, Shoup's run
1. Reed mine, near the roll.
2. Reed mine, Head of Main gangway
3. Reed mine, West side of basin.
4' 2"
10
1' 11"
2' 7"
9
11"
3' 1"
8
10"
Eastern axis
Powel axis
Dudley basin
Powelton basin, Barnet coal bed
225'
310'
1050'
250'
Sections of the COOK bed on Shoup's run
R.H.Powell Sons & Co.
a.
b.
c.
d.
9"
1' 3"
1' 4"
1'
1' 0"
4
1
8½
3
1' 11½
rock 1' 2"
6"
7"
5
1' 11"
rock 1' 4"
1' 0"
1' 9"
5½
½
1' 7½
rock 3 & 1
1 to 6
F.C.
10
1' 2"
4' = 1"
T3.

just inside the Carbon township line until within $\frac{5}{8}$ mile of its junction with Trough creek at the carding mill, and tannery, and grist mill. *Yellow branch* cuts off a broad, high knob from the Broad Top City part of the mountain, on the south; and a run on its west side cuts it off from the main mountain on that side.

This *Chilcoat's knob* is a mile long east and west and $\frac{3}{4}$ mile wide north and south, covered with Conglomerate, doubtless containing Long's coal bed, but none of the Broad Top coals. The East Broad Top railroad makes its way from Robertsdale down Trough creek; crosses the bend at the mouth of Yellow branch; keeps down the west side of the creek $1\frac{1}{2}$ miles; crosses to the east side in the gorge between Rocky ridge and Wray's hill; tunnels through the sharp ridge of red shale; makes a bow and then runs south along Sideling hill 2 miles to the west end of the tunnel, which is within $\frac{3}{4}$ mile of the Carbon county corner. The structure of this south-east corner of the county including Long's ridge, Rocky ridge.

---

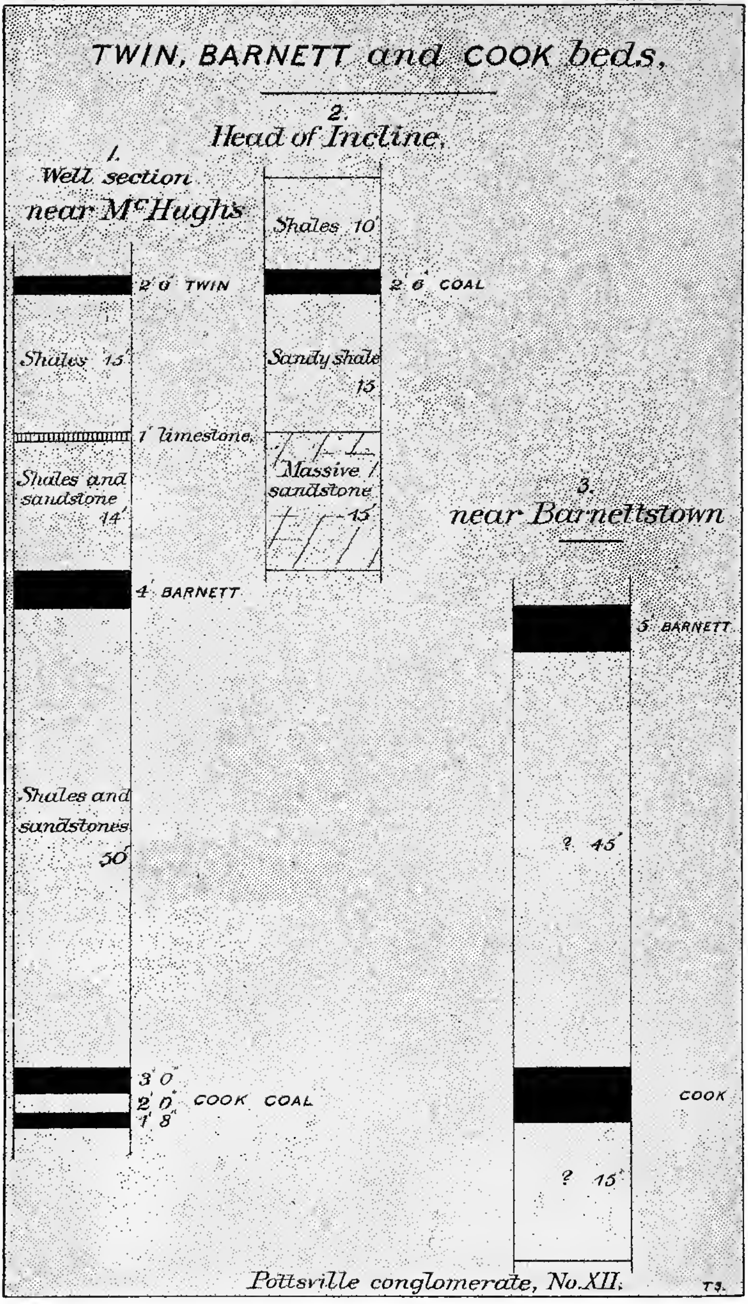
16. *Carbon.*

This township, lying between Todd township and Bedford county, from Terrace mountain on the west to Sideling hill on the east, holds the important coal fields of Shoup's run and Robertsdale.

Its south line from one mountain to the other is $9\frac{1}{2}$ miles. From the west edge of the conglomerate No. XII, at Coalmont, to the east edge in Wray's hill, is about 8 miles, but the extreme width of the coal measure area is not much over 6 miles.

Its western half is drained by Shoup's run westward from Broad Top City (1983 A. T.) to Coalmont (1106 A. T.), and through the gap in Terrace mountain leading out to the Raystown branch at Saxton (859 A. T.)

Its eastern half is drained northward by Trough creek, from the Robertsdale mines on the west side of Wray's


TWIN, BARNETT and COOK beds.
1.
Well section
near McHughs
2' 0" TWIN
Shales 15'
1' limestone
Shales and sandstone 14'
4' BARNETT
Shales and sandstones 50'
3' 0"
2' 0" COOK COAL
1' 8"
2.
Head of Incline.
Shales 10'
2' 6" COAL
Sandy shale 15'
Massive sandstone 15'
3.
near Barnettstown
5' BARNETT
? 45'
COOK
? 15'
Pottsville conglomerate, No. XII.
T3.

hill, and southward by Sideling Hill creek at the east foot of Wray's hill.

The *Broad Top anticlinal*, which determines this double drainage, is the same which elevates the Barrens in Todd township. It passes north and south across the Broad Top coal region, and comes out in a deep notch at its south side in Bedford county, making there a long prong which resembles Wray's hill and Rocky ridge.

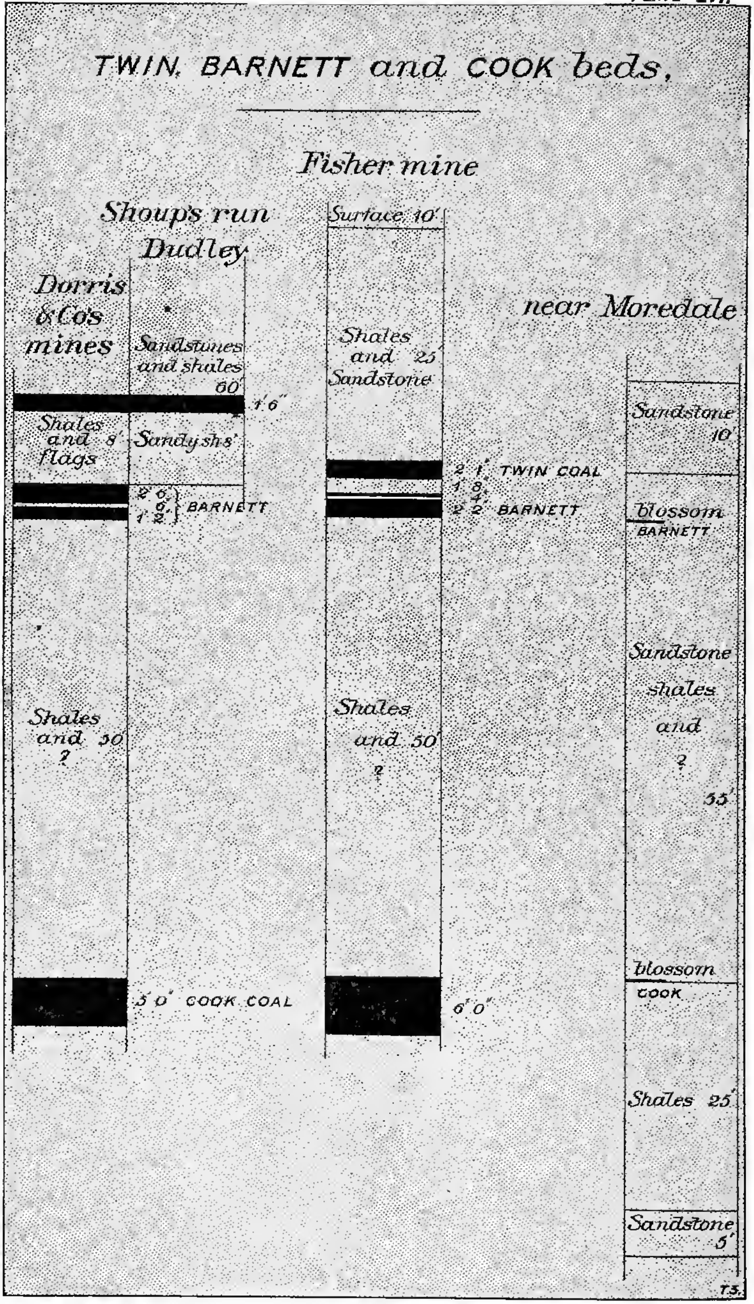
The *East Broad Top basin* is flat and shallow. The western slope of the anticlinal down Shoup's run is long and wavy; that is, it is crossed by smaller rolls parallel to the great anticlinal, producing several basins each deeper than the one east of it. Then all the rocks rise steeply toward the west and bound the coal region on that side in straight lines. Here the red shale No. XI comes up in a prolongation of Tatman's run valley. Then No. X comes up in Terrace mountain. Shoup's run gap through Terrace mountain is at the south-west corner of the county. From the gap northward to *the Todd township line* along the mountain is only 3 miles.

The following section was made in the gap along Shoup's run road. (See Plate XV, Fig. 2.)

Shoup's run road section (*A*).

1.	*Pottsville conglomerate.*	
2.	*Mauch Chunk shales, No. XII,* . . . about,	1050′
3.	Gray sandstone, pebbly in streaks, top of *Pocono X,*	200′
4.	Massive, pebbly sandstone, makes cliffs, grayish white, .	200
5.	Concealed, ...	300′
6.	*Dark fossiliferous shales,* strike S. 35° W., ...	100′
7.	Concealed, dip 25°-30°, ...	200′
8.	Massive sandstone, gray,.	100′
9.	Concealed, green sandstones and *red shale,* dip 25°,.	125′
10.	Sandstone, greenish gray, massive, ...	25′
11.	Concealed, and *red shale,*	75′
12.	Sandstone, greenish gray, massive, makes cliffs,. . . .	25′
13.	*Red shale,* where road ascends hill to the east from Shoup's run, ... visible,	20′
	Total, ...	2320′

On the opposite side of Shoup's run the following succession was observed along the railroad: (See Plate XII.)


TWIN, BARNETT and COOK beds.
Fisher mine
Shoup's run
Dudley
Dorris & Co's mines
near Moredale
Surface 10'
Sandstones and shales 60'
Shales and 25' Sandstone
1' 6"
Shales and 8' flags
Sandy shs'
Sandstone 10'
2' 1" TWIN COAL
1' 8"
4"
2' 2" BARNETT
2' 6"
6"
1' 2"
BARNETT
blossom
BARNETT
Shales and 50' ?
Shales and 50' ?
Sandstone shales and ? 35'
blossom
COOK
5' 0" COOK COAL
6' 0"
Shales 25'
Sandstone 5'
T.S.

Shoup's run railroad section (B.)

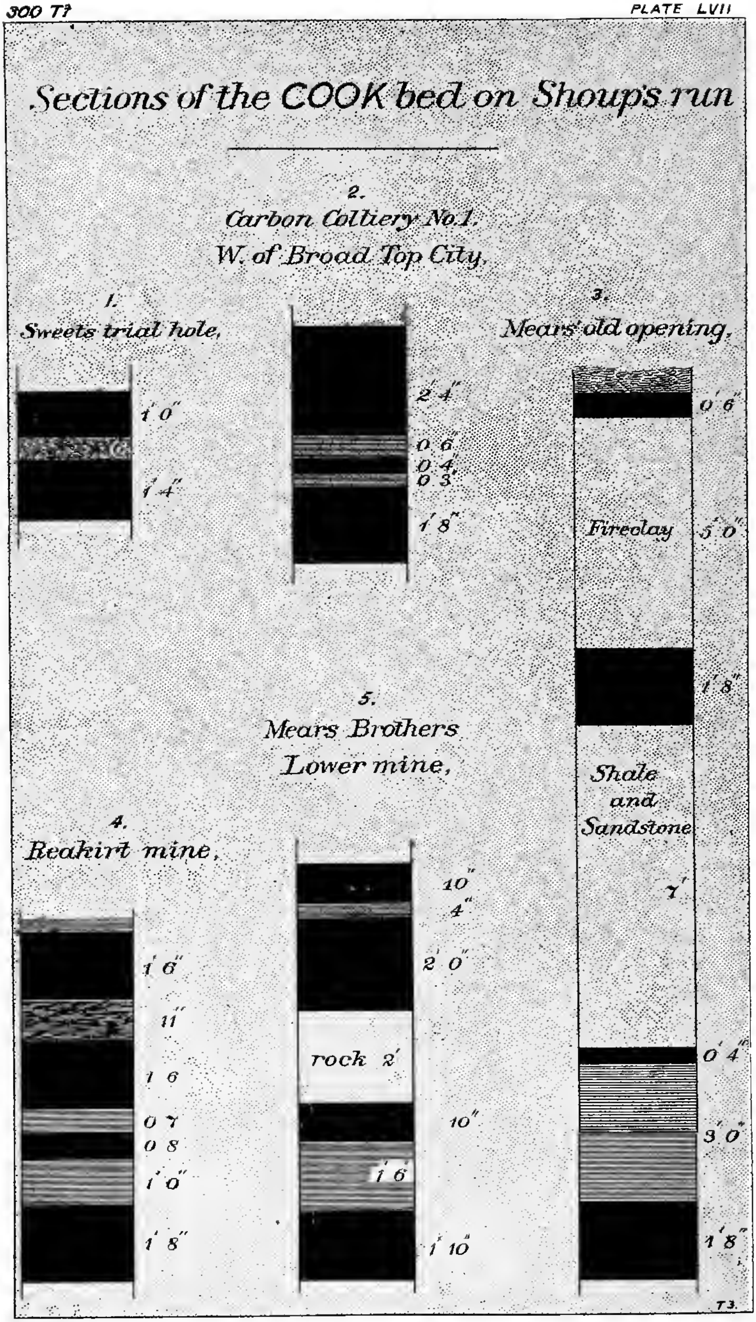
1. *Mauch Chunk red shale.*		
2. Coarse, massive sandstone, gray, dip 25° to 30°, . .	210′	
3. Sandstone, dark gray, with some thin dark slates interstratified, . . .	100′	
4. Concealed horizontal interval, 335′ dip at top 30°, at base 60° to 75°, about	250′	
5. Gray, flaggy sandstone and shales, ...	100′	
6. *Red shale,*	15′	
7. Grayish green sandstone, ...	55′	
8. Bluish black shale, with a few thin sandstones interstratified, containing *Lepidodendron Gaspianum* at top, and *Rhynchonella*, *Productus*, *Spirifera Orthis*, and other forms very abundant throughout 20′-25′ at base, .	100	
9. Massive, gray sandstone, ...	20′	
10. Sandy shales, ...	10′	
11. Sandstone, yellowish gray massive, visible, ...	25′	
Total, ...		885′

The fossiliferous dark shale seen both on the road and railroad is an important feature of the *Pocono series*, the lower part of it containing so many *shell remains* as to make some of the layers an impure limestone. A species of *Rhynchonella* seems the most abundant, filling the shales by the thousand, although other forms are quite numerous, especially *Productus* and *Orthis*.

The Trough creek limestone of Todd township was seen at the base of the *Mauch Chunk red shale*, just at the entrance to the gap; the upper layers *red*, as usual; with a bed of greenish-gray siliceous limestone lying upon the *Pocono sandstone*.

The manganiferous iron ore of Todd township is also visible just south of the railroad, where it was once exploited by a short tunnel. The ore comes in nuggets which seem quite plentiful but hardly in sufficient quantity to warrant mining.

The first Broad Top basin or synclinal axis crosses Shoup's run near the saw-mill below Coalmont, but it is so shallow that no coal beds remain on the Conglomerate mountain here. In Bedford county however it deepens and holds the *Cook and Barnett coals. The Cook coal* was once opened in it on the west slope of the mountain in sight of Saxton. Those who took no account of the flattening of


Sections of the COOK bed on Shoup's run
2.
Carbon Colliery No.1.
W. of Broad Top City.
1.
Sweets trial hole.
3.
Mears' old opening.
1' 0"
1' 4"
2' 4"
0' 6"
0' 4"
0' 3"
1' 8"
0' 6"
Fireclay
5' 0"
1' 8"
5.
Mears Brothers
Lower mine.
Shale
and
Sandstone
7'
4.
Beakirt mine.
10"
4"
2' 0"
1' 6"
11"
1' 6
0' 7
0' 8
1' 0"
1' 8"
rock 2'
10"
1' 6
1' 10"
0' 4"
3' 0"
1' 8"
T3.

the rocks on Shoup's run as the dying north end of a basin deeper further south, thought that this was a coal bed beneath the true coal measures. When it reaches Six Mile run this basin holds the *Kelley coal* of the Kemble Coal Company.

The *first anticlinal* is mentioned by Prof. Stevenson in T[2] as a slight wrinkle in the *Mauch Chunk red shale* where it crosses Six Mile run above Riddlesburg, about half-way between that town and the Mt. Equity mine. On Shoup's run it is scarcely appreciable, only slightly reversing the dip of the *Conglomerate*, and giving a small area of the *Cook coal bed* in the vicinity of Mr. Dougherty's, formerly known as the Arnold Haupt tract to the first basin. The blossom of a coal is visible near the Haupt house, but it is so near the surface and so thin that it gives no promise of proving valuable.

The *second* (*Coalmont*) *basin* crosses Shoup's run near *Coalmont.* North of Shoup's run the coal measures have been swept from this basin by Sugar Camp run, which cuts through the conglomerate into the red shale. The little run which comes from Bedford county to Coalmont flows in this basin. On Six Mile run the basin may be represented by that of Mt Equity mine, which holds all the coal measures up to and including the *Mahoning sandstone.*

The New York Coal Company made an attempt several years ago to open up this coal basin from the Shoup's run side, just over the Bedford county line, by a switch from the railroad above Coalmont, along a route very expensive for grading on account of trestles and rock cuts. Thus the town of Coalmont came into existence. But after the outlay of a great deal of money, mining at the northern end of a basin which deepened southward proved impracticable, and the railroad was abandoned. At its terminus are abandoned mines in both the *Cook* and *Barnett beds*, which are *reported* to have been, the upper (Barnett) 5′; the lower (Cook or Fulton) 8′ thick (coal 3′, slate 2′, coal 3′); separated by 50′ of sandstone and shale; and the lower coal lying 15′ above No. XII. (See Plate LIII, Fig. 2.)

The Barnet coal was opened in the bluff directly over the *Cook* drift, so that I could measure the interval with sufficient accuracy (by barometer), as the dip is gentle.

From all accounts that I could get concerning the coals in this basin it would seem that they possess an unusual thickness and purity, so that the failure of the New York company was not due to *lack of coal* on the property controlled, but to a mistake in mining methods, due to an imperfect comprehension of the geological structure of the basin. This basin cannot be mined by a drift at water level from Shoup's run, since it descends rapidly toward Six Mile run; but it could be mined by shafting.

Just above Coalmont is a steep bluff on the north side of Shoup's run. Here I made the following section: (See Plate XII, Fig. 2.)

Coalmont Section, A.

1. Concealed from top of knob, ...	50′
2. Very massive, pebbly, white conglomerate, (No. XII), .	15′
3. Concealed,	60′
4. Sandstone, basal member of *Pottsville conglomerate*, grayish brown, contains large *Sigillaria* trunks, (No. XII),	15′
5. Concealed, and *red shales*, (No. XI),	200′
6. Sandstone, massive, rather coarse, yellowish, (No. XI), .	35′
7. *Limestone, brecciated*, (No. XI), . .	2′
8. Green, and *red shales* to railroad, (No. XI), .	10′

The bottom mass of No. XII is probably 10′ thicker than seen, say 25′ thick. The top of No. XII is in the concealed interval No. 1 of this section. No. XII cannot be here more than 175′ thick.

No. 2 and No. 4 make bold cliffs along the steep hill, dipping rapidly east into the Third or Powelton basin; and their large angular blocks are strewn over the slopes.

No. 6 is a very massive sandstone and makes a line of cliffs along the hill. It and the underlying *limestone* are well exposed in the railway cuttings, a furlong above Coalmont.

No. 7 *brecciated limestone* is rather pure. It is higher in the series of red shale than the bed seen on Round Top at Paradise furnace.

The hog-back opposite Coalmont shows the following rocks:

Coalmont section, B.

1.	*Conglomerate*, white at top, gray and yellowish below,	100′
2.	Concealed and *red shales*,	150′
3.	Sandstone, *red shales*, and concealed, (no limestone visible), ...	100′
4.	*Red shales*, alternating with thin, green, sandy beds to railroad in cut just below Coalmont, .	50′

The Third or Powelton basin crosses Shoup's run one mile above Coalmont, and deepens rapidly into Bedford county; so that on Six Mile run all the *Lower coal measures* are buried deeply. Within the last year (1883,) Messrs. Brown and Sweet have tunneled westward to the Kelly coal on the *Second axis*, and mined the bed northward in the direction of the rising basin, the gangway gradually curving east.

A branch of Six Mile run rises in this basin near the county line and flows down its middle line to within a mile of its mouth. Here turning east it cuts across the next *anticlinal* to the east. For a long distance this stream flows upon the Mahoning sandstone, the strata rising rapidly from the water course on each side, making the basin easy to follow even by the shape of the ground, so that there can be scarcely a doubt that the *Powelton basin* is the *Second basin* of Stevenson's Bedford County report.

Most of the mining in the *Powelton basin* has been done north of Shoup's run, on the lands of the late R. H. Powell, and under the immediate supervision of Edward McHugh, to whom I am gratefully indebted for many facts with regard to the structure and other points in the geology of the Powell property.

The *main Powelton basin* is just deep enough, where it crosses Shoup's run, to carry the *Barnet coal* nearly down to water level, where the center line crosses the creek 100 yards above the upper end of the Powell coke ovens. From this center line of the basin the *Barnet coal* rises both ways (east and west) at an angle of 10° to 15° and soon gets to be 200′ above the creek.

The Barnet bed was formerly the only one mined on the property, and it is mostly mined out from the northern end of the basin. As the hill north of the creek rises 450′ the prevailing belief was that *beds of coal* overlying the *Barnet* could be found in it, and a large amount of prospecting was done, which resulted in making out the following general section: (See Plate VII, Fig. 1.)

Powelton (Minersville) general section.

1.	*Mahoning sandstone*,		30′
2.	Shales, sandstone and concealed,	100′	200′
3.	*Coal, "Twin" seam*,	2′	
4.	Shales and sandstones,	8′ to 30′	
5.	*Barnet coal bed*,	3′ to 5′	
6.	Shales and sandstones,	50′	
7.	Shales, dark, containing *fossil plants*,	5′	
8.	*Cook (Fulton) coal*,	5′	
9.	Shales and concealed,	15′	
10.	Sandstone, grayish-white, massive and pebbly near base more flaggy above; (No. XII),	40′	122′
11.	Concealed,	10′	
12.	*Coal* impure, 1′ 8″	say 2′	
13.	Fire clay, and shales with a green sandstone near center,	20′	
14.	Massive, grayish-white conglomerate, visible,	50′	

The so called "*Pittsburgh vein*," is a bed of coal above the *Mahoning sandstone* once opened south of Shoup's run in the *Powelton syncline* on the New York Coal Co's. land; and reported to be 4′ to 6′ thick. It was opened at several points near the hill-tops along the county line, but seems to have proven rather slaty and impure at all of them. The name was no doubt given to it by mistake after Prof. Lesley had identified the coal bed on the high knob south of Six Mile run with the Pittsburgh coal bed.

I judge from the section that the *Kelly* (*Upper Freeport*) *coal* is either not present on the Powell property, or so small as to have escaped notice, in spite of the vast amount of exploration.

The Mahoning sandstone outcrops in several ledges on this property, and is everywhere a coarse, massive, grayish-white, usually conglomeratic stratum. It makes the high hill on which Powell's dwelling house stands, half a mile from the coke works. Its outcrop is almost always broken up into huge blocks. Its finest exposure on the Powell property is just west of the "Rye field." Here it makes a long line of cliffs consisting of immense fragments piled upon each other.

The Barnet coal has been almost exhausted from this property. It was mined from several openings: one, at the foot of the hill, a short distance above the coke works; another, 200′ higher up the hill, further east, at the inclined plane; a third, still further east, using the same plane. But these mines have not been in operation for several years, the *Cook vein* being now mined; but the Powell Company is making arrangements to re-open the old mines and take out the pillars.

In a new adit, a few hundred feet north from the Coke ovens, the *Barnet bed* shows thus: (See plate LIII, Fig. 3.)

Section at Powelton coke ovens.

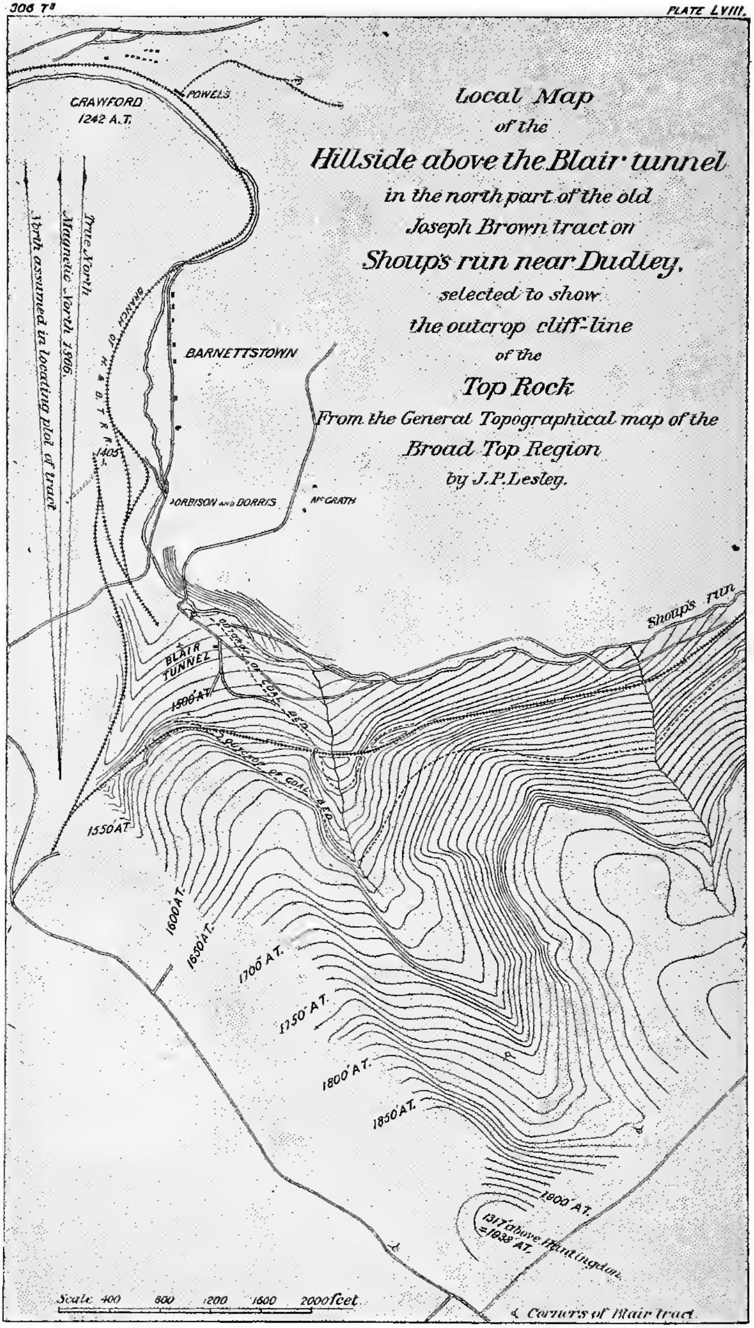
1. Sandstone.			
2. Slate,			0′ 15′
3. Barnet coal	Slaty coal,	6″	4′
	Coal,	25″	
	Slate,	2″	
	Coal,	15″	
4. Concealed,			50′
5. Cook (Fulton) coal,			5′

Both the *Barnet* and *Cook* have recently been opened here, on the west side of the basin, with the intention of starting a new mine on both beds; but the area of coal accessible from this side of the basin is so diminished that the project may not be carried out.

Mr. Edward McHugh, while connected with R. H. Powell's coal mining operations here at Powelton, collected data from actual survey for an underground contour-map of the *Barnet coal bed.*

In doing this he found that the flexures of the rock, however slight, are remarkably persistent, and are all approximately parallel, having in this mine a direction of N. 35° E. These were traced northward for more than a mile in the Powell mine until the coal basin spoons up into the air near the line of Miller's run, at the northern line of the property.

It was found that the central portion rises to the north-


Local Map
of the
Hillside above the Blair tunnel
in the north part of the old
Joseph Brown tract on
Shoup's run near Dudley,
selected to show
the outcrop cliff-line
of the
Top Rock
From the General Topographical map of the
Broad Top Region
by J. P. Lesley.
CRAWFORD
1242 A.T.
POWELS
True North
Magnetic North 1806.
North assumed in locating plot of tract
BRANCH OF H. & B. T. R. R.
BARNETTSTOWN
1405
ORBISON AND DORRIS
McGRATH
BLAIR TUNNEL
OUTCROP OF COAL BED
1500 AT
1550 AT
1600 AT.
1650 AT.
1700 AT.
1750 AT.
1800 AT.
1850 AT.
1900 AT.
1317 above Huntingdon.
=1938 AT.
Shoup's run
Scale 400 800 1200 1600 2000 feet
Corners of Blair tract.

east along the line of strike at the rate of about 2½′ in 100′, or more accurately, 178′ in 4500′ N. 35° E.

It was also found that in addition to several minor rolls, two considerable anticlinals extend through the Powelton property on the east rise of the basin. One, named on the mine map the *Powell anticlinal*, is distant 1050′ S. 55′ E. from the synclinal axis at the coke works; and elevates the bed to 225′ above the bottom of the trough. The other, named the *Eastern anticlinal*, is 1300′ S. 55° E. from the synclinal axis; and lifts the coal to an elevation of 310′ above the bottom of the trough. Both cross the property as far as mining operations have been carried and keep parallel to each other. (See Plate LIV, Fig. 4.)

The west dip of the *Eastern anticlinal* is rapid, and a "*rock fault*" runs along its crest for 1600′. This "*rock fault*" is a narrow area on the crest of the anticlinal where the coal has been squeezed off from the crown of the arch almost entirely, and piled up in the syncline west from it, where Mr. McHugh reports that the *coal* was in some places 20′ to 30′ thick.

At the end of 1600′ in the mine however the bending of the rocks at the crown of the anticlinal becomes greatly lessened and then the coal passes over the axis with its normal thickness only slightly reduced, so that the workkings east of the "Eastern anticlinal" have been connected with those west from it at the end of the squeeze.

Five smaller rolls are shown on Mr. McHugh's map (some of which lift the coal 20′ to 30′, others only 5′ to 10′) between the *Powell anticlinal* and the western edge of the *Powelton basin*.

The Twin coal (No. 3 of the section,) is a clean dry coal, containing no slate and coming out in large blocks. It is better for general steam and fuel purposes than for coking, is in fact rather too hard and dry for the latter purpose. Its position above the *Barnet bed* varies (as stated in the section,) between 8 and 30 feet. It was once opened and several tons of coal taken out just east of the head of the plane, where we see the following: (See Plate LV, Fig. 2.)

Powelton plane section.

1.	Shales,	10′
2.	*Twin coal*, "good,"	2′ 6″
3.	Sandy shale,	15′
4.	Sandstone, rather massive,	15′
5.	*Barnet coal*, (concealed),	

The sandstone (No. 4) is here quite massive, and makes a cliff along the coal road where the cutting for the grade passes through it. Elsewhere the rock is a mere sandy shale or flaggy sandstone. At one place in the *Barnet coal* it was only needful to cut through 8 feet of measures to reach the *Twin coal.*

The Fulton bed (as the *Cook bed* is called in the Powelton basin) is now mined extensively by R. H. Powell's Sons & Co., and coked in Belgian ovens opposite the mouth of the mine. Under the guidance of Mr. John Palmer, mine boss at the Powelton coal works, several sections of the *Fulton bed* were taken in different parts of the mine as follows: (See Plate LIV.)

Fulton (Cook) bed, section (A.)

1.	Slate full of *fossil plants*,		6′ 3″
2.	Coal,	9″	
3.	"Bone" and coal mixed,	7″	
4.	Coal,	15″	
5.	Parting,		
6.	Coal,	16″	
7.	Sand rock,	12″	
8.	Coal, middle bench,	12″	
9.	Slate,	4″	
10.	Coal not measured,		

Fulton (Cook) bed, section (B.)

1.	Slate,		
2.	*Coal*,	8½″	4′ 9″
3.	Slate and "*bone*,"	5 ″	
4.	*Coal*,	23½″	
5.	Rock,	14 ″	
6.	*Coal*, middle bench,	6 ″	

Only a few yards off the rock parting (No. 5) enlarges to 4 or 5 feet.

At the head of "No. 4 entry" on the western slope of the basin, the following was got:

Fulton (Cook) bed, section (C).

1. Slate		
2. *Coal,*	7″	7′ 2″
3. Bone,	5″	
4. *Coal,*	23″	
5. Rock,	16″	
6. *Coal,* middle bench,	12″	
7. Slate,	2″	
8. *Coal,* lower bench,	21″	

At another place in the same entry:

Fulton (Cook) bed, section (D).

1. Slate.		
2. Bony *coal,*	5½″	5′
3. Parting,	⅛″	
4. *Coal,*	19½″	
5. Rock,	3″–12″	
6. *Coal,* middle bench,	1″–6″	
7. Fire-clay,	10″	
8. *Coal,* lower bench,	14″	

Sections (A) and (B) do not expose the bottom of the *Cook bed*; but (C) and (D) show *upper*, *middle*, and *lower* benches; with two partings, the upper of which is often a regular *sandstone*, and always as hard to blast as sandstone would be. The middle bench, called the "*Little seam*," is clean, bright, black and usually free from impurities. *The lower bench* is not taken up when the lower parting is thick.

The coal from each of the three benches was analyzed by Mr. McCreath with the following results:

	Top.	*Middle.*	*Bottom.*
1. Fixed carbon,	72.893	69.403	73.785
2. Volatile matter,	21.082	20.776	19.199
3. Ash,	4.145	8.635	5.830
4. Sulphur,	1.312	.752	.670
5. Water,	.568	.434	.516

The samples from which the above analyses were made, were selected with a view to representing as much of the thickness of the several divisions as possible.

The Fulton (Cook) coal has not been mined so extensively on the Powell property as the *Barnet bed*, owing to the fact that it is not so good a coal, and also because the hard rock parting through the middle of the bed, renders the mining both difficult and expensive.

At the little ravine 100 yards above the coke ovens, Mr. Edward McHugh sunk a well for water, beginning about 20′ under the *Barnet coal bed.* Connecting the record of this well with the exposures at the surface, a section would be: (See Plate LV, Fig. 1.)

McHugh's well section.

	1. *Twin coal,*		2′
	2. Shales,		15′
☞	3. *Buffish, siliceous limestone,*		1′
	4. Shales and sandstone,		14′
	5. *Barnet coal,*		4′
	6. Shales and sandstones,		50′
	7. *Fulton (Cook) Coal,*	Coal, 3′ Rock, 2′ Coal, 1′ 8″	6′ 8″

The Fulton *coal bed* roof shales are filled to the exclusion of almost everything else at the Powell mines with an *Alethopteris* very close to *A. pennsylvanica.* Some of the forms, however, closely resemble *A. serlii,* and it is possible that this species is present in addition to *A. pennsylvanica.*

Lepidodendron obovatum, and a species of *Lepidostrobus* are about all the other plants observed in this shale.

The Barnet and Fulton coals were once mined quite extensively on the south side of Shoup's run, just below Powell's coke ovens, by the H. & B. T. R. R. Co., but as the coal basin settles rapidly southward, the mines could not be well drained, and abandoned several years ago.

Conglomerate rocks come up in a great ledge, just below where the H. & B. T. R. R. mines are situated. They are grayish white, very massive, somewhat pebbly, and probably belong to the middle of the formation No. XII. The section of No. XII as given in the Powelton section (on page 304 above) was fairly well exposed along Miller's run. Here the *upper member* (No. 10 of the section) 40′ thick, shows in its upper beds a disposition to split into slabs 3′ to 5′ long and 6″ to 8″ thick, in natural exposures and quarries. Its *lower layers* are rather massive, somewhat pebbly, and often make a cliff.

The coal bed (No. 12 of the section) shows at two or three places on Miller's run. Mr. McHugh reports it as 1½′ to 2′ of poor coal.

No. 14 of the Powelton section is the most massive portion of the *Pottsville Conglomerate*; a grayish white rock, usually pebbly; always making a cliff. This is the rock of the high cliff just alluded to below the H. & B. T. R. R. old mines, on the south side of Shoup's run. It is also frequently seen jutting out in cliffs along Miller's run.

The Dudley coal basin.—A few hundred feet east of the railway station at Powelton, the *Conglomerate* rises from water-level, rapidly, toward the east in a line of rugged cliffs on each side of Shoup's run, until more than 100′ of No. XII is visible; then the dip changes, and the *Conglomerate* sinks again up stream into the *Dudley coal basin.* Its beds are shown in Plate VII, Fig. 5, as follows:

Section of Dudley basin measures.

1.	*Coal smut Fulton (Cook) bed.*		
2.	Concealed,		10′
3.	Sandstone massive, and flaggy (upper XII) . visible,	30′	127′
4.	Concealed,	20′	
5.	Sandstone, massive grayish white, slightly pebbly (middle of XII,)	50	
6.	*Fire clay and coaly streak,* (Long's coal bed of Todd township,)	2′	
7.	Sandstone, massive brownish gray (bottom of XII,)	25′	
8.	Shale, *green,*	2′	
9.	Sandstone, yellowish, visible to bed of Shoup's run, just below where the Dudley road crosses it,		2′

The top of No. XII where it rides over the arch is here (by barometer) 1455′ A. T. and the *Barnet bed* ought to be at least 55′ higher, *i. e.*, 1510′. The *Barnet bed* at the bottom of the Powelton basin is about 1225′; difference, 285′. The rise in the mines by Mr. McHugh's transit levellings inside the Powell mines (several hundred feet north of Shoup's run) is 310′.

The Reed mine.

The Barnet coal is now extensively mined by the Reed Bros., nearly on the crest of the *arch*, half a mile north of

Shoup's run. The platform at the head of the inclined plane (1500′ long) is 320′ above the railroad ; and the mouth of the drift is 60′ higher than the head of the inclined plane, *i. e.* about 1700′ A. T.

The mine was first opened by R. H. Powell. A squeeze being encountered on the crest of the anticlinal the mine was abandoned. The Messrs. Reed however drove through the "roll" or rather east from it until the coal was encountered again, and have thus rendered accessible a large body of good coal. The capacity of the mine is 100 tons daily, and the entire output is used by R. H. Powell's Sons & Co. for the Powelton furnace at Saxton.

About 500 yards from the mouth of the mine and near the roll the bed showed: (See Plate LIV, Fig. 1.)

Coal, bony at top,	50″	6′ 9″
Gray slate,	10″	
Coal,	21″	

This shows the coal thicker than normal, since it is just southeast from the "roll" which squeezes the coal out entirely.

Near the head of the main gangway in the center of the basin the bed showed thus: (Fig. 2.)

Coal, bony at top,	31″	4′ 3″
Slate, sandy,	9″	
Coal,	11″	

On the western side of the basin thus: (Fig. 3.)

Coal, (4″ bony at top called "ripping,"	37″	4′ 5″
Slate,	6″	
Coal,	10″	

The coal of the *Barnet bed* mined here is of a most excellent quality, being comparatively free from slate, sulphur, and other impurities, and possessing a lustrous black appearance. It would make good coke, and preparations are now being made to coke it in the Belgian ovens below Powelton station.

The "ripping" or *bone coal* at the top of the upper bench is difficult to wedge down from the roof to which it adheres strongly.

The roof is a gray slate, or sandy shale in which were observed a few specimens of *Lepidodendron*, (closely akin to *L. obovatum*,) *Sigillariapes-caprioli*, *Neuropteris flexuosa*, and some fragments of an *Alethropteris* akin to *A. pennsylvanica.*

The Twin coal bed I did not see, but was informed that it overlies the bed mined by 8′ or 10 feet and is about 2′ thick.

The *Barnet bed* at the mouth of the Reed mine is 200′ higher than it is on the crest of the axis only one half mile south-west. This shows the rapid rise (of both basins and rolls) northward which carries the *coal measures* into air about one mile north from Shoup's run.

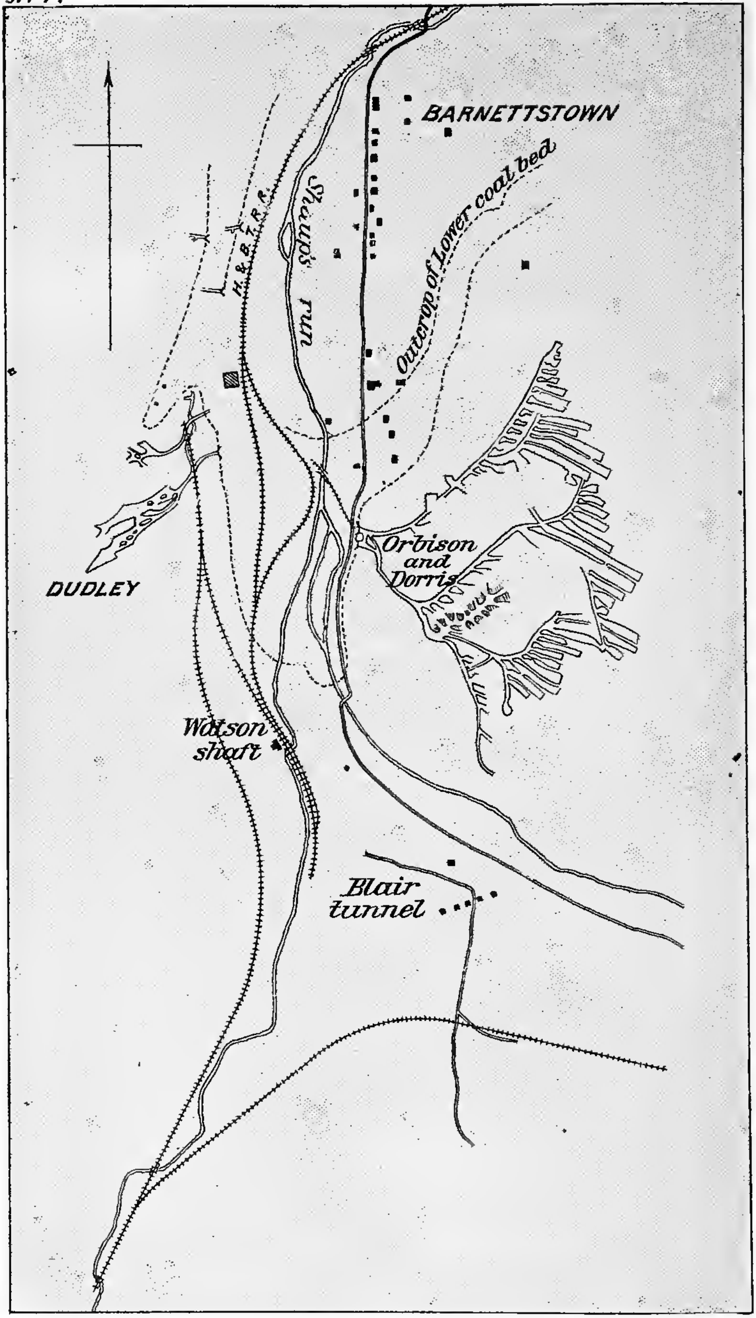
The Reed mines extend back under the road which passes north from the mine mouth between Powelton and Broad Top City.

The Dudley basin passes directly through the town of Dudley, its center line crossing the railroad about 100′ west of the depot, and also just west of the Catholic church, on the hill south of the depot. It is deep enough to carry the *Barnet bed* below the level of Shoup's run at Dudley, and puts several hundred feet of overlying measures into the hills south of the town. It seems to be the basin of Fair Play on Six Mile run and of Round Knob. But although this basin holds more coal measures its bottom line is not as near sea level as that of the Powelton basin by 175 feet, for in the *Powelton basin* the lowest place in the *Barnet coal* on Shoup's run is 1225′ A. T.; in the *Dudley basin* 1400′ A. T.

Original Barnet mine.

The Barnet bed was mined just below Barnetstown on the west side of Dudley basin by R. H. Powell on the land of Mr. Philip Barnet; and the *Fulton* (*Cook*) *bed* was also mined by Mr. Powell immediately under it; thus: (See Plate LV, Fig. 3.)

1. *Barnet coal*, ... reported	5′
2. Concealed, ...	45′
3. *Fulton* (*Cook*) *coal*, ... reported	6′
4. Concealed	15′
5. *Pottsville conglomerate*, ... visible	20′


BARNETTSTOWN
Outcrop of Lower coal bed
Shaups run
H. & B. T. R. R.
Orbison and Dorris
DUDLEY
Watson shaft
Blair tunnel

Both gangways have been long abandoned; but a miner who had dug coal from them reported to me the thicknesses given above, including the parting rocks and shales.

In the *Barnet* roof shales I saw specimens of *Lepidodendron*, *Sigillaria*, and *Stigmaria.*

In the *Fulton* roof shales I saw *Neuropteris hirsuta*, *N. flexuosa*, *Pseudopecopteris nervosa*, and *Sphenophyllum schlotheimii.*

These two old openings are on the north side of Shoup's run. On the south side are several old openings in both beds between the crest of the *axis* and Dudley; all now abandoned, except one owned by Sweet & Co., and this one has been idle for some time.

Dorris & Co.'s mine.

Just below Dudley Messrs. Dorris & Co. have been operating mines on both beds; but the *Fulton bed* has been the principal scene of operations, for the last 20 years.* Here the section is: (See Plate LVI, Fig. 1.)

Twin coal,			1′ to 1½′
Shales and flags,			8′
Barnet coal	Coal,	2′ 6″	4′ 2″
	Rock,	6″	
	Coal,	1′ 2″	
Shales, sandstone and shales,			50′
Fulton (Cook) coal,			5′

The Twin is visible in the cliff above the *Barnet*, varying from 1′ to 1½′.

The structure of the *Barnet bed* in the Dorris mine, as given above, I obtained from a reliable miner who had worked there, but as the mines have been idle for several months, I could not personally inspect them. The detailed structure of the *Cook (Fulton) bed* was not obtained though I learned that it had a thickness of something like 5′, including the partings of rock and slate.†

*These mines have been in operation nearly all the time for 20 years, until within the past year (1883), during which they have been idle.

[† I insert here Plate LVIII, from my own surveys on Broad Top, made some years ago, in order to show the general lay of the workings in the Orbison & Dorris mine at Barnetstown.—J. P. L.]

David Blair mine.—The Barnet coal was once mined extensively by a slope just below Dudley station; mouth of slope at nearly the same level (1425′ A. T.); slope 90′ long at 30°; bottom of slope about 1375′, almost exactly in the center of the Dudley basin; showing that it sinks southward from Shoup's run, where the coal bed at the bottom of the basin is about 15′ under water or say 35′ below grade at Dudley station, *i. e.*, 1390′. The coal was mined east and south-east up the slope. Nothing has been done here for several years and the works are fallen into decay.

Dudley section.

A high bluff of sandstone and sandy shale rises from the bank of Shoup's run, just back of Dudley, showing the following section: (See Plate LVI, Fig. 2.)

1. Sandstones, gray, shaly and flaggy, cliffs,	60′
2. *Twin coal* bed,	1′ to 1½′
3. Sandy shales and sandstone,	8′
4. *Barnet coal* bed,	——

No. 1 is also seen on the south side of Shoup's run, just east of the crest of the *axis* where it makes a rather bold cliff of grayish white, micaceous sandstone.

Ocean mine section.

The Ocean coal mine is situated about half a mile south-east of Dudley, and is operated by Mr. Sweet. The *Barnet bed* is here reached by a tunnel 700′ long; on account of the gentle rises of the measures eastward; the tunnel extends beyond the *Barnet bed* 400′ further to the *Fulton (Cook) bed.* By connecting surface exposures with the tunnel measurements, the following section was obtained: (See Plate VII, Fig. 2.)

1. Concealed and sandstone.	
2. "*Four foot vein,*" slaty,	4′
3. Concealed, and flaggy sandstone,	60′
4. *Top Rock*, massive, pebbly,	40′
5. Shales, and thin sandstones,	30′
6. "*Kelley coal,*"	1′
7. Shales, and hard sandstones,	100′
8. *Twin coal,*	2′
9. Shales, sandy,	4′

10. *Barnet coal.*	Coal, bony, ... 6″ } 3′ Coal, good, ... 2′ 6′ Sandstone hard gray, ... 11′ Coal, ... 0′ 6″		14′ 6″
11. Gray shales and sandy beds; the last 15′-20′ filled with iron ore nodules, and *fossil plants*, ...			55′
12. *Fulton (Cook) coal.*	Coal, ... 12″ Rock, ... 6″ Coal, ... 14″	2′ 8″	
Total, ...			313′

Above the *Four foot bed* lie 75′ to 100′ of rocks in the hill just south-east of Dudley, and near the top is a rather massive, and somewhat pebbly sandstone.

The "*Four foot coal*" is the same as that opened on the New York Coal Company's land in the *Powelton basin* south of Shoup's run, near the county line, the so-called "Pittsburgh coal" mentioned on page 304 above. An attempt was once made by Mr. Watson to mine it just south of Dudley, along the little stream which flows along the "Y" of the railroad; but it proved too slaty and impure, although more than 4′ thick. On the east side of this same run several openings were made on it with the same result. Mr. Sweet struck this bed in the upper part of Dudley, south of Shoup's run, near the bottom of his well, at a depth of 35′, where it was 4′ thick.

Below the *Four foot bed* lie 130′ of rocks (Nos. 3, 4, 5 of *the section*), of which the *massive pebbly* bed (No. 4) 40′ thick is the *Top Rock* of Broad Top City. The upper sandstones (No. 3) are yellowish gray to brown, and, lying in layers 6″ to 12″ thick, interstratified with shales.

The *Top Rock* (No. 4,) makes a great cliff around the hill above the Ocean mine; circling round the run south of Dudley as a cliff 50′ high beneath the Catholic church. Just above the Ocean mine it is a perfect mass of quartz pebbles, varying in size from a pea to a walnut. Its fragments strew a large surface underneath.

Just above the tipple of the Ocean mine an *air shaft* was sunk to reach the *Barnet* workings, which had been carried to this point from the Blair slope in Dudley. The shaft mouth is 10′ under the *Top Rock*. At 90′ depth the shaft was stopped and a bore hole drilled 30′ deeper to the *Bar-*

net bed. The work was superintended by Mr. Sweet, a careful and accurate man, from whom I got the details.

This shaft and boring are of the greatest importance in determining the interval (135′) between the Top Rock and the Barnet coal.

The *Kelly bed*, as I consider it, was passed in the shaft at 20′; therefore 30′ beneath the *Top Rock*. It was only 1′ thick. Its blossom shows in a railroad cut just below the tipple; it was also cut in the tunnel. These are the only places in Huntingdon county where I have recognized the *Kelly coal* of Bedford county.

The Twin coal is here close enough to the *Barnet* to be mined with it. When the parting increases to 3′ or 4′ it is cut up through and the Twin coal mined separately. The parting varies from 1 foot to 12 feet in the Ocean mine and gets to be 30 feet thick in the *Powelton coal basin.* The *Twin coal* here as in the Powelton basin is a hard, dry coal without slate partings, clean coal from top to bottom. Together with the *Barnet coal* it makes one of the best steam coals in the Broad Top region, and is used in preference on the Company's locomotives; the entire output of the Ocean mine (100 to 140 tons daily) is sold to the R. R. Co. for its own consumption.

The *Barnet coal* is virtually a double bed in the Ocean mine tunnel, consisting of two beds separated by *eleven feet of hard sandstone.* That the lower bed *6 inches* thick is a split from the upper bed is evident from Mr. Sweet's information. In many parts of the mine it is only *six inches* or *one foot beneath* the upper coal and is mined out with it; but the intervening sand rock often rapidly thickens and obliges the miners to leave the lower coal beneath the floor. Mr. Sweet has seen the bottom coal sink from within 6 inches of the upper coal to a distance of 10 feet, and that so rapidly that it might easily get 30 feet beneath the main coal before returning to it.

The *Fulton (Cook) bed* was struck at 1160′ from the mouth of the tunnel; too thin to warrant mining on this property, and only about 500 tons of it were taken out. Its roof shales in the tunnel are crowded with fossil plants among which are *Alethopteris pennsylvanica*, (or a form intermediate between it and *A. serlii*), *Neuropteris hirsuta*, *N. clarksoni*, a beautiful fruiting *Pecopteris*, *Lepidodendron obovatum*, and *Stigmaria ficoides*. This latter is very abundant in the partings of the *Barnet bed* also.

Many nodules of iron are inclosed in the shale.

The old Howe mine.

On the *Barnet bed*, 1000′ north-east of the Ocean mine.

The coal bed of the Howe mine, and the coal bed lying 45′ or 50′ below it, were always considered to be higher in the series than the two beds mined at Dudley and Powelton, although the two pair were so much alike, and the associated rocks so much alike also. Believing that the two Howe mine coal beds which had been identified all along Shoup's run with the two Broad Top City beds, were also identical with the two Dudley and Powelton beds, and that, if he could connect his gangway with the headings on the Barnet bed in the old Blair mine, he could drain the Howe workings through the Blair mine to the creek at Dudley, Mr. Sweet (then mine boss at the Howe mine) drove toward the Blair mine and actually made the connection; settling the question whether there were four workable beds on Shoup's run, or only two.

It seems then that the upper bed at Broad Top City is the *Barnet bed* of Powelton and Dudley, and that the *Cook bed* of Broad Top City is the *Fulton bed* of Powelton and Dudley.

Fulton (Cook) bed at Sweet's trial hole.

The Fulton (Cook) coal was opened by Mr. Sweet at about 300′ further up the track of the H. & B. T. R. R. from the *Barnet* opening at the Howe mines, but the coal was scarcely 3′ thick, with a parting of 6 inches, thus described by Mr. Sweet. (See Plate LVII, Fig. 1.)

Coal,	12″	2′ 10″
Shale,	6″	
Coal,	16″	

For more than a mile above the Howe mine there are no mines in operation until we come to Moredale; the measures rising gently eastward, carrying the *Barnet bed* into the air over much of the area.

Moredale; Reakirt's Cook (Fulton) coal.

Near Moredale Reakirt & Bro. have extensive mines on the *Cook coal*, (idle during the summer of 1883) with a capacity for shipping 90 or 100 tons daily. The main gangway is nearly a mile long. The coal bed at the far heading shows the following section. (See Plate LVII, Fig. 4.)

1. Slate, dark, good roof.		
2. Coal, good,	1′ 6″	8′
3. Bone and gray slate,	10″ to 1′ 0″	
4. Coal,	1′ 6″	
5. Black slate,	4″ to 10″	
6. Coal, good,	6″ to 8″	
7. Slate, dark,	1′ 0″	
8. Coal,	1′ 8″	
9. Sandstone, &c.		

The several partings given above exhibit great variations in different parts of the mine.

No. 3 parting sometimes thins away almost entirely, and coal seams Nos. 2 and 4 come together as the main *upper bench;* but this parting sometimes thickens up to 4 feet.

No. 5 parting is occasionally 14″ thick.

No. 7 parting is sometimes 20″ thick.

When all the partings begin to swell up together we often see new ones making their appearance in thin streaks within the body of Nos. 2 and 4.

No. 6 coal is called the "*foot coal*" because the coal next under it very frequently is too poor to mine; containing according to Mr. Reakirt more sulphur than the other layers.

The sudden and great variations in this coal bed are splendidly exposed in this extensive mine.

The coal is mostly shipped to South Amboy and Greenwich, N. J., for steam purposes.

Just above Reakirt's present opening is another one on the same *Cook coal*, abandoned.

Fisher mine.

The Fisher colliery on the *Barnet bed*, ¼ mile above Reakirt's, once extensively operated, is now idle. Here a gentle basin crosses the creek, the *Barnet bed* remaining near the surface.

The following section was constructed at this point from my own observations combined with those of the mine boss, Mr. Nathaniel Mosby: (See Plate LVI, Fig. 2.)

1. Surface,		10′	
2. Shales and sandstones,		25′	
3. *Twin coal*,	2′ 1″		6′ 3″
4. Slate, sandy,	1′ 8″		
5. *Barnet* coal, { bone, 4″ / coal, 26″ }	2′ 6″		
6. Concealed, shales, &c.,		50′	
7. *Cook (Fulton) coal*,		6′	

The *Twin* and *Barnet* are here in places mined together. But as I passed through the mine in company with the former mine boss I could see the great variations in the interval which separates them; in some places not more than a foot, in others 8 or 10 feet. At such places holes are cut up through the rock and the *Twin coal* mined out separately over considerable areas, as far as it can conveniently be brought to the holes; and it is a dry, hard coal here as elsewhere, entirely free from slate. That it is the *Twin bed* admits of no doubt, since the air shaft which passes through 40′ of rocks above it found no other coal. In the Powelton basin the *Twin* is sometimes 30′ and sometimes only 8′ above the *Barnet.*

The *Barnet coal* extends from the Fisher colliery eastward to and beyond Broad Top City. About 100 tons of coal were daily shipped from the mine when in operation. *The Cook bed*, on this property, having been mined out from under the *Barnet coal* to a large extent, the Barnet works are drained through the old Cook workings underneath them, the interval between the two beds at the shaft being 45′.

Fisher's *Barnet bed* has an average thickness of 3′; is sometimes 3½′, but where I measured it it was only 2½′.

The top layer is always *bony*, according to Mr. Mosby, who has dug coal in every part of the mine.

On the north branch of Shoup's run the *Barnet bed* was once mined to a considerable extent about half a mile above Dudley, but the mine has long since been abandoned.

The *Cook bed* on its east rise gets above water-level half a mile above Dudley, and remains so all the way up to Broad Top City on the north side of Shoup's run. Trial holes and shafts along the outcrops of both beds abound; and the coal was always thin. Both the *Barnet* and the *Cook* seem to thin away and become less minable on the *north* side of Shoup's run above Dudley, having been found (both of them) thin and slaty in several trial pits.

The Top Rock descends into the crest of the hills, north and south of Shoup's run, one mile above Dudley, with a gentle eastward dip, affording a good opportunity for determining its height above the two coal beds. A careful barometric measurement gave, on the north side of the run, 125′; from the base of the *Top Rock* down to the *Barnet* gave me, on the north side of the run, 125′; on the south side, 110′. From the Top Rock down to the Cook, on the south side of Shoup's run, was 170′.

The *Cook coal* on the north side of Shoup's run, just below Moredale, was once mined to a considerable extent; but it has long been abandoned, and the mine is now fallen in.

Moredale section.

A short distance above Moredale, a steep bluff makes the north bank of Shoup's run, showing the following section, (See Plate LVI, Fig. 3.)

1. Sandstone,	10′
2. Concealed,	5′
3. *Coal, blossom, (Barnet,)*	—
4. Sandstone, shales, and concealed,	55′
5. *Coal, blossom, (Cook,)*	—
6. Shales, dark,	25′
7. Sandstone,	5′
8. Shales and sandy slates to water,	15′

Here both beds have been tried and found to be too thin to mine; and the north side of Shoup's run from Dudley up to the forks of the stream above Moredale, seems to be filled with "*rolls*" and irregularities which cut out both the *Barnet* and *Cook coals*, rendering this territory worthless for coal. Thinking that valuable *coal beds* under water level might be found at Moredale a company was formed and a shaft begun and abandoned. A borehole 40′ deep was then drilled and abandoned. This hole is said to have passed an 18 inch coal bed, 20′ down ; perhaps the thin coal seen in the Powellton section at 60′ or 70′ under the Cook ; or possibly a bed on top of No. XII ; for the interval between No. XII and the *Cook coal* thickens up considerably east of the *Dudley trough.*

Mear's Bros. old mine ; Cook bed.

The Cook coal becomes again valuable east of *Wilson's run*, about two miles above Dudley, on the north side of Shoup's run, where it has long been mined at several adits by the Mears Bros. of Broad Top City. At one of these mines a short distance above Moredale, passing under the railroad track on the Y, the bed has its usual structure, as I was informed by Mr. Mears ; but only 250 yards distant it is so split by three partings (5′, 7′, and 3′ thick) as to cover nearly 20′ of section, thus: (See Plate LVII, Fig. 3.)

1. Shale,		19′ 2″
2. *Coal,*	6″	
3. Fireclay,	5′ 0″	
4. *Coal,*	1′ 8″	
5. Shales and sand rock,	7′ 0″	
6. Coal,	4″	
7. Slate,	3′ 0″	
8. Coal,	1′ 8″	

The coal benches themselves are of the usual size, and therefore the total thickness of coal is the same as usual. If the two localities were not so close together that the exposures permit one to trace the bed from one to the other, such a change would not be believed ; but the mine had to be abandoned because the coal benches got so far apart.

A quarter of a mile higher up the stream Mears Bros. have lately opened a new mine on the bed, in which at the end of the main gangway it exhibits the following section: (Plate LVII, Fig. 5.)

Mears Bros. lower mine; Cook bed.

1. *Coal,*	10″	3′ 2″	9′ 0″
2. Bone,	4″		
3. *Coal,*	2′ 0″		
4. Rock,		2′ 0″	
5. *Coal,* middle bench,	0′ 10″	3 10″	
6. Slate,	1′ 6″		
7. *Coal,* lower bench,	1′ 6″		

The lower bench is not mined at this locality, since it is not so good as the upper ones, containing more sulphur, slate, and other impurities.

The bony ply (No. 2) contains some gray coal, and occasionally it has the appearance of *cannel.*

The middle bench (No. 5) is very pure and clean coal, in fact the best part of the bed.

Carbon Colliery No. 1.—Half a mile above the new opening, at the end of the railroad, Mears Bros. have had another mine in operation for some years just west of Broad Top City, the gangway extending under the town. Here the bed shows thus: (See Plate LVII, Fig. 2.)

Carbon colliery No. 1; Cook bed.

1. Fire clay,		5′+
2. *Coal,*	2′ 4″	
3. Slate,	0′ 6″	
4. Coal,	0′ 4″	
5. Slate,	0′ 1″ to 0′ 6″	
6. *Coal,*	1′ 8″	
7. Coal reported,		

The two Carbon Collieries of Mears Bros. have a capacity of 175 or 200 tons daily and the output is shipped to Jersey City, South Amboy, and other points in New Jersey for steam and glass-making purposes.

A roll 200 yards wide runs nearly north and south across the upper mine, and had to be cut through with the main entry before the body of the coal could be reached beyond it. Mr. Mears informs me that this *roll* consists in an enormous *thickening of the partings* of the coal, accompanied by a *thinning of the main upper bench* of coal to only 18″ or 20″. The shale partings between the upper and lower benches get to be 15 and 20 feet thick and even more ; these partings changing into an impure fire clay. But while all the other portions of the bed are affected by the *roll* both in character and thickness, the *lower bench* retains both its usual quality and thickness entirely across, apparently quite undisturbed by it.

The *roof* at these collieries is often a sandy, worthless *fire clay* of great thickness, as much as 25 feet of it having been passed through in air shafts. But ordinary *roof shales* must replace the fire clay ; for I saw on the dump many fragments of *ferriferous shale* filled with the beautiful *Alethopteris*, *characteristic of the Cook coal* at Powelton, Dudley and other points along Shoup's run.

The Barnet coal crops out in the bluff almost vertically above the *Cook bed* at Mears' upper mine, but too near the surface to make much of a field, and the coal is only about 3′ thick. The *Twin bed* (mined with it at the Fisher colliery) has apparently been thrown into the air by the thickening up of the interval to 15′ or 20′ as at Powelton.

The Old Cook mine is just opposite the Mears' opening and not more than 200 feet distant. Here 50 years ago the bed was named from Jesse Cook, who supplied his neighborhood with coal in a small way.

Specimens of the *Cook coal* were collected from the Mears Bros. mines, representing the upper, middle, and lower benches, of which analyses by Mr. McCreath gave the following results:

	Top.	*Middle.*	*Lower.*	*Lower.*
1. Fixed carbon, ...	72.498	75.817	72.589	73.891
2. Volatile matter, ...	17.918	17.050	18.499	17.072
3. Ash, ...	8.420	5.325	7.420	7.715
4. Sulphur, ...	.642	1.298	.916	.774
5. Water, ...	.522	.510	.576	.548
Totals, ...	100.	100.	100.	100.
Coke per cent, ...	81.560	82.440	80.925	82.380
Color of ash, ...	Gray.	Red. gray.	Cream.	Cream.

The Cook coal has an elevation of 1875′ A. T. at the old

Jesse Cook opening, as determined by Mr. J. Murray Africa from actual leveling, thus showing a rise of (1875′–1325′) about 550′ from the center of the Dudley basin to this point, the air line distance being not quite two miles. This rise is not regular and gradual; the rocks rise quite rapidly for short distances, and then flatten or almost reverse the dip. One of these rapid rises is seen a short distance below Mears' upper opening, where the top of No. XII gets 15′ or 20′ above water-level, but immediately goes under again by the flattening out of the dip.

Mr. Fisher has an opening in the *Cook coal* just below Mears' upper mine, and on the south side of the run. A considerable quantity of coal has been taken from this mine; but recently the same *roll* has been encountered which crosses the Mears' workings, running nearly north and south, with a width here of 600 feet, *i. e.*, on the line of the gangway which runs diagonally across it and has not yet reached its other edge.

East from the last mentioned mine *on the Cook coal*, the rocks continue rising toward the *Broad Top anticlinal*, the axis of which runs just east of Broad Top City, carrying the *Cook coal* up to about 1950′ A T. (75′ higher than the Jesse Cook bank) on the crest of the arch. Just north from Broad Top City the coal crops out. To the south it seems to ride over the *anticlinal*, and begin its gentle descent into the *East Broad Top basin* at the township line.

The East Broad Top basin contains at Robertsdale the *Twin*, *Barnet*, and *Cook* coals.

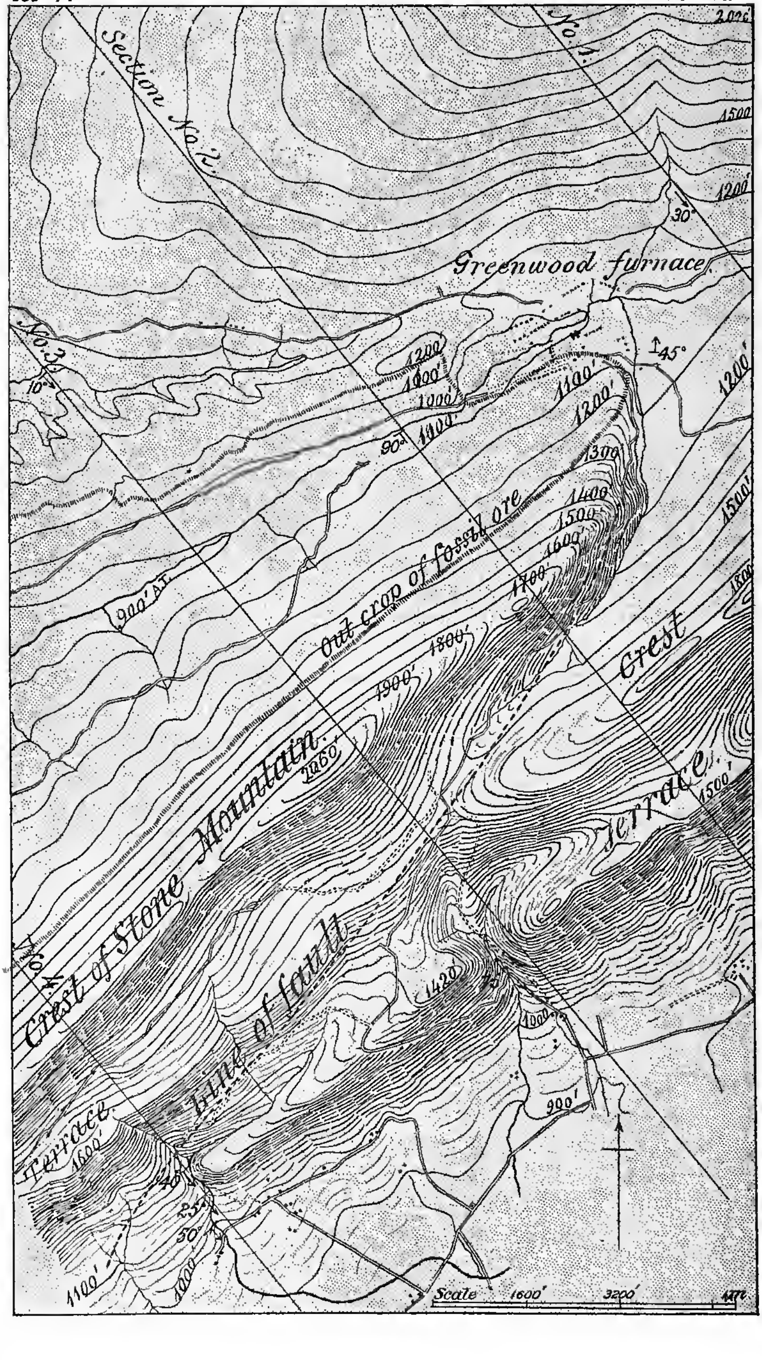
The wild, rough, and unfrequented region north of Shoup's run, edged with cliffs of Conglomerate overlooking Trough creek valley, is practically destitute of coal, except on high ground on the line of the Powelton basin (which crosses Miller's run below Dougherty's saw-mill) where a patch of the Cook bed probably remains, extending northward 3 miles from Shoup's run.

The Broad Top anticlinal enters this township from Bedford county, just south from the North Point road, where it brings up the *Pottsville conglomerate*, and scatters its huge sandstone bowlders over the ground.

The North Point road forks at 130 rods north from the Bedford line, and on the fork which leads east toward Big Trough creek, the *Broad Top axis* crosses at 50 rods from the Broad Top City and North Point road. Here the *blossom* of the *Cook coal* is seen on both sides of the arch, but the coal is quite thin, and apparently worthless, since the Rock Hill Iron and Coal Company has sunk several trial holes and found only 1′ or 1½′ of coal in any of them.

The dip on either side of the Broad Top anticlinal, where it enters the township from Bedford, is 10° to 15°.

The top of the *Pottsville conglomerate* is barely brought above the surface on the east running road at the summit of the ridge made by the arch; and north from this point toward Broad Top City the *coal measures* seem to arch over and cover up No. XII entirely for two or more miles, when the Conglomerate again puts out to the surface.


Section No. 2.
No. 1.
No. 3.
No. 4.
Greenwood furnace
Out crop of fossil ore
Crest of Stone Mountain
Line of fault
Crest
Terrace
Terrace
Scale 1600' 3200'

CHAPTER V.

The Stone Mountain fault.

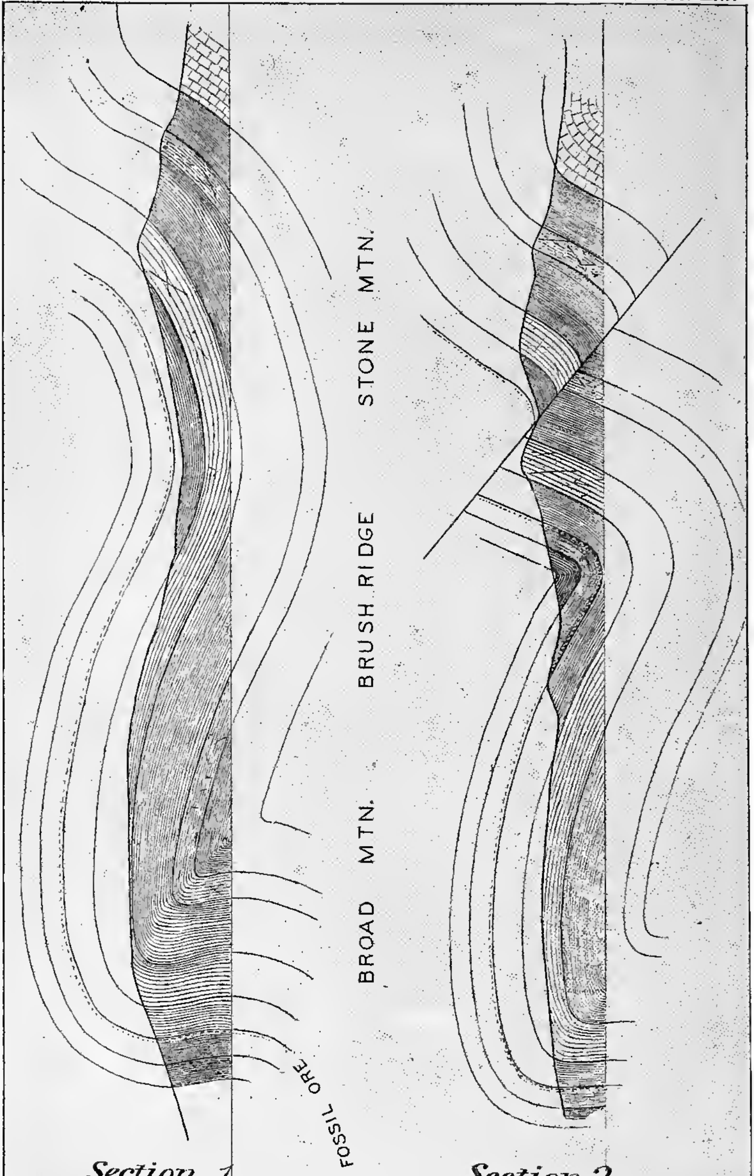
The beautiful topographical map of the range of the Seven Mountains, executed by Mr. C. E. Billin, in 1877, exhibits a region 50 miles long, by 5 miles wide in the middle, and 10 miles wide at each end; stretching from Huntingdon county east-north-eastward through Clinton into Union county; as a system of parallel interlocking low mountain ridges of Medina and Oneida sandstone (No. IV), between the great Kishicoquillis limestone valley on the south, and the Penn's, Brush and Nittany limestone valleys on the north.

Thirteen cross sections, from two to four miles apart, drawn by Mr. Billin, on two sheets, exhibit the structure of the belt; its apparent complexity; its actual simplicity. No verbal description can make it plainer; its local details will be described by Mr. Billin himself; but its connection with the region to the south-west of it, with Huntingdon county described in this report, should be explained; and this can be done in a few words.

The gradual convergence of the two outside bounding outcrops of No. IV, Tussey mountain and Stone mountain, eastward, is shown on the map and by the sections. The distance from crest to crest at the Juniata river is 15 miles; across Barree township, 10½ miles; across Jackson township through Boalsburg and Greenwood furnace, 8½ miles; these measurements being made from one outcrop of the *Upper Medina*, or high crest, across the great basin, to the other.

About 2 miles east of Boalsburg one of the two Shaver's creek basins heads up in a high knob of *Upper Medina* (2300′+); the other also in a high knob 4 miles east of Boalsburg (2220′ A. T.)

From this latter knob across to a similar *Upper Medina*



Section 1. Section 2.

Across Stone mtn. NE of Greenwood Furnace.

Sect. 1 showing the unbroken synclinal beyond the fault.

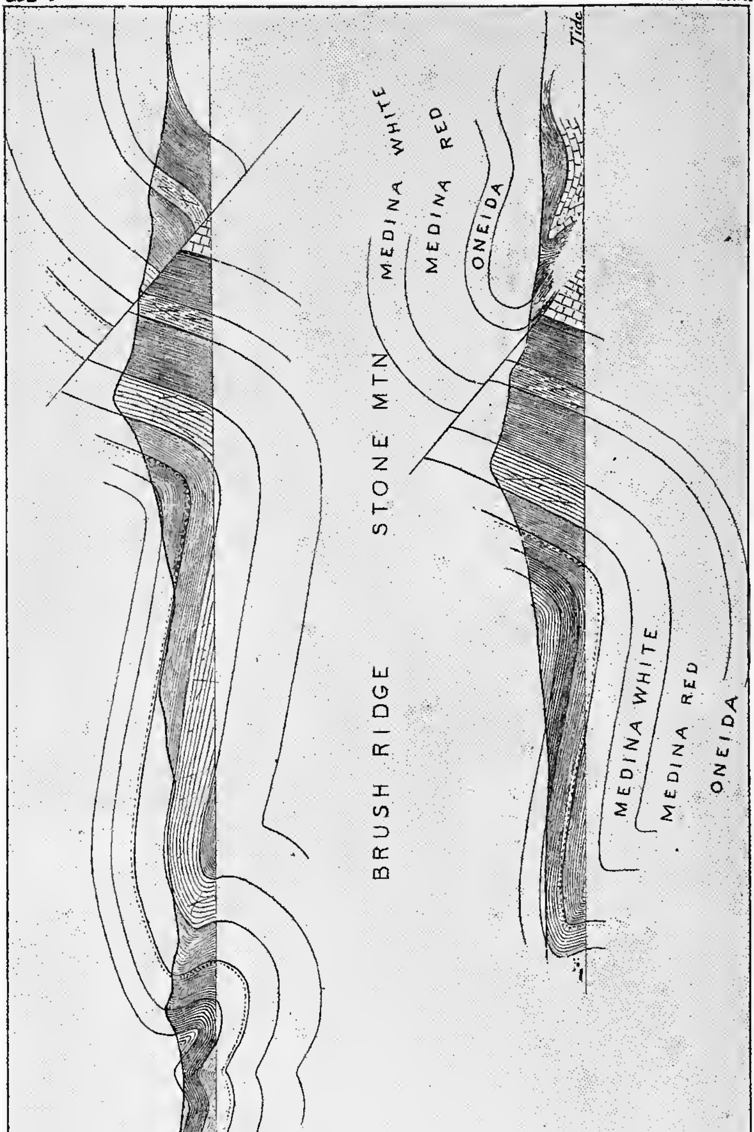
high knob (2200′+) at the east end of the Greenwood furnace basin ($4\frac{3}{4}$ miles east of the furnace) is 6 miles.

The *Oneida* terrace outcrop is broken at Boalsburg by a deep ravine ; and 4 miles east of Boalsburg it is broken by another deep ravine. Between the two the terrace has a height at one place of 2100′+; but this is exceptional ; for on both sides of the Boalsburg ravine the terrace is only 1700′ ; and east of the second ravine the terrace runs regularly at 1800′ for $1\frac{1}{2}$ miles ; and then rises into a synclinal knob, six miles east of Boalsburg, 2000′ high A. T. The end of the synclinal spur looking towards Potter's Mills (4 miles distant) is 7 miles east of Boalsburg, and 1900′ high A. T. This is the extreme mountain end of the Southern or main Shaver's creek basin.

In a similar manner, on the Kishicoquillis valley side of the belt, the *Oneida* terrace, running along the south flank of Stone mountain, and broken by six small ravines and then a seventh deep one near Milroy, has a height between the ravines varying between 1400′ and 1500′ A. T. From the Greenwood furnace road to Milroy is 11 miles. From the terrace knob where the road enters the gap to the point of the spur overlooking Milroy, is a perfectly straight line of $9\frac{1}{2}$ miles. The point of the Milroy spur is 1500′ ; Milroy in the valley being 746′ A. T. railroad grade. This spur is the *Oneida* outcrop end of the Greenwood furnace basin. From this Milroy *Oneida* spur end across to the *Oneida* spur end pointing towards Potter's Mills, is a distance of $6\frac{1}{3}$ miles.

Beyond the Milroy spur (eastward) the mountain crest and the terrace is set back a mile and a half to the north. Beyond the other spur the terrace is set back a mile and a quarter to the south ; and here is no Medina to make a crest ; nothing but an Oneida terrace. The mountain belt is thus reduced to a width of just 4 miles, measuring from terrace to terrace ; and thus the belt runs on eastward for six miles, with a constant width of 4 miles.

The northern terrace runs on quite straight nineteen miles from Potter's Mills eastward, past the gorge of Penn's creek, past Woodward, to the deep ravine at the head of



Section 3. *Section 4.*

Across Stone mtn. S W. of Greenwood Furnace

Sect. 4 showing the fault in Kishicoquillis valley.

Laurel run on the Union county line. The Medina crest first reappears two and a half miles before reaching Woodward and has a maximum height of 2200′, while the maximum height of the terrace opposite Woodward is only 1700′ A. T. Beyond Laurel run Dull mountain is 1900′ high. Here the mountain mass swells out and covers the country northward all the way to the Susquehanna river at Williamsport, six miles of its width being represented on the map; beyond which, northward, Mr. Billin's survey did not extend.

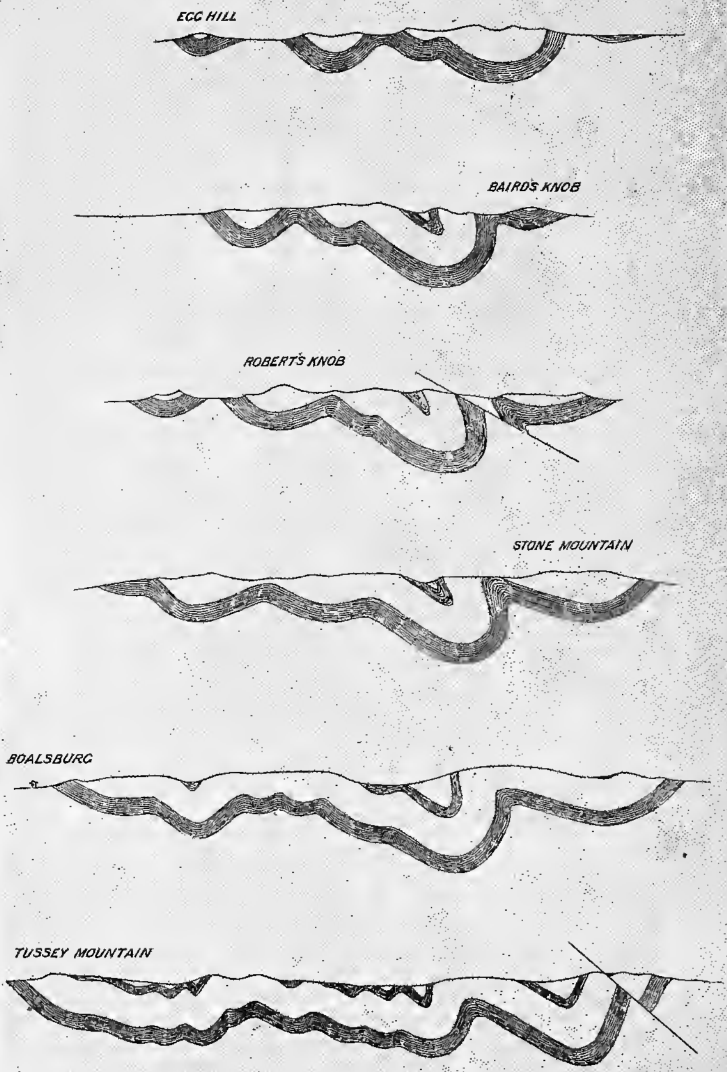
Returning to Milroy, a terrace spur projects into the head of Kishicoquillis valley, with a knob at the end of it, 6 miles east of Milroy, 1700′ A. T. This is represented on the map; but not the still higher Medina mountain synclinal crest which soon takes its proper place upon the broadening spur.

It is evident from the map and sections that the great Huntingdon county synclinal trough has grown steadily shallower eastward from the Juniata river to Greenwood furnace, by the sloping upward of its bottom lines, allowing its side outcrops to converge, and bringing Tussey and Stone mountains together.

If the basin were single, and its cross section a simple V, the two mountain outcrops would meet like the straight sides of an isosceles triangle. But the bottom of the great trough is crumpled into several basins, and the sides approach each other in a a series of zigzags—spurs and loops—three on the Boalsburg or Potter's Mills side, and one on the Greenwood or Milroy side. The deepest part of the whole trough is nearer the Milroy side; consequently the only *Medina* crests which remain to the mountain belt, where it is so shallow as to be only four miles wide, are the two, one mile apart, which run on eastward from the Milroy-Potter's Mills road seven miles, enclosing a straight and deep little valley, heading up at the next road. Here the two crests come together, at an elevation of 2013′ A. T. and there is a remarkable high synclinal divide from which the rainwater descends westward between the crests, and leastward aso between them when they part again.

Sections across the Seven Mountains.

8. Though Egg hill.
9. Through Baird's knob.
10. Through Robert's knob.
11. East of Boalsburg.
12. Through Boalsburg.
13. West of Boalsburg.



From C.E.Billin's Report of Progress S.

This point is one of the most remarkable in Pennsylvania; and should rivet the attention of American geologists. Here the central line or axis of the bottom of the great trough which crosses the State, and is deep enough to preserve the anthracite coal measures in Luzerne and Lackawanna counties, and the Broad Top coal measures in Huntingdon, Bedford and Fulton counties, is represented at the present surface by one of the highest mountains in the State, a flat-topped synclinal ridge only half a mile wide, with steep slopes on both sides overlooking two extensive regions, which formerly rose to an immense height into the air, but are now worn down to within 600′ or 800′ of ocean level.

The most interesting feature of the mountain belt above described, is its corrugation. The aspect of its map is that of the grained surface of a planed piece of gnarled wood. The arches and basins into which the rock formations have been pressed, being approximately regular and symmetrical, and gently tilted up towards the east as far as the remarkable point mentioned in the last paragraph, and then gently down in the same direction from that point onward, are of different depths, as the cross sections show. Consequently, in the general erosion of the whole country every formation has been developed in zigzag outcrops, projecting one beyond the other three or four miles, showing the growing depth of the trough towards its bottom line; which however is not strictly a central line, but lies nearer the southern side; and that, because the two sides of the trough taken as a whole slant inwards at different angles, the northern side slanting gently and the southern side steeply; as if the thrust which produced the trough and its wrinkles, had been made from the south, as it undoubtedly was.

In geological phraseology, the north dips are generally stronger than the south dips. This is in fact a general law throughout middle Pennsylvania, as Prof. H. D. Rogers has shown in his geology of Pennsylvania, 1858; a law discovered by the geologists of the first survey before its termination in 1841. We have seen, in preceding pages of this report, how gentle the *south dips* of Tussey mountain, Warrior's ridge, Allegrippus ridge, and Terrace mountain are compared with the *north dips* in Sideling ridge, Jack's mountain, Sand ridge, and Stone mountain. It is as if the great Huntingdon synclinal had had its south side turned up almost vertical.

A strain sufficient to produce such an effect on the trough as a whole, would necessarily wrinkle the formations which it contained, or which, in proper language, make it up. And this wrinkling would naturally take place more at the bottom of the trough than upon its sides, for the weight of so many formations, piled upon each other to a total thickness of 20,000 or 30,000 feet, would oblige most of the commotion produced by the great side-thrust to take place along the middle of the trough, although the sides would participate more or less. But while the side-thrust would turn up the south side of all the formations to steep north dips, it would not necessarily compel all the subordinate wrinkles to assume that lop-sided form; in fact, we see upon Mr. Billin's maps and in his sections, that the subordinate basins have some of their steeper dips on the north side, as, for example, the 60° and 85° south dips on Range 18; 40° and 60° south dips on Range 10; 50° and 85° south dips on Range 4. (See Plate XLII, page 236.)

On the other hand the north dips are generally steeper than the south dips; and in the case of Range 3, where the fossil ore crosses a branch of Stone creek, 2½ miles W. N. W. of Greenwood furnace, the *north* side of the great rock-arch (Broad mountain anticlinal) is completely pressed over beyond the vertical so as to dip underneath backward *south* 40°.

It is plain that a thrust from the south, violent enough to bend the vast mass of palæozoic strata into a loop, so as to make the lower formations overlie the upper ones, must have produced many extraordinary effects. Such a loop would under certain circumstances crack along its upper line, and the southern side of the loop be driven up past and over the northern side. This would be called an up-throw fault. Many such have been discovered, and no doubt many more exist which have not yet been noticed, or are merely suspected. Two very large ones have been carefully studied by Mr. Billin, and their locations fixed upon his maps. Their character is exhibited by his sections. They can be understood also by the breaks in the color-belts on his colored geological map of the mountain region. They will both be descibed in his report; but one of them requires description here, because it belongs to Huntingdon county, and because it will illustrate the nature of the faults of Morris and Warrior Mark townships to be described in subsequent pages of this report.

The Stone Mountain Fault passes diagonally through the mountain near Greenwood furnace. The course of the mountain is N. 46° E., that of the fault N. 33° E.

The mountain is broken like a splintered bone, when the two ends of the fractured bone are drawn back by the muscles so as to lap each other. The lap in this case amounts to exactly one mile. The mountain from the west ends in a point opposite the furnace. The mountain from the east ends in another point 2400 feet further south. The crest of the northern mountain runs down from 2000′ A. T. to 1800′ at the point opposite the furnace; that of the southern mountain runs down from 2020′ to 1780′, opposite the other point and continues to decline to 1660′ where the road from Belleville gets to its highest lèvel and begins to descend the ravine, eastward, following the line of the fault in the lap.

The terrace of the mountain from the west, at this highest place in the road (the southern entrance to the gap) abuts against the end of the crest of the mountain from the east. The terrace of the mountain from the east runs on westward from the road just two miles, and there ends, being sliced off by the fault. The *Oneida* rocks are here brought to a point on the sloping side of the Kishicoquillis valley, with the underlying slates closing in upon it in both walls of the fault, at an elevation of only 1120′ A. T.

The further progress of the fault westward in the slates cannot be traced; nor has its method of passing through the slates into the body of the underlying Trenton limestone been studied; but it no doubt runs on further and possibly makes connection with the central anticlinal of the valley somewhere between Belleville and Harrolstown. A survey of the edge of the limestone in this part of the valley would decide the question.

The north-east end of the fault is lost in a confusion of *Clinton red shale* strata (No. V) about a mile south of Greenwood furnace. The *Medina white sandstone* of the mountain is seen in the point of the mountain over the road; but the exposures in the road side as it rounds the point, are of red shale crushed and crumpled into a thousand minute folds. On the road from the furnace east to the next notch in Stone mountain (1¾ miles distant) regular 30° N. W. dips show that the south side of the red shale cove is undisturbed; and there is nothing on its north side to show that the fault extends even to the middle line of the cove. The south slope of Broad mountain is quite regular; and we must suppose that the fault is used up in the general crush of red shale in the middle of the cove. This is a very interesting fact; and strongly contrasts with the sharp and long side throw of the rocks in Kishicoquillis valley; where no doubt the movement was at its maximum.

Section 1, Plate LXI, page 330, crosses the cove about 4000′ N. E. of where the *Medina sandstone* disappears in the fault, near its N. E. end. This section shows a perfect regularity of the basin. No doubt it ought to show also a crumpled condition of the red shale along the center line of the basin. It shows the fossil ore in Ranges 1 and 2.

Section 2, of the same plate, crosses the fault mid-way up the ravine, just a mile south of the furnace. It shows the duplication of the *Medina white sandstone* crest, and the southern *Oneida* terrace; but the northern terrace is swallowed up in the fault.

Section 3, Plate LXII, page 332, crosses the fault at the south-west end of the ravine, two miles south of the furnace (by the road), where the point of Slate No. III interposes between the *Oneida* terrace rock from the west and the *Medina* crest rock from the east. Its show the outside (southern) mountain reduced in height to the level of the terrace, and the inside (northern) mountain at its maximum height of 2060′ A. T.

Section 4, on the same plate, crosses the fault at the west end of the southern terrace, 3 miles from the furnace, where the *Oneida sandstone* is still of full width, but the *Medina red rocks* have been swallowed up, and there are already 800′ of slate (No. III) at the surface *behind the southern terrace.*

A proper construction of section 4 determines the *hade* or slant of the fault in sections 2 and 3; and it cannot be considered certain that the true slant has been assigned to it. The best construction has been adopted which the scanty data exposed at the surface suggested. It is embarrassing to see a dip of 40° *south* in the *Oneida* rocks, close to the fault on its south side; and still more surprising to see dips of 25° *south* and 30° *south* further away from the fault (to the south) in the slates which *underlie the Oneida.* These dips exhibit a complete overthrow of the rocks for 3000 feet south of the fault; the Oneida outcrop occupying only 600 feet of this distance. In this case such an overthrow cannot be of the nature of a "brush" due to friction; first, because it is in the wrong direction, since the slide of the southern wall of the fault on its northern wall has been downward and backward, not upward and forward; and secondly, because of the great thickness of measures (at least 1500′) which has been completely pressed over and doubled under.

Perhaps the best explanation of the case would be got by imagining the fold in the valley pressed over northward, collapsed, snapped, and the southern mass shoved forward over the northern upturned mass; then, as a second stage of the operation, a subsequent reverse movement, or sliding back of the southern mass down the plane of the fault, without losing its overturned curled shape.

It seems to me impossible to explain both conditions by one and the same operation; for, all our snapped anticlinals, so far as they have been studied, show the continuance of the forward northward movement after the snap, whether the snap has taken place at the crest or on the steep side of the fold.

It is of the greatest importance to the proper comprehension of Palæozoic geology to observe *the complete absence of indications of nonconformity* of the *Oneida Conglomerate formation No. IV a upon the Loraine (or Hudson river) shale formation No. III.*

Whatever changes in the general topography of America, or of the world, took place at the close of the Loraine age, they were certainly not sufficient to carry the Loraine deposits out of water and subject them to surface erosion. The upper surface of formation No. III must have been smooth and unchanged when the coarse sand (with small pebbles) of formation No. IV*a* were spread upon them. In fact no abrupt change in the character of the strata is noticeable in passing from the under to the upper formation; certainly no more change in passing from III up to IV*a*, than there is in possing from IV*b* (soft red Medina shales and sandstones) up to IV*c* (coarse and massive white Medina sandstone.) The cause of this quadruple alternation must have operated hundreds of miles away from Huntingdon county. And what is true of this special neighborhood is true of the whole area of Pennsylvania: no convincingly satisfactory evidence has yet been obtained of the temporary emergence and erosion of the Lower Silurian (Siluro-Cambrian) limestone and slate deposits, formations Nos. II and III, and their subsequent submergence to receive nonconformably the Upper Silurian formations Nos. IV, V, and VI, in any part of the State. On the contrary, along outcrop lines of contact of III and IV, measuring many hundreds of miles, the uninterrupted continuance of deposits, coarse upon fine and fine upon coarse, is proven beyond doubt by the regular thickness of each deposit within the limits of variation due to variable river flow and tidal current action.

A few exceptional cases occur, some of which are explained by the neighborhood of faults; the others must, therefore, be accepted as faults, whether these have been precisely located or not; and cases will be discussed in describing Morris and Warrior's Mark townships.

I will go further; and insist upon an argument which has never been advanced, or at least urged with proper determination.

Were there any general non-conformability between III and IV, the phenomenon of the Seven Mountain belt could not have come into existence. It only needs to glance down the group of six cross sections on Plate LXIII to be convinced that no geological horizon between formation II and formation VI is a horizon of emergence and erosion. The waves of these sections are all drawn on measurement in their actual shapes, and can be relied on as expressing the precise character and amount of horizontal and vertical movement which has taken place, not at one spot, but along a belt of country large enough to furnish the amplest ground for a safe generalization. The regularity of these waves, their very shapes, indicate unbroken sequence in the strata beneath the surface; and this logical inference is converted into a simple observation of the fact wherever the waves bring up to the present surface the several rock-horizons so that the contacts can be examined and the formations measured.

It will be well to add another remark here. The division of the Palæozoic system into 13 formations by the First Survey of the State has been a great convenience; but it has also been a great drawback to correct knowledge. The more these formations are studied the plainer it appears that, except in the single case of the seventh formation (the *Oriskany*) there are no sharp dividing lines, no absolute limiting-planes or time-horizons between the formations. They pass more or less insensibly into each other. There are transition groups, or passage-beds, between them all. None of the formations are homogeneous. Each one is made up of heterogenous materials, alternations of the most dissimilar strata soft mud-shales in the very middle of massive sandstone formations, and isolated massive sandrock or even conglomerate strata in the middle of great thicknesses of muddy shales. No. IV (Medina and Oneida) was originally subdivided into three: Upper, Middle and Lower; and this subdivision of it is still in convenient use in the whole region west of the Susquehanna river in front of the Alleghany mountain, as far west as Bedford and as far south as Juniata county ; but it is of no use along the southern outcrops, where the formation consists of half a dozen massive coarse sandrock and conglomerate strata separated by as many thick deposits of finer material. If the sections of the Seven Mountains and of the Stone Mountain fault, therefore, be drawn in lines representing the limits of the formations, and No. IV (2500 thick) is seen expressed by two intermediate lines, so as to subdivide it into IV*a*, IV*b* and IV*c*, resting upon a thousand feet of Loraine slate No. III, it must be understood that the subdivision is more for convenience of description than in reality, and that in the majority of cases if not in all the field geologist will find it hard to discover on the ground the exact stratum to be selected as at the extreme top or at the extreme bottom of any single formation or subdivision of a formation. In fact one of the rarest events is the happening on a locality where the contact of No. IV and No. III is exposed,—or one where any rocks can be seen which can be called with certainty the top of No. IV alongside of others which can be confidently described as the bottom of V. And this touches the greatest of all the difficulties which a systematic geologist may expect to encounter in studying in the field any and all of the Palæozoic formations of Pennsylvania. The formations, their subdivisions, their individual groups of beds, are discernible enough everywhere ; but their exact limits, if indeed they have any, are everywhere obscure ; and all recorded measurements in our reports of progress must be handled with a certain reserve in view of these facts.

Another important lesson is taught by the cross sections of eastern Huntingdon and the Seven Mountain belt, when taken in connection with the Broad Top cross sections of Rocky Ridge and Wray's Hill in Plate L, page 286. The waves exhibited by all these sections are similar in shape ; but, on Broad Top the Carboniferous rocks at the top of the series are plicated ; in the Seven Mountains, the Silurian rocks towards the bottom of it. We are enabled to see the waves in both cases because the erosion of the country has removed more or less of the series of strata, developed the outcrops, and cut ravines through them. If the entire mass of coal measures had remained on Broad Top the strata underneath would have lain in waves all the same, but the waves could not have been seen, because buried deeply under ground. The original upper surface of the coal measures however would have shown the waves.

In a manner we can restore the Devonian and Carboniferous formations which have been swept from off the present Silurian surface in the Seven Mountains country; but in doing so (see section 8, on Plate LXIII) the waves of Silurian formations III, IV, V, VI and VII must go up through the overlying Devonian formations VIII, IX, and the still higher Carboniferous formations X, XI, XII and XIII (the coal measures) to the original surface of the Palæozoic deposits. They are more evident at the present surface where the edges of the great sandstone formations IV, X and XII make mountains; but they are just as plainly marked by the little hills and ridges along the outcrops of the Ore sandstone, the Oriskany sandstone, the Portage flags, the Allegrippus and Lackawaxen conglomerates, &c.

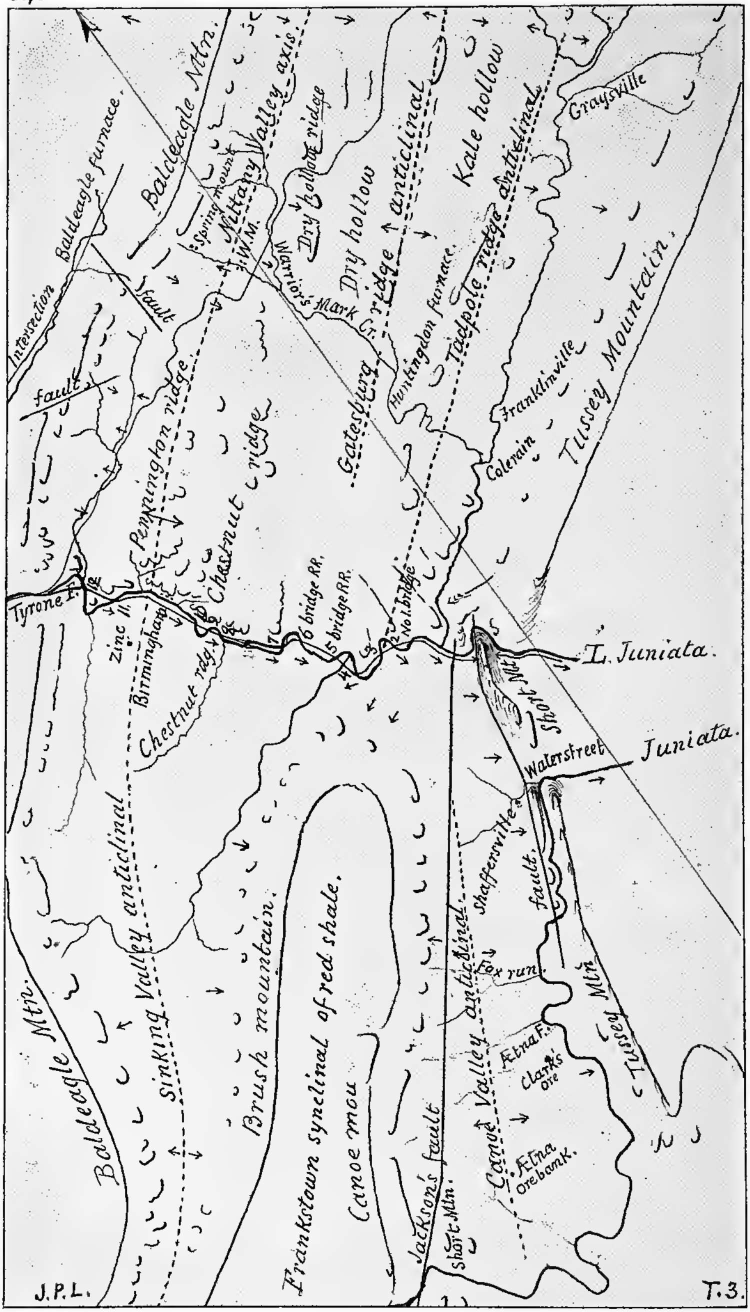
In fact these subordinate layers or groups of hard beds testify to a more extensive but minute crumpling of the softer formation, between the fewer and larger folds of the great hard formations. The thrust of the whole country north-westward rumpled the entire mass of 40,000 or 45,000 feet of Palæozoic deposits; throwing it into several grand arches and troughs of the first order; into a considerable number of subordinate folds of the second order; and into a multitude of still smaller local irregularities, overturned creases, bulgings, faults, most of which took place in the slates of No. III, the red shales of V and XI, the black slates of the Genesee and Marcellus, and the olive shales of the Chemung, No. VIII.

In a word, while the massive sand strata simply bent or broke, the massive intermediate mud strata were mashed and crumpled, were squeezed thick and thin, were bulged into sharp pointed arches, and wrinkled in the bottom of every basin. Of course the overlying hard formations had to conform more or less to the irregular shapes into which their softer supporters were jammed. Consequently, all the waved lines of a cross section differ appreciably from each other, and there is a perceptible flattening out of the waves in going from the bottom lines to the top lines of a section.

This is undoubtedly a deception produced by the necessity under which we lie to draw each formation the same width throughout; for it is only possible to draw the irregularities where they have been exposed by erosion, along ravines and in cliffs for example, or where they have been discovered by extensive mining operations, as on Shoup's run in Broad Top, or at the anthracite collieries.

If the reader will refer to the Reports of Progress of the Anthracite Survey, to the sheets of sections published in its atlases, he will see that the XIIIth formation at the top of the series was just as serious rumpled as the IVth formation 20,000 feet underneath it. But where this IVth formation forms the present surface, there is no possibility of discovering the shape of the waves in the XIIIth which once occupied the sky at the height of two or three miles. And the same must be true of the waves of No. IV buried so many thousand feet beneath the folded Conglomerate No. XII of Broad Top.

The subject of the foregoing paragraphs has engaged my attention for many years, and has recently come into general discussion, but its inherent obscurity is so great, that very little more is known about it now than was discovered in the progress of the first geological survey of the State half a century ago. The number and accuracy of our sections have greatly increased and improved; but we are not yet able to construct a satisfactory vertical cross-section of any one block of the plicated Palæozoic System, chiefly because most of the lateral movement has been taken up in two ways: 1. by a completely universal sliding motion of one stratum on another; and 2. by a packing process, chiefly under the crown of each arch, and at the bottom of each trough; but also at various places where obstructions accumulated, or friction was in excess. A very small part of the whole movement was absorbed by faults. But a still more obscure item of the process consisted in an absolutely unknown, at least unmeasurable, stretching and thinning of the yielding strata in some places, and a correlative full-ing and thickening in other places, even along the unplicated planes or sides of the waves. It is hard to see how this part of the phenomenon can ever be succcessfully investigated. And yet, until it has been, we must hold at rather a cheap price our scheme of columnar measurements, and speculate with extreme caution about the oceanic deposits.


Intersection
Baldeagle furnace
Baldeagle Mtn.
Nittany Valley axis
Spring mount
W.M.
Dry hollow ridge
Dry hollow
ridge
anticlinal
Kale hollow
Tadpole ridge anticlinal
Graysville
fault
fault
Warriors Mark Cr.
Huntingdon furnace
Gatesburg
Pennington ridge
Chestnut ridge
Chestnut
Franklinville
Tussey Mountain
Colerain
Tyrone F.
zinc
Birmingham
Chestnut rdg.
6 bridge RR.
5 bridge RR.
No. 1 Bridge
L. Juniata.
Short Mt.
Juniata.
Waterstreet
Shaffersville
fault.
Sinking Valley anticlinal
Brush mountain.
Frankstown synclinal of red shale.
Canoe mou
Jacksons fault
Short Mtn.
Canoe Valley anticlinal
Fox run.
Etna F.
Etna F.
Clark's ore
Etna Orebank.
Tussey Mtn
Baldeagle Mtn.
J.P.L.
T.3.

Chapter VI.

17. *Morris.*

This township naturally belongs to Blair county; for it lies not only west of Tussey mountain and south of the Little Juniata river, but has a long spur of Blair county running up between Tussey mountain crest and the Juniata river as far north as the Water Street gap. From Water Street gap north to Spruce Creek gap the line between Morris and Porter townships traverses the top of Short mountain lengthwise, but its relation to the two little crests of Short mountain is not known. The survey of the west line of Potter is a puzzle to those who have only the county and township maps to refer to. Our very careful topographical survey maps of Canoe valley shows the Tussey mountain crest running straight along the county line for several miles and then bending more south to the head of the Loop, which does not agree at all with the county and township published maps. (See Plate XXXVII, page 212.)

Morris township extends south-west from the Little Juniata to Fox run about 5½ miles, and from Tussey across to Canoe mountain, say three miles. The terrace of *Oneida sandstone* No. IV*a* supported by a slope of *Loraine shale* No. III projects so far out that the flattish limestone floor of Canoe valley is only 2 miles wide. Its character may be seen by consulting the atlas sheet of Report T, and is sufficiently indicated on Plate XXXVII, page 212; on which the crest and terrace of Canoe mountain appears 2200′ and 1640′ high A. T.; while the low round top of one of the limestone swells is marked 1060′, and the Juniata river bed at the mouth of Fox run is between 800′ and 790′ A. T.

The Canoe Valley anticlinal.

Canoe valley is traversed lengthwise by one of the great anticlinal arches of the State; limestone exposures along the foot of Tussey showing eastward dips of 16°, 21°, 24°, 29°, 45° (between Spruce Creek gap and Water Street gap); then (still going south up the Juniata river) 40°, 43°, 40°, 40°, 45°, 40°, 48°, 54° (at the south end of the Loop.)

On the western side the map shows but one dip, 32° westward; but further south there are others of the same kind; so that the anticlinal structure of the valley is not only evident from the mere fact of the limestones of No. II, coming up in it, between opposite walls of No. III and IV, but the general shape of the arch is well revealed by a sufficient number of measurable rock exposures, chiefly along its eastward slope, but also on the Canoe mountain side, and in the middle of the valley on the crown of the arch.

It appears however from all these exposures both in Huntingdon and Blair counties, that the arch is broken along its axis. The eastward dips extend much further into the valley than the westward dips. Measuring the limestones which come to the surface by cross distance and dip, they amount on Fox run say 4000 feet. The anticlinal axis crosses Fox run somewhere near the road 7,000 feet from the slate at the foot of Tussey, and 3,200 feet from the slate at the foot of Canoe mountain.

Two dips toward Tussey at the mouth of the run are 45°, one dip toward Canoe mountain between the forks of the run is 57°. These insufficient data indicate a proportion of 4900′ on the east side of the arch to 2700′ on the west side. Allowing for any probable variations of dip there will not be room enough on the west side of the axis for all the limestone that comes up east of it to go down again under the Canoe mountain slate. The arch is therefore broken and slipped.

This is rendered more evident by what appears further up the valley in Blair county. A mile and a half south of Fox run on a line across the valley past Ætna furnace the place of the axis is well defined between two dips 49° westward and 34° eastward. It crosses the church and schoolhouse road and run 8500′ from the Tussey mountain slate, and only 4200′ from the Canoe mountain slate. The *westward* dips read 40°, 61°, and 49° ; the *eastward* dips 34°, 36°, 49°, 39°, 48°, 47°, 40° around the furnace ; which indicates a proportionate thickness of strata 5400′ on the east to 3100′ on the west.

But it does not follow that the arch is broken exactly on or near the axis of the arch either here or at Fox run. In fact there is good reason for placing the fault within say a thousand feet of the slate, *i. e.* 3000 feet from the crown of the arch, as will be shown directly.

At the lower end of the valley between Water Street and Spruce creek, Plate XXXVII (page 212) shows, as has been already said *eastward* dips of 18°, 21°, 24°, 29°, 45°, 40°, 43°, 40° (increasing going south,) and only one *westward* dip 32°, opposite Water Street, but 900 feet from the Canoe Mtn. slate, and certainly not very far from the axis, as will appear to any one who protracts the *east* dip strike lines southward to a cross section line at Water street. When this is done it will be seen that the location of the axis will fall about 1000 feet from the Canoe Mountain slate, and 5600 feet from the Tussey Mountain slate ; while the westward dip is actually not so steep as the nearest eastward dips. Supposing an equality of dip on the two sides of the arch, only one fifth of the limestone mass which comes up from under Tussey, goes down under Canoe ; the other four fifths must of course be swallowed by a fault, and this fault must run about the same distance from the slate here as at Fox run and the Church run.

The Canoe Valley fault.

Now when a ruler is laid so as to draw a straight line five miles long through these three localities, it is seen to run, parallel with Canoe Mountain, from Dr. Jackson's fault at the Williamsburg gap to a fault which Mr. Sanders reports to cross the Little Juniata river 1500′ east of Spruce creek. A great fracture therefore traverses Canoe valley on a line N. 38° E. past Yellow Springs from river to river ; the east dipping limestones being lifted and pushed over the west dipping limestones, leaving only the upper or *Trenton* subdivision visible along the foot of Canoe Mountain terrace.

Canoe valley, measured across from one edge of the limestone to the other, is 5700 feet wide at a mile and a half south of Spruce Creek station; 7000′ at 2½ miles (Water Street); 8600′ at 4 miles; 9500′ at 5 miles; 12,000′ at 6 miles (Ætna furnace); 15,000′ at 7 miles (Clark's ore bank); 19,000′ at 8 miles (north of Cove forge); and then contracts suddenly to 14,000′ (south of Cove forge.) These figures can only be explained by a steady rise southward of the crest of the anticlinal arch, spreading the two slate outcrops at the edge of the limestone wider and wider apart, and allowing the emergence of a constantly increasing quantity of limestone at the surface.

In other words, lower and lower strata of No. II rise successively to the surface along the line of the arch going south, the north end of the valley being excavated in Trenton limestone (the upper division of the whole formation), while the underlying iron-bearing strata come to the surface south of Fox run, in Blair county.

But the emergence of lower and lower limestone strata takes place only on the east side of the fault. This is shown on Plate LXIV page 346. In the neck of the valley, in Morris township, between the end of Canoe mountain and Short mountain (or half way between Spruce creek and Water Street) where the Oneida outcrops are 10,000′ apart, and the two edges of the limestone belt are less than 6000′ apart, the dips near the slate being 21° and 24° *eastward* and 25° *westward*, with an unknown amount of flattening on the arch there may not be more than 1000′ of the uppermost (*Trenton*) limestones above the present surface.* At Ætna furnace, where the crown of the arch is 8500′ from the Tussey mountain edge of the limestone, with east dips of 34° near the axis and 36° at the river, the total thickness of limestone strata appearing at the surface must be at least 4500′, the ore bank east of the church and north

*In Report T^4, Plate V, page 38, shows how far beneath the slates the ore horizon of the Pennsylvania furnace banks in Centre county lies. It must be far underground in this part of Morris township.

of the school on the westward dip of 49° occupying a horizon 4000′ beneath the slate. The Clark ore bank (half a mile south of Ætna furnace) is on a horizon 3200′ beneath the slate.

It is therefore not to be wondered at that no ore-banks have ever been opened in Morris township. The principal ore-bearing limestones lie buried two or three thousand feet beneath the surface.

The crest of the anticlinal appears to be strongly marked by two opposite dips of 80°± (N. 20° W.) and 50° (S. 30° E.) at the so-called *Bottomless Cave*, at the side of the road near P. Tippery's house, 6000′ west of the river at Water Street, or 3000′ due west of Shaffersville. The course of the axis here, if got from the two strike lines, would be N. 60° E. which is impossible; but it illustrates the irregularities of all the dips and strikes, produced by excessive pressure. The axis of the anticlinal here runs undoubtedly along the road. The *cave* or sink hole is located on some great fissure opened on the squeezed arch.

A small sink hole may be seen on the hill 1500′ west of the *Cave.*

A great sink hole, 2700′ west of the *Cave*, and near the head of the vale, is of great interest; for here can be seen the contact of the *Trenton limestones* with the overlying *black Utica slates*, dipping 40° (N. 35° W.); and several hundred feet further west the slates dip 60° (N. 40° W.) in under Canoe mountain. But there is no show of a fault; and the *limestones graduate upwards into the slates.* The fault must run between this contact line and the anticlinal at the Bottomless cave. A large stream from the mountain plunges into this sinkhole.

The excessive contortions of the mass of limestone are illustrated by a remarkable dip on the road 3800′ north of the *Cave* and 1600′ south of the Harnish house. It reads 35° (S. 50° W.) This would make the outcrop strike nearly across the crest of the anticlinal, which must run almost through this exposure.

Further on and just north of the house the limestone rocks dip either 20° (N. 15° W.) or 70° (S. 40° E), the rock being so cleft as to make either reading possible; but both are diagonal to the course of the anticlinal.

Further on, and at a point 6600′ north of the Cave, the edge of the *Utica slate* touches the road, but does not seem to cross it to the east, but keeps along near it (on the west) to the cross-roads at Moore's house. Just before reaching the house (say 450′) limestone dips N. 70° W against the slate. But it is not *Trenton limestone*. Therefore the great fault may be safely located at this point. But it cannot run in a straight line; and it is probably complicated with other minor faults.

Two large sinkholes lie west of the road from Moore's cross-roads to the river at Spruce Creek; parallel with the road; and 400′ west of it; the first one 2600′ and the other 3300′ north of Moore's. What these sinks mean cannot be told, but they must be on some line of fracture, because the slate points towards them in a very remarkable manner. The distance from Moore's to the brow of the terrace of Canoe mountain is here 4500′; and the breadth of the whole slate belt (No. III) 3800′, which is twice or three times what it ought to be. The Morrison Cove map sheet No. 1 does not properly represent the slate belt here. The edge of the slate runs along just west of the road past Moore's to a point at least 1800′ north of Moore's, and then returns to cross the other road (from Moore's to Birmingham) 1600′ west of Moore's. Thence it keeps west of the road, between it and the foot of the mountain; and the limestone along that road 3000′ from Moore's dips 25° (S. W.), and 4000′ from Moore's 40° (S. 70° W.), under the slate belt which follows the mountain.

All the dips along the Little Juniata river from the axis at railroad bridge No. 3 below Union furnace, down to the Spruce Creek tunnel, a distance of 8400 feet, are south-south-east dips, with perfectly horizontal rocks on the crown of the axis at the bridge. The actual distance at right angles to the strike is 7800′; and successive exposures of 0°, 12°, 30°, 40°, 16° and 18°, descending the river, would give a thickness of just 4000′ of limestone exposed along the river between bridge No. 3 and the slate at the west end of the

Spruce Creek tunnel, if they lay in a conformable series of beds upon each other. But this is not the case; the series is broken into two by a fault 1300′ down the railroad from Spruce Creek Station; where the beds do not fit, and the dip is suddenly flattened. This is the place where the Great Canoe Valley fault must reach and cross the Little Juniata river.

Of the two series, the *upper one* runs east of the fault along the Short mountain side of the valley, with a general strike nearly north and south*; the *lower series* with a general strike of S. 45° W.† on the west side of the fault, bear away directly towards the end of Canoe mountain, but must gradually swing round between the river and the mountain; and the curve represents the dying end of the great *Brush Valley anticlinal* coming from Centre county, and crossing the Little Juniata at Bridge No. 3; the remarkable feature of the structure being the sudden dying down of this great rock wave against the upturned end of a great rock trough; producing a strike of the rocks square across both.

The impinging of the strike lines of the *upper and lower series* of limestones on the two sides of the line of fault is very striking. The angle they make with each other is about 45°, and the conclusion is inevitable that the great *Canoe Valley fault*, crossing the railroad 1300′ below Spruce Creek station, 2800′ above the west end of the Tunnel, must meet the *Tunnel or Water Street fault* somewhere in the body of Tussey mountain, say a mile north of the gap.

The extraordinary throw of the mountain to the west, north of the river, is to be accounted for by one or both of these faults; complicated perhaps by a cross fracture, of which however we have as yet no evidence.

Canoe mountain ends in a rapid curve of its high crest (2200′ A. T.) around the north end of the Clinton red shale

* Mr. Sanders has recently revised the observations, and reports dips of 16° (S. 80° E.); 18° (S. 80° E); 12° (S. 90° E.); 12° (S. 90° E.); 12° (S. 80° E.) along 2000′ of the road leading from the river up the run towards Water Street, 2000′ in front of the Tunnel.

† Mr. Sanders reads 30° (S. 25° E.); 30° (S. 40° E.); 30° (S. 45° E.) for 600′ along the road from Spruce Creek station towards Water Street.

cove of Blair county; its terrace also sweeps round, in a wider curve, into Sinking Creek valley, its platform knobs, (1640′, 1680′, 1520′, 1620′, &c., A. T.) being separated by the usual ravines. Canoe valley here widens rapidly northwards into Spruce Creek valley, across which the Little Juniata flows in a crooked trench between limestone hills about 1000′ A. T. the railroad level at Spruce Creek station being 777′ and the river bed about 750′ A. T.

It is plain that we must give up altogether the old idea that the Canoe Valley anticlinal crosses the Little Juniata river and runs on through Franklin township on the west side of Spruce creek.

The fact however is that the Canoe mountain is not entirely squared off at its end by this opposition of the Brush Valley arch. The map shows that while the crest of the mountain describes a perfect semi-circle of 3200′ radius, the terrace projects at one place further than everywhere else; namely, the knob marked 1620′ A. T. 4300′ south-west of Union Furnace station; and it is through this projection of the terrace that the synclinal axis passes *to the west of the* Brush Valley anticlinal; and, we see the synclinal passing the river just above Bridge No. 5, (say 2400′ above U. F. station) between two opposite dips, one 60°, S. 80° W. and the next one higher up 30°, S. 40° E.

Thus far the discussion of this most remarkable piece of structure has not been subject to insuperable difficulties. The general aspect of the case is tolerably clear. Nor are additional difficulties encountered in Franklin township; for Tussey mountain suddenly bends (or breaks) at Spruce Creek gap and runs on straight for many miles in a course between N. 58° and 60° E., consequently parallel to the Brush Creek anticlinal; the strike of the exposures along the river above the tunnel, stated above at N. 65° E., representing the beginning of the curve around the end of the dying anticlinal.

The Tunnel or Waterstreet fault.

We must now take into consideration a group of facts along the foot of Short and Tussey mountains in Morris township, which seriously complicate the structure.

The fault at the west end of Spruce Creek tunnel is indicated by the thinness of the slate outcrop (No. III) between the limestone (No. II) in the river bed and the *Oneida sandstone* (No. IV) cliffs of the hogback, 300′ above them. No. III is more than 900′ thick in the Canoe terrace opposite; appears to be 700′ thick on the west slope of Short mountain half a mile south of the tunnel; 600′ at Water Street; 400′ a mile and a half further south. Either the formation has been squeezed down to one third its size, or else the limestone has been thrown up so as to conceal the lower two thirds of it. The direction of the hogback is N. 17° E. and this must be the direction of the line of fault; and such a line is exactly parallel to the crest of Short mountain; and when projected S. 17° W. to Water Street exactly hits the point where the limestone abuts against the overturned slates; these here dipping 71° *towards the limestone* and the limestone dipping 49° *towards the slates; consequently against their under sides.* In this case the "brush" nature of the overturn in the slate is evident, and shows that the mountain rocks on each side of the fault have *sunk*, or the valley rocks on its west side have moved *upwards.*

If the above S. 17° W. be changed at Water Street to S. 18° W. for a mile and then to S. 20° W. for another mile, it will follow the contact of the slate and limestone to where the river first breaks through the slate to flow along the heart of the mountain. This conduct of the river was evidently compulsory. From Williamsburg into Morris township the river could make its channel in the Trenton limestone, cutting always down dip into the bottom slates. But here, the slates being faulted *down* to the east, while the limestones were faulted *up* to the west, the river naturally took to the lower or eastern side of the fault, and could not get back to the limestones on the higher western side on account of the wall of the fault; which, moreover, was continually getting higher and higher going northward, brushing up the slates, and then the sandstone; so that in another mile the river had to leave the upturned slates and sandstone to the left and make its way along the (10° to

20° dipping) softer middle rocks of the mountain, until it reached the gap, where it had to abandon its northward course entirely.

The *Water Street Narrows* are thus explained. The long narrow hogback between Shaffersville and the river is the outcrop ridge of the *Oneida sandstone* and underlying slate strata, brushed up and turned over to a dip backward of 70° to 74°. The hogback is cut off by the Shaffersville run, which enters the bend of the river at Water Street. On the north side of this run the *Oneida sandstone* runs up the end of Short mountain to its top, where it makes a short crest 1760′ A. T. 1200′ west of the real crest 1840′ A. T. made by the *Medina sandstone.* But here, where the mountain is so high, the horizontal distance from the indicated IV–V contact line (*top of Medina*) on the east slope to the indicated III–IV contact line (*bottom of Oneida*) is 3000′, and Mr. Sanders' measurements throughout Blair county make the total thickness of IV 2896′ (see page 144.) It looks as if the vertically upturned outcrop of IV was complete. It remains unexplained, however, why the two crests (or crest and terrace) are here only 1200′ apart, when they ought to be 2000′, judging by the construction of the Canoe mountain terrace and crest opposite.* Something must be allowed for errors of topographical survey; and more for the uncertainty as to which of the massive sand-rocks in IV make the two short crests, or peaks, of Short mountain; but it seems hardly possible to avoid the conclusion that the previously described Spruce Creek fault line N. 17° E. does *not* represent precisely the direction of the fault in its passage along the west slope of Short mountain from the tunnel to Water Street; but that the fault describes a curve conforming to the foot of the mountain, and the edge of the limestone.

The *Oneida sandstone* outcrop, which makes the lower of the two crests of Short Mountain, can be seen descending

* From brow of terrace to top of crest=3400′; rise from 1680′ A. T. to 2200′ A. T.=520′; dip at base of mountain 32°, flattening to horizontal under center line of red shale, 3500′ west of crest; calculated thickness from brow-rock (*Oneida*) to crest-rock (*Medina*)=2000′.

the mountain to the hogback at the tunnel. In doing this it strikes north and gradually curves to N. 17° E. This shows the upturned brush. The strata stand vertical at the top of the mountain and gradually fall over to the west and grow less and less steep as the outcrop is followed down, until at the tunnel they have got their normal dip of 20° S. 73° East. The fault merely cuts them off without brushing them up.

Chapter VII.

The Little Juniata section.

The order of exposures from bridge No. 3 up to the Tyrone gap, as given on a sheet of the Morrison Cove topographical survey map, is as follows:—*

At bridge No. 3, dip *horizontal* (*0′*) on the crown of the Brush Valley anticlinal, as stated above.

1500′ along the railroad west of No. 3, dip 10°, N. 65° W. into the Canoe mountain synclinal.

River bend, 1500′ further west, and just below bridge No. 4 (Mt. Union), dip 40° N. 70° W. still into the synclinal, which is evidently not rising here rapidly.

Bridge No. 5, 1000′ west of the next bend of the river, but only 1600′ west of the last (measured across the strike) dip 60°, S. 62° W., diagonally in to the now rapidly rising synclinal.

Within the next 1000′ the axis of the synclinal is passed, and then the reverse dips begin to be abundant; for example:

For 1000′ before coming to bridge No. 6, are dips of 30°, 20°, 30°, S. 30°±E. The strike of these exposures (N. 60° ±E.) is at right angles to the strike at bridge No. 5, above cited on the east side of the synclinal. This shows the rapid curve of the strike lines around the axis, and how rapidly the basin is rising on an axial line as near as pos-

*My own observations of dips along the river are given on the Lyon, Shorb & Co.'s map, 1872.

sible N. 33° E.—It cannot go far on this course into Warrior Mark township before bending to the east to keep its its place west of the Brush Creek anticlinal, unless it should split and receive an intermediate roll.

At 3600′ west of the 30° at bridge No. 6 (2000′ beyond bridge No. 7) is an exposure dipping 34°, S. 57° E.—At bridge No. 9 (2500′ further along the railroad) dip 14°, S. 57° E.—900′ further, dip 10°, S. 57° E.—400′ further, dip 20°, S. 57° E.—At Birmingham 1400′ further, dip 34°, S. 57° E.—This group represents the strata on the gentle eastward slope of the great Nittany valley (Sinking Creek valley) anticlinal arch which runs through Warrior Mark township, Centre, Clinton and Lycoming counties, Nippenose and Oval valleys, up Muncy creek into Wyoming county—one of the greatest and longest rock arches which traverse the State.

The surprising fact is that this group of exposures between Birmingham and Bridge No. 7, all agree in a common strike line of N. 33° E., S. 33° W. which ought to take their outcrops northward towards Bald Eagle Mountain, and southward towards Brush mountain; for, Bald Eagle mountain has a strike of N. 45 E.; and Brush mountain terrace along Sinking Spring creek from Arch Spring 11,000′ (from the river) for 2½ miles south-west of Arch Spring has a strike of S. 50° W.; then it bends and runs S. 38° W. 4 miles further to the point where the axis of the anticlinal brings the outside or lower edges of the two belts of slate together. From here onward the anticlinal axis runs S. 44° W 5½ miles to the high anticlinal knob overlooking Hollidaysburg.

These strike lines along the river must sweep round S. W. and W. to cross the axis of Sinking Creek valley. But that they do so very gradually is shown by a recent revision of the exposures south of the river by Mr. Sanders. From Bridge No. 6 a road runs straight W. S. W. up Sinking Creek valley. At 3000′ from the bridge the Water Street road meets it at right angles. Here the limestones dip 30°± (S. 30° E.); and 1400′ further on they dip (S. 40° E.) At 3800′ further on another road (from the Arch Spring) strikes the main road, and here the limestones dip (S. 40° E.) It appears therefore that the great anticlinal is regular on its south side for at least 2 miles south-west of the river.

But between the road and Brush mountain there are some disturbances. Taking the Water Street road south-eastward, at 1200′ there is a dip of 30° (S. 30° E.) as before; at 2100′, a dip of 50° (S. 60° E.); and at 3000′, a dip of (S. 40° E.) on the north side of the creek, and within 1000′ more or less of the edge of the slate; and the strike here would run diagonally into the slate, as if there were a fault.

Taking the other road (to the Arch Springs), at 1000′ is a dip of 25° (S. 25° E.); at 1500′ a perfectly measurable dip of 40° (S. 10° W.) just north of the creek and where the road forks, up to Arch Springs, and down towards the mouth of the creek. Taking the last road, at 1800′ (from the forks), at the bend in the creek, is a dip of 20° (*South*); and 500′ further down the creek a dip of (S. 20° E.)

When these dips are all plotted it is evident that, in spite of some crumpling and waving, the strike of the limestones in general conforms to the line of the slate belt at the foot of Brush mountain, and that there is no occasion for supposing a fault.

Little Juniata section, continued to Tyrone.

At McCahan's Mill, 2000′ above Birmingham station, the great anticlinal having been passed, the limestones stand vertical (90°) descending *westward* to pass under the Bald Eagle and Allegheny mountains. This west side of the Birmingham anticlinal is first overthrown and then broken, as appears from the following dips higher up the river:

At Bridge No. 11, near Ironsville, 4400′ (in straight line) from Birmingham station, the *overturned* dip is 70° *eastward.*

At 1000′ further west along the railroad, which here cuts across a sharp bend in the river through a notch isolating a limestone knob 100 feet high in the bend) the *overturned* dip is 45° *eastward.*

At Bridge No. 12, at Tyrone Forge, 800′ further, the *overturned* dip is 54° *eastward.* The railroad here crosses again to the south-west bank 1500′ above the sharp bend at

Ironsville. Just at the bend, and almost on the strike of the last exposure, the limestones stand vertical, at the mouth of the run which comes in from the south-west, following the foot of the terrace, but keeping in the limestone, at a distance of sometimes 500′, sometimes 1000′, from the edge of the slate; always in the same soluble Trenton strata in which Sinking Spring creek, on the opposite side of the valley, cuts its channel.

When the river emerges from the Bald Eagle mountain at Tyrone Forge, it meets the great fault and turns square to the right, runs (under Bridge No. 12) parallel with the fault and then turns sharp to the east. It is at this sharp bend that the vertical (90°) rocks are seen.

In the gap of the terrace, at 2000′ west of Bridge No. 12, the slates dip 80°, north-west, with a strike exactly N. E. and S. W. And this is the course of the Bald Eagle mountain for several miles south-west of the gap.

The top limestone appears on the railroad 1300′ from Bridge No. 12. Then something over 1000′ of vertical slate. Then 2600′ of vertical Oneida and Medina sandstone. Here the railroad begins its great semi-circular curve out of the west mouth of the gap round to Tyrone City station, a distance along the railroad of 3000′, all in vertical *Clinton shales*, measuring 2000′ through. Beyond this the Lower Helderberg limestones appear, also standing vertical. Between Tyrone Forge, Bridge No. 12, and Tyrone city, at least 7000′ of rocks standing vertical, or nearly so, are cut through at right angles.

But there have been some irregularities in the upturning movement of this huge mass of rocks; for, at one place on the north bank of the river, a crush fault shows itself on the face of the cliff; some sandstone layers being jammed into a letter S against others which stand vertical and otherwise quite undisturbed.* The cross faults which break and shift the mountain mass three miles north-east of the

* The negative of a photograph of this exposure made by Mr. E. B. Harden during his topographical survey of the vicinity, was unfortunately broken, so that a heliotype plate of it intended for this report, has been omitted. The exposure is near the bridge by which the Lewisburg and Tyrone railroad crosses the river.

gap will be described directly ; and they afford an *a priore* argument for the considerable size and importance of this apparently insignificant crush fault in the gap. I have collated the two topographical surveys of the Bald Eagle mountain ; that to the west made by Mr. Sanders, and that to the east by Mr. Harden ; the former published with Report T (see its Atlas), the other published in this report (T[3]) on a sheet by itself ; both on a scale of 1600′ to 1″ ; and it appears on this compilation (see page Plate LXIV, page 346) that the crest line and terrace line of the mountain is shifted to the north at the gap. How this is done does not clearly appear ; but apparently the fault comes from the east. How it is connected with the break in limestone near Tyrone Forge is entirely obscure ; the probability is that there are several lines of fracture ; and that there is a general confusion of strike and dip in the limestone, slate and sandstone east of the river.

The Little Juniata section repeated.

Character of the limestone beds.

The following summary of Prof. H. D. Rogers' description will be found to be useful :

Massive gray limestones exhibit themselves for 250 yards above Spruce Creek dip 40°.

Thin-bedded magnesian, dark-gray, and blue limestones make many exposures further up the river dipping 40°, S. 60° E.

Cherty light-blue limestones crop out at the bend between Bridges 2 and 3.

Cherty siliceous and magnesian ash-colored limestones, weathering to a *herring bone surface, as if they were covered with hieroglyphic scratches*, the more siliceous sort *delicately striated with long and parallel lines*, appear 300 yards above the bend.*

These are the lowest strata in the series that appear at the surface on the Brush valley anticlinal ; for the dip now changes to 37°, N. 80° W. into the Canoe mountain synclinal, at Wallace's old mill.

*See Geol. Penn., Vol. I, p. 502.

Rough calcareous *sandstone* beds, overlying magnesian limestone beds, dipping 40°, N. 80° W make a *cliff* ¼ mile above Wallace's old mill. Massive blue limestone make fine exposures, dipping 45°, S. 80° W. 200 yards below Union furnace. At Union furnace the dip is due west.

Massive blue limestone dip 60°, N. 60° W. at the upper end of the island; and (as has been already said) 60°, S. 62° W. on the railroad after crossing Bridge No. 5. The *synclinal axis* crosses the railroad a little further on; for, ¼ mile above the island the *south-east dips begin again.** The rapid rise of the synclinal north-east of the river, makes the Union furnace rocks sweep round in concentric curves, on the high plateau covered by the Huntingdon furnace property, and back to the river below and above Bridge No. 6, and the township line (between Franklin and Warrior's Mark) which strikes the river at Bridge No. 7. Thus the sandstone of the cliffs above Wallace's old mill, above mentioned, comes back to the river past the *Stone quarry* on the hill where the the road up from W. Stewart's turns the nose of the hill towards J. Fisher's, W. Wray's and S. Thompson's houses, and overlooking the school-house on the river road. Here all the strata for 1000 feet and more along the railroad approaching Bridge No. 6, dip only 30°, S. 30° E. into the synclinal.

From Bridge No. 6 therefore lower and lower limestones in the series continue to come up for 2½ miles up the river, or 11,000′ across the strike, making (with dips of 34°, 22°, 14°, 10°, 20° and 34°, say an average of 20°) 4000′ of rocks. This great thickness added to the thickness of exposures from Bridge No. 3 down shows that the strata at Bridge No. 6 must be repetitions of those at Bridges No. 1 and 2. And this conclusion is justified by an examination of the anticlinal and synclinal waves as they run north-eastward through both townships into Centre county.

On the Juniata only *two anticlinals* including between them the Canoe mountain synclinal can be seen.

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*At Wallace's house at the foot of Canoe mountain, the upper (*Trenton*) limestones dip 40° west, and again 35°, S. 25° W. the strike pointing to the middle of Short mountain. See Geol. Penn., Vol I, p. 502.

In Centre county Mr. d'Invilliers in his report T⁴ shows *three anticlinals* including between them two basins; and this state of things exists in the north-eastern half of Franklin township; the middle Centre county arch flattening out and allowing the two basins to become one. The eastern arch is the *Brush Valley anticlinal* which reaches the Juniata at Bridge No. 2. The western arch is the *Nittany Valley anticlinal* which crosses the Juniata 1000′ or so above Birmingham, *overturned* (as has been already described) on its western side, all along its course for some distance south of the river, and along its course through Warrior's Mark township into Centre county.

The Birmingham section is described by Prof. Rogers in Geol. Pa. I, page 503, but the description follows the tortuous bed of the river and the data, however valuable as a catalogue of the strata, must be plotted and calculated to show the real order and thickness of the strata:

Beginning at Union Furnace and going up the river—

1. Thin blue limestone, 48° (S. 50° E.)		
Interval, ...	yards	150
2. Massive blue limestone.		
Interval, ...	yards	100
3. Massive dark-blue limestone, 35° (S. 45° E.)		
Interval, ...	yards	25
4. Massive blue limestone.		
Interval, ...	yards	100
5. Dark-blue limestone.		
Interval, ...	yards	50
6. Massive pure limestone, 35° (S. 60° E.)		
7. Massive and thin alternations for	yards	250
Interval, ...	yards	100
8. Blue and gray limestone, in cliff (300′ high.) *		
Interval, ...	yards	200
9. Thin gray limestone, 36° (S. 50° E.)		
Interval, ...	yards	30
10. Dark gray *siliceous strata.*		
Interval, ...	yards	200
11. Light-blue† *cherty, siliceous* limestone, 33° (S. 30° E.), .		60
Interval, ...	yards	70
12. Light *ochreous impure* limestone.		
13. Dark gray *calcareous sand rock.*‡	yards	200

*1½ miles above the furnace.

† Weathering yellow.

‡ Becoming more siliceous approaching Robinson's saw-mill; and just below the mill-dam, *interstratified sandstone beds.* The mill and bridge are ⅜ of a mile below Railroad Bridge No. 8.

14. Dark-gray calcareous beds at dam, 50° (S. 30° E.)
Interval, ... yards 100
15. *Cliff of calcareous sandstone*, 38° (S. 39° E.)*
Interval, ... yards 400
16. *Sandy* limestone, 25° (S. 35° E.)
Interval to Birmingham (¾ mile). . . . . yards 1320

Then passing the great arch:
17. Massive *white-veined* limestones, steep (S. 40° E.)
18. *Black slates* of No. III, full of white veins.

Above this a few rods:
19. Broken siliceous limestone, 50° (S. 50° E.)

Then in the hollow above Birmingham:
20. Cherty calcareous rock, confused dip (S. 50° E.)

About 150 yards above the black slate:
21. *Crushed sandstone* (like No. IV; then
22. Red shale; then, soon, a regular dip of 35° S. 50° E.) exposed often in massive strata for . . yards 150
23. Fragments of sandstone follow. The sandstone is upheaved along the fault, nearly ¾ mile from Birmingham, 150 yards below Bridge No. 11.
24. Thin blue limestones, dip 45° (S. 50° E.) † . . . yards 60
Interval, ... yards 40
25. Blue thin limestones, 85° (S. 60° E.)
Interval, ... yards 70
26. Light-gray, ochreous limestone, 90°
Interval, ... yards 75
27. Dark-gray, siliceous rock, 90°, ... yards 100
Interval, ... yards 350
28. Rocks dip 85° (S. 70° E.)
Interval, ... yards 370
29. Dark-gray hard limestone, 45° (S. 60° E.) ‡
30. Light buff limestones, 48° (S. 65° E.), behind Ironville.
31. Pure blue limestone, massive and *fossiliferous*, appears below the Tyrone Forge Bridge No. 12, *overturned* to 65° (S. 50° E.)
32. Limestones in the end of the hill opposite the lower forge, 85° (S. 65° E.)
Interval, ... yards 300
33. Slates of III appear at the base of the mountain, dip 90°.

Last exposure limestone, alternating with slates, occur 900 feet above the forge.

Professor Rogers concludes that the anticlinal arch at Birmingham has been pressed over, broken and thrust up over the vertical and overturned and distorted strata west

*For 80 yards along this cliff are seen gray, granular, calcareous, siliceous strata. These strata make *Chestnut ridge* through Warrior's Mark township.

† Becoming steeper, or 80°, and more massive, and veined like a marble. Distorted and horizontal dips succeed. Strata near the bridge are vertical.

‡ *Overturned*; at Ironville.

of it, so as to allow the sandstones of the Potsdam formation No. 1 to appear at the surface in the east wall of the fault. This was Dr. Rob. M. S. Jackson's theory when he studied the region in the First Survey. And this was Mr. C. E. Hall's view of it when he collected specimens and fossils along the river for the Second survey. But there are good reasons for regarding the sandstone strata (13, 15, 16 of the above section) as interstratified sub-divisions of the great magnesian limestone series No. II, as already said.

List of Specimens.

A collection of specimens for the Museum of the Survey was made by W. A. Fellows in 1876, along the Little Juniata river from Tyrone Gap down to Spruce creek. The list is published in Report of Progress O, page 113.

Specimens 2573 (1,) is a compact grayish-black limestone from Nearhoff's quarry.

Specimens 2574 to 2586 were taken from beds of Trenton limestone beginning 600′ and ending 640′ above Tyrone forge.

Specimen 2583, 560′ above the forge, contains a shell belonging to some species of *Rhynchonella.*

Specimens 2587 to 2593, are from beds nearer the forge.

Specimens 2594 to 2604, are dolomitic limestone of *Calciferous age*, from the beds still nearer the forge.

Specimens 2605 to 2624, are dolomitic limestone from the cut east of Bridge No. 12.

Specimens 2625 to 3631, are dolomitic limestone from the cut west of Bridge No. 11.

Specimens 2632 to 2647, are dolomitic limestone from the wagon road leading from Bridge No. 11 to Birmingham.

Specimens 2648 to 2651, are dolomitic limestone from the road west of the covered bridge at Birmingham.

Specimen 2652 is *white, compact, fine-grained sandstone*, from an outcrop on the river road above the Birmingham covered bridge and opposite the Lead and Zinc works.

Specimens 2652 to 2656 are also *sandstone*, from the same locality.

Specimens 2657 to 2660 are *ferruginous sandstone* speckled with oxide of iron from the same locality.

Specimen 2661 is (*Potsdam ?*) *sandstone*, *hard*, *gray*, from below the Birmingham covered bridge, and opposite the railway station.

Specimens 2662, 2663 are *shaly limestone containing much carbon*, from the same locality.

Specimens 2664 A to 2667 A are *dolomite* with distributed veins of calcite, from the south side of the river, opposite the *sandstone* locality above mentioned, and on the railroad east of Sub. Div. shanty near the Birmingham station.

Specimens 2664 to 2679 are limestone from the railroad east of Birmingham station.

Specimens 2680 to 2688 are limestone from Bridge No. 10 east to Bridge No. 9.

Specimens 2689 to 2697 are limestone from Bridge No. 9 to Bridge No. 18.

Specimens 2697 to 2699 are limestone from east of Bridge No. 8—Specimens 2700 to 2714 being taken from the limestone quarry east of the bridge.

Specimens 2715 to 2718, east of Bridge No. 7.

Specimens 2719 to 2726 (184), east of Bridge No. 6—2726 (185) from a large quarry.

Specimens 2727 to 2733, east of Bridge No. 5.

Specimens 2734 to 2743, east of Bridge No. 4.

Specimens 2744 to 2748, east of Bridge No. 3.

Specimens 2749, 2750, east of Bridge No. 2.

Specimens 2751 to 2753, east of Bridge No. 1.

Specimens 2754 to 2777, east of the engine-house at Spruce Creek station.

Specimen 2778 (the 240th of the original collection) from the lime-kiln near the *Spruce Creek tunnel.*

Fossils of No. II.

The first specimen of the above list was not obtained at the river, but at Coplay Nierhooff's quarry, 1½ miles north-east of Tyrone forge; where, also, was got specimen 213 (Palæont. Coll. Report O, page 232.) Specimen 212 (same coll.) was got on hill top on road from Tyrone gap to Warriors Mark. Specimen 211 (same coll.) was got in the river bluff above Tyrone forge and below the covered bridge. These three specimens contain *Trenton fossils*, and establish the fact that the slates of III rest conformably on the upper subdivision of the great limestone series of II. Specimen 210, got near Bellefonte, and Specimen 203, got west of Bellefonte, show the same thing; as also do Specimens 201, 202, 204 and 205, got at Reedsville in the Kishicoquillis valley, and Specimen 214, got 2 miles from Belleville in Mifflin county. No systematic collection of fossil forms was made by the Survey in this district; but *some of the Trenton strata are crowded with* the stems of a stone lily (*Schizocrinus nodosus*); the heads of another (*Streptelasma corniculum**); bivalve shells (*Orthis testudinaria, Strophomena alternata, Leptæna sericea*, very abundant; and occasionally *O. tricenaria, O. subequalis*, and two other doubtful species; with *Lingula curta*); also whorled shells (*Pleurotomaria gracilis, Murchisonia gracilis*, &c.); a little pteropod shell (*Leperditia*); and at least two trilobites (*Trinucleus concentricus* and a *Calymene*.)†

But this abundance of animal life existed only here and there at restricted localities, and at the close of the long limestone age; marking a change of sea margin, and the invasion of the black muds of the *Utica slate formation* (bottom of No. III.) Why animal remains are so exceedingly difficult to find through this vast pile of limestone deposits, except near its top, may be reasonably accounted for by the great depth of sea, and by the heavy charge of magnesia. Only a few large gasteropod shells have been found in Blair county (notably the large *Maclurea magna*,) and only in the upper half of the mass. But Mr. Hall found in the lowest strata of the series at the river a few fragments which he considered to belong to *Calciferous* types.‡ And Prof. Ewing found in Centre county in the lower part of the formation numerous specimens of a supposed *Pleurotomaria*,§

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*Also *Chætetes lycoperdon.*

†See Prof. Ewing's list in Report T. 4, p. 424.

‡ Report T, p. 59.

§ Report T[4], p. 423, where it is described in general terms.

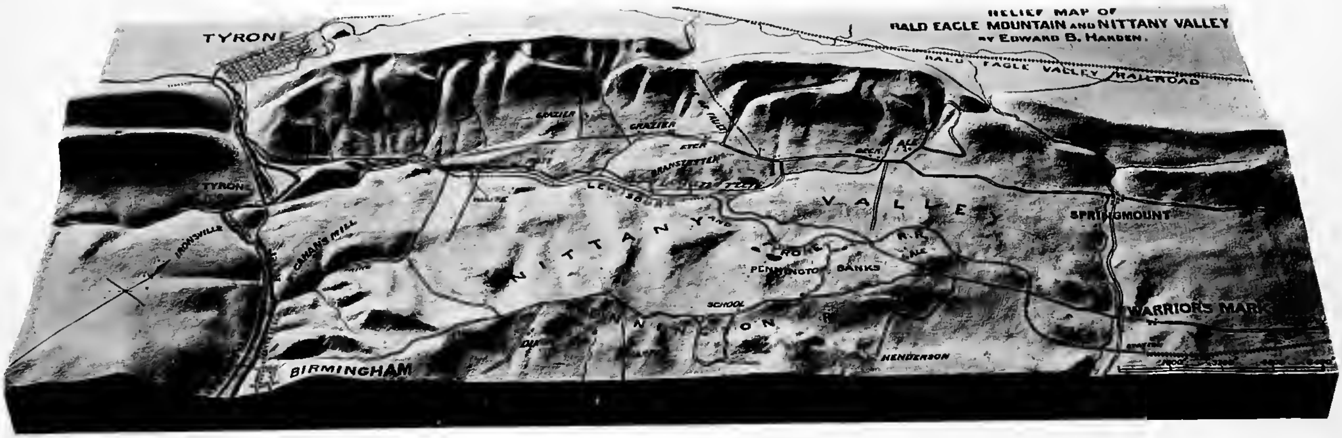
and fragments of a few other gasteropods. *Chazy* forms occur in Spec. 207, (Report O, p. 232) found in high rocks in Morrison's cove; and *Calciferous* forms in Spec. 208, found in the lowest rocks ⅛ mile east of Williamsburg. In the so-called *Potsdam* sandstone rocks at Birmingham Mr. Hall could find no fossils; which is another argument for considering them part of No. II, although not a conclusive one.

The Bald Eagle Mountain faults.

The topography around Tyrone Forge is remarkable. Logan Springs run cuts rapidly down into the limestone as it approaches the river, and isolates a bold hill 260′ high from the elevated plain of the valley; while a small nameless run which descends from the mountain and cuts through the slate outcrop to the river isolates the hill from the mountain. The Lewisburg and Tyrone railroad follows the little run behind the hill and comes out on to Logan run, above Hamer's mill, at an elevation of 180′ above the river.

Two cross-faults interfere with the straight line of the Bald Eagle mountain east of the Tyrone gap. The first one may be called the Vail station fault, because it points directly towards Vail station, on the Bald Eagle Valley railroad; the other, the Bald Eagle Furnace fault, being just opposite that station.

The *Vail station fault* cuts the crest of the mountain just three miles east of the river. It is similar to the Stone Mountain fault of Jackson township, already described, in all particulars but one, viz: the direction of its movement. In the Stone Mountain fault the broken ends have slipped past each other; in this fault they have slipped away from each other. In both cases the dip of the rocks is northwestward; but here it is nearly vertical. In both cases the *Medina crest*, coming from the west, ends abruptly; but here in a bold knob 1620′ A T, other places on the crest towards the river being 1760′, 1780′, and 1670′. In both cases a ravine of red shale runs up behind the knob; but here it is exceedingly short and dry; a road follows it. In both cases the *Oneida terrace* from the west is contin-



HELIOTYPE PRINTING CO, BOSTON.

BALD EAGLE MOUNTAIN AND TYRONE GAP AS SEEN FROM THE SOUTH EAST.

HORIZONTAL SCALE OF MODEL 1600; VERTICAL SCALE 800 FEET TO AN INCH.

ued as a *Medina crest* eastward; but here is not even a considerable notch to mark the change of rock; only a sudden rise from 1500′ on the terrace to 1750′ on the crest, the ravine to the west, by which the road ascends, having nothing to do with the fault, but being one of the innumerable ravines which cut up the terrace into knobs or spurs to the crest. In both cases, also, the terrace from the east ends abruptly in front of the mountain; but here a ravine behind it is very pronounced.

By drawing a line past the west end of the east terrace, (south of the mountain) and the east end of the west crest, (north of the mountain) the line of the fault will be found to point exactly from a limestone quarry on the road near D. & H. Nierhoof's, towards Intersection (Vail)station (see the map), *i. e.*, N. 75° W., a direction like none of the other faults of the region as yet measured.

The throw can be easily measured; the crests east and west of the fault being out of line with each other 1400′, and the horizontal slip along the line of fault 1900′.

In the case of the *Stone Mountain Greenwood Furnace fault* the steeply slanting measures were subject to a crushing strain and gave way along a line nearly coincident with the strike, being diagonal to it less than 10°.

In the case of this *Bald Eagle Vail station fault* the vertical measures were subjected to a tensile strain along a gentle curve pressed outward, so that the line of fracture took place transversely, on a diagonal to the strike of 58°.

It is evident that the three mile block of upturned country between this fault and the Tyrone gap has moved outward (westward) a distance of 1000′ or 2000′. The curve is shown by the varying strikes of the Bald Eagle mountain crest:—West of the gap N. 45° E.—West of the *Vail station fault* N. 49° E.—For a mile east of it N. 54° E.—For the next mile, to the next fault N. 59° E.—East of it for some distance N. 70° E.—After which, still going east, the strike of the crest gradually returns to N. 50° E.

If, with a radius of 6 miles, an arc of a circle 6 miles long, be struck from a center point on the hill top 2 miles north of the Spruce Creek tunnel, the arc will exactly describe the bulge (westward) in the range of the Bald Eagle mountain from Tyrone gap to Warrior run notch; the maximum of movement (westward) being $\frac{5}{8}$ mile, or 3300′; which is twice the amount of displacement at the *Vail station fault.* The rest of it is accounted for by whatever displacement exists at the Tyrone gap, and by the exactly measureable displacement at the next fault to the east now to be described.

The Bald Eagle Furnace fault cuts off the crest of the mountain, leaving a knob 1780′ A. T. the top of which is in a straight line 9800′ north-east of the knob left projecting in a similar manner by the *Vail Station fault.* The four highest points on the crest between the two faults are 1750′, 1740′, 1750′ and 1780′ A. T.

A brook (flowing north-west into Bald Eagle creek $\frac{1}{2}$ mile above the station) here cuts half through the mountain and so deeply that on the crest line water-level reads 1300′ A. T. On the east side of this half gap the crest is resumed and rises to 1700′ A. T. From summit to summit across the half gap is 4400′.

The terrace from the south-west runs as a separate ridge (cut off from the crest by a long ravine descending south-west and issuing at the Vail Station fault) for 3500′, and then continues as a broad terrace (1640′, 1620′, 1600′ A. T. at its brow) 4000′ further, where it ends in a spur of the crest (1600′ A. T.) at the ravine, and 1100′ behind its re-commencement (1610′ A. T.) towards the north-east. The recommencement of the crest north-east of the ravine, is exactly in line with the terrace spur; but the crest now runs on north-eastward N. 70° E. instead of N. 61° E.; or rather, instead of N. 52° E. the line of the brow of the terrace.

The throw of the fault at right angles to the strike is 1300′; and the slip along the fault is 1400′; the slight difference in this case being due to the direction of the fault, which is as near as possible *north and south* (as far as it can be determined by the topography) and therefore nearly at right angles (75°) to the direction of the Vail

Station fault; the two lines when projected eastward and southward meeting at a point 1000′ west of the *East Pennington ore-bank.* It is somewhat significant that the line of this fault when drawn north and south passes between two sink holes on the road in the valley 1000′ east of Alex. Ale's house; but, the value of this fact is partly neutralized by the occurrence of a sink hole on the same road at S. and S. Beck's, 1200′ further south-west. Nothing can be more uncertain than the precise line of a fault in cases like this where we have nothing to lay it down on the map by but the features of the surface. The approximate north and south course of this fault however is determined by the shape of the mountain.

But a difficult question remains to be asked and answered: Why does not the crest from the west run on N. 60° E. 1500′ further, until it is cut off by the fault? *i. e.*, why is it not projected beyond or behind the crest from the east, just as the terrace from the west is projected beyond and behind the terrace from the east, and to an equal distance? It looks as if there is another and diagonal fault, running from the fault in the ravine westward to Bald Eagle Furnace station. Some careful explorer may succeed in answering this question.

Whether there be other faults similar to those just described, breaking the Bald Eagle mountain further to the east; is not known, because our instrumental topographical surveys could not be continued further east without trenching on funds required for other parts of the State; but the mountain seems to become quite regular; and after entering Centre county the normal north-west dips of the great Nittany anticlinal become less and less steep; showing that the *maximum* thrust of the country north-westward, which produced the breaks already described, took place along the Little Juniata river. It is necessary now to show how this thrust has affected the limestone strata in the valley, and determined the range of the iron ore deposits which constitute its principal wealth.

18. *Franklin.*

This township has a length of 10½ miles along Tussey Mountain crest, 5½ miles along the Centre county line, and a breadth of 3¼ miles at the Little Juniata river.

Spruce creek enters it at Pennsylvania furnace, and flows past Graysville, Franklinsville, and Colerain forge, to the river, about a mile above the tunnel. The course of the creek has been described in preceding pages.

Tadpole ridge 200 to 300 feet high runs along on the north-west side of the creek, formed of sandy limestone strata, lifted to the surface along the axis of the Brush Valley anticlinal.

This ridge is broken through at Pennsylvania furnace by a branch of the creek called *Half Moon run*, furnishing a roadway for the railroad from Tyrone. The mouth of Half Moon run is at about 1000′ A. T., and the top of the ridge reads 1320′ A. T.

Two other breaks in the ridge occur in the distance of six miles. Then *Warrior's Mark creek* makes a deep gorge through it, exposing the opposite dips of the anticlinal, 33°, 22½°, and 33° S. E., and 10° and 30° N. W The gorge is very winding, between very steep walls, 300′ high, the top of the ridge (1260′ A. T.) being 500′ north-west of the crest of the arch (300′ above the stream) immediately in the center of the gorge, 960′, A. T., the stream descending from this point 1¼ miles (bee-line measure) to join *Spruce creek* (840′, A. T.) at *Colerain forge.*

The ridge can scarcely be traced the remaining 3½ miles to the river, because it spreads out as a plateau across the township, sending long finger ridges however down towards the gap, the ancient drainage into which is thus illustrated in a rather unusual manner. All this high land is included in the old *Huntingdon Furnace* property, situated behind the ridge, at its foot, and where a wide open vale descends to the Warrior's Mark run from the west. The ore banks are situated along the township line, two miles from the furnace, at the head of the vale, and will be described with the ore banks of Warrior's Mark township as Nos. 31, 32; ore bank No. 30 being on the main run, two miles north of the furnace. (See map.)

Cale hollow, a long straight valley lying back of Tadpole ridge, is crossed by Half Moon run at the county line, where the water is about 1100′ A. T. The first divide in the floor of the hollow is 1190′, the next divide 1180′, and then it descends slowly to Warrior's Mark run at the *grist-mill* ½ mile above the furnace. Here the run (1000′ A. T.) turns and flows in the hollow down to the furnace (980′ A. T.) where it enters the gorge through the ridge.

The synclinal shape of *Cale hollow* is well seen on Half Moon run; for, the rocks in the ridge dip *up* the run (N. W.) 43°, 40°, 50°; and then half a mile further, on the other slope of the hollow, they dip *down* the run (S. E.) 25°; and half a mile further only 2°. (See the map.)

The synclinal shape of *Cale hollow* is shown as plainly on Warrior's Mark run by a 12° (S. E.) dip. (See the map.) The iron ores of Cale hollow are therefore the same as those of Spruce creek. Huntingdon furnace opened banks for itself in the hollow more than half way towards Half Moon run. The Kerr & Bredin bank (No. 27) and the Hostler bank (No. 28) will be described in a subsequent chapter.

The Gatesburg ridge, broad and high (1340′ A. T.) at its north-eastern end, narrow, sharp and lower (1220′ A. T.) at its south-western end, runs back of Cale hollow, unbroken by a ravine of any kind the whole six miles, from Half Moon run (here in Centre county) to Warrior's Mark run. Its *anticlinal* structure is proved on H. M. run by the 21° and 2° (S. E.) dips already cited and by 2° and 10° (N. W.) dips half a mile higher up the run. Also by its having two crests nearly half a mile apart at the county line. But its long, steady and regular decline in heighth and width towards W. M. run shows that the arch is dying down; and the absorption of the ridge in the general plateau between the W. M. run and the Juniata, taken together with the entire absence of N. W. dips on the Juniata where it should cross that river, proves that this roll dies out entirely on the south side of the great Nittany Valley (or Birmingham) arch.

The limestones exposed along the Little Juniata river form a series more than 6000 feet thick, extending from the top of the *Trenton formation* downwards to the top of the *Potsdam sandstone proper*, if that designation be admissible in a region so completely and widely separated from every known outcrop of Potsdam age in northern and eastern New York, New Jersey and south-eastern Pennsylvania. There can be no mistake about the identity of the *Trenton formation*, because its fossil shells have been found at various points along the edge of the limestone area, and in great numbers in Nippenose valley.* But the great sandrock beds which outcrop along the Brush Valley and Nittany Valley anticlinals and form *the Barrens* are interstratified in the series of limestones (*Calciferous formation*) like the sandstone intervals in Missouri; and like the bed of rough sandstone, which makes *Grindstone hill* in the Cumberland valley, seven miles south of Chambersburg, and which has there been quarried for millstones.†

Along Tussey mountain in Franklin township and in Centre county, there is no difficulty in recognizing the Medina white crest, the Medina red interval, and the Oneida gray sandstone terrace, with its steep slope of Loraine and Utica shales, all dipping conformably about 30° south-eastward into the mountain; 31°, for example, is the dip of the *Oneida* in the deep ravine near the Centre county line, 1½ miles due south from the Pennsylvania Furnace ore bank. The Trenton limestone strata, underlying the slates with apparent conformity, crop out on the long gentle slope which leads down from the bottom of the (*Utica black*) slate to the bed of Spruce creek; on the western bank of which rises the bold *Tadpole ridge* which carries the Brush Valley anticlinal.

Spruce Creek at the county line and at Graysville P. O. is 1½ miles from the brow of the terrace and 2⅛ miles from the crest of Tussey mountain; while it is only ⅜ mile from the top of the anticlinal ridge. But as it flows west, deep-

*Trenton fossils are found in the same upper limestone beds at Chambersburg and elsewhere in Franklin and Cumberland counties.

†See Geol. of Penn., Vol. I, page 259.

ening its channel in the limestones as it goes, it gets nearer the terrace and further from the ridge (the terrace and the ridge running quite parallel to each other), so that at Franklinville (1 mile above the mouth of Warrior Mark run) it flows midway between them, *i. e.*, about ⅝ mile from each; and in the deep gorge-like valley which it has made approaching the river the terrace slopes up steeply from the creek for only half a mile.

The rocks in which the creek excavates its channel are therefore quite different at different distances along its course. At Graysville the strata dip 47°; and a mile north-east of Graysville, on the road up the mountain, they seem to dip 55°. Taking the breadth of outcrop at 5000′ and the average dip at 50°, the creek at Graysville must flow along the outcrop of limestone beds nearly 4000′ down the series beneath the slate, while more than 1000′ of still lower limestones appear between the creek and the top of ridge to the west of it.

At Colerain, below Franklinville, on the contrary, the dip is only 33°, and the creek flows almost along the contact of the slate and limestone. All the dips along Warrior's run, near Colerain, are gentle (for this country) viz: 33°, 22½°, 33°, S. E.; then, after passing the arch, 10° and 20°, N. W. So that only about 2500′ of limestone strata come to the surface.

19. *Warrior's Mark.*

This township occupies the other half of the valley, and holds a similar relation to Bald Eagle mountain, along the crest of which its north-west line extends 6½ miles, but not to the gap; the south-west line descending obliquely to the river ¾ mile above Birmingham bridge and station; then down along the river 2½ miles to Bridge No. 7.

The Bald Eagle mountain with its *terrace*, *ravines*, and *faults* have been described in a previous chapter.

Warrior's Mark village is near the center of the township, where the high road from Tyrone to Bellefonte crosses a run (1080′ A. T.) which descends from the gap leading over to Bald Eagle furnace. Warrior's Mark run heads in

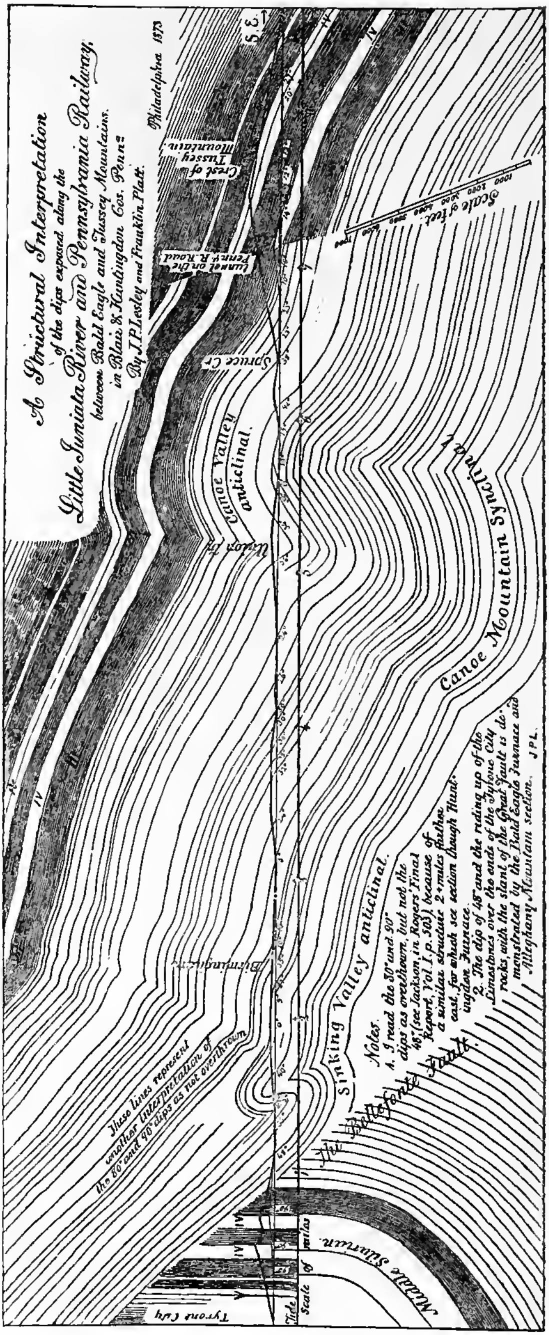

A Structural Interpretation
of the dips exposed along the
Little Juniata River and Pennsylvania Railway;
between Bald Eagle and Tussey Mountains.
in Blair & Huntingdon Cos. Penn.
By J. P. Lesley and Franklin Platt.
Philadelphia 1873
S.E.
Crest of Tussey Mountain.
Tunnel on the Penn. R. Road
Scale of feet.
Spruce Cr
Canoe Valley anticlinal.
Union Fy
Canoe Mountain Synclinal.
Birmingham
Sinking Valley anticlinal.
These lines represent another interpretation of the 80° and 90° dips as not overthrown
The Bellefonte Fault.
Notes.
1. I read the 80° and 90° dips as overthrown, but not the 48° (see Jackson, in Rogers' Final Report, Vol. I. p. 503), because of a similar structure 2+ miles further east, for which see section through Huntingdon Furnace.
2. The dip of 48° and the riding up of the limestones over the ends of the Tyrone City rocks with the slant of the great fault is demonstrated by the Bald Eagle Furnace and Allegheny Mountain section.
JPL.
Middle Silurian.
Tyrone City
Scale of miles
Tide
IV
III

Fig. 1.

Centre county, near the line, at 1200° to 1300′ A. T. where a high divide (1380° A. T.) separates its springs from those of Half Moon run; and this divide is in reality a spreading out southward of the slope of mountain. The map alone will suffice to explain the intricate and at first apparently irregular topography of this great valley here called Warrior's Mark valley.

But the main features are easily designated; a *Dry hollow*, broad and shallow on the high divide at the county line (1280′ A. T.) and descending three miles to W. M. run (1000′ A. T.) a mile above Huntingdon furnace, and there merging with the *Cale hollow*;—*Dry hollow ridge* northwest of Dry hollow, 1300′ A. T. at the county line, and 1260′ where it points out boldly upon W. M. run, and then resumes its course to the Juniata, with a summit of 1300′ A. T. a deep ravine, and then two summits of 1260′ A. T. overlooking the river, and here called *Chestnut ridge*, just east of Birmingham;—*Pennington ridge*, at Birmingham, as high as and scarcely separated from Chestnut ridge, but diverging 10° from it and running on, with four little summits (each 1280′ A. T.) to join the B. E. mountain north of W. M. village;—and then the deep vale of *Logan Springs run* between Pennington ridge and the mountain, heading up at *Spring Mount*, a village ¾ mile from W. M. village on the road to the mountain.

The railroad from Tyrone gap ascends Logan run; crosses Pennington ridge at 1200′ A. T. ⅝ m. south of W. M. village; descends to and crosses the little run ¼ m. below the village (at 1080′); ascends the W. M. run and crosses Dry Hollow ridge (1280′); descends into Dry hollow (1060′); ascends Dry hollow and crosses the divide (1270′) to descend to Half Moon run (at 1140′ A. T.) and so down the run to Pennsylvania furnace.

It is surprising to see such breadths of ridge and vale totally destitute of water. The drainage of the township is to a large extent carried on underground through innumerable tortuous and intersecting caverns, into which the rainfall creeps through the loose rock, or pours through funnel-shaped sink-holes, especially along certain strike lines

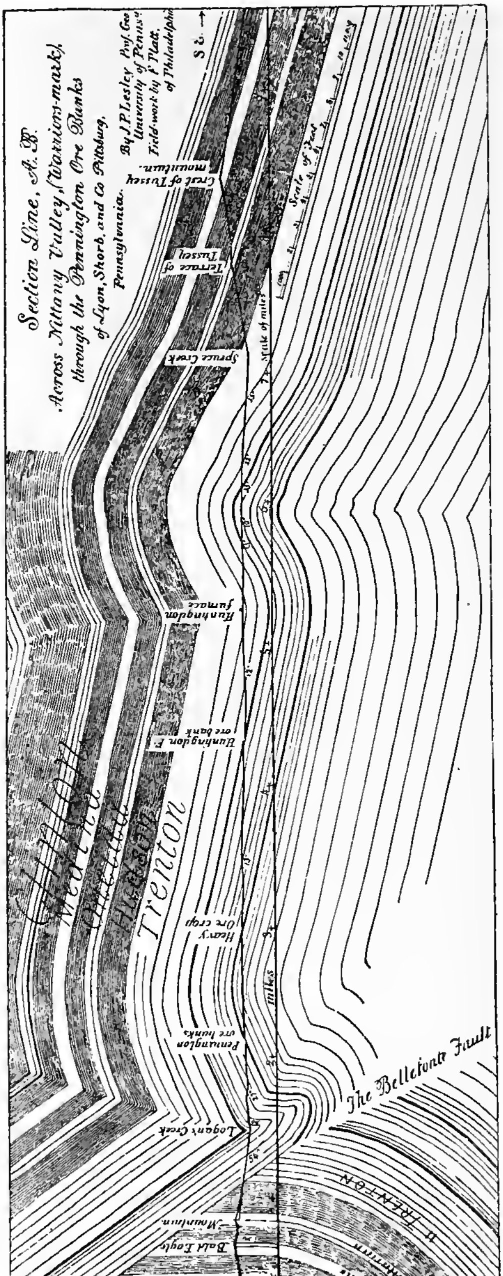

Section Line, A. B.
Across Nittany Valley, (Warriors-mark), through the Pennington Ore Banks of Lyon, Shorb, and Co Pittsburg, Pennsylvania.
Crest of Tussey mountain.
Terrace of Tussey
Spruce Creek
Huntingdon furnace
Huntingdon F. ore bank
Heavy Ore crop
Pennington ore banks
Logan's Creek
Bald Eagle Mountain
Bald Eagle Creek
Trenton
The Bellefonte Fault
TRENTON
Scale of miles
Scale of feet
Level of tide

Fig. 2.

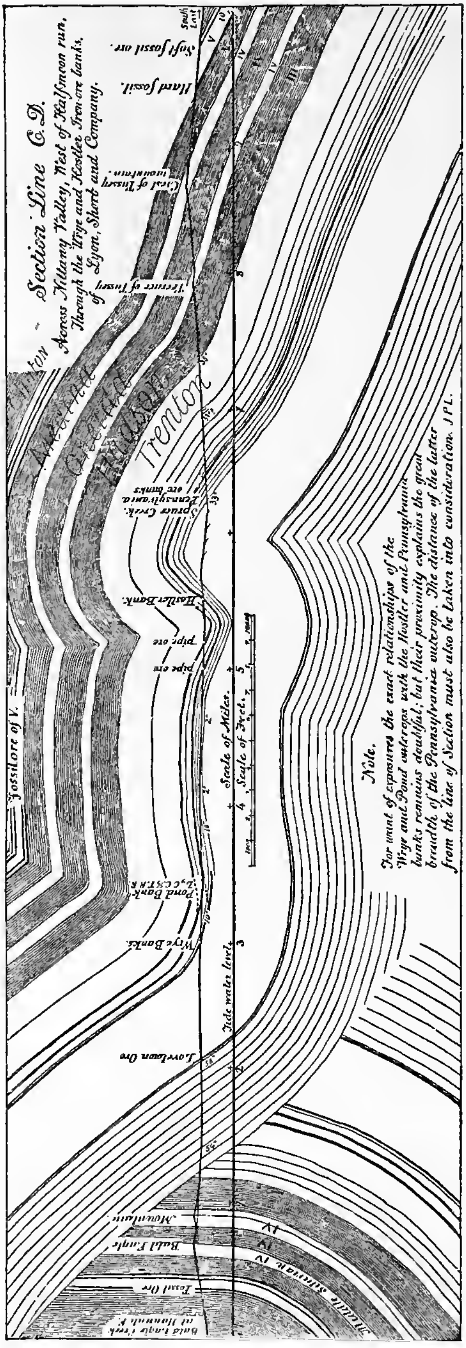
up and down the valley; issuing at a few copious springs, such as the *Six Springs* on the hillside north of Huntingdon furnace.

McCahan's run, half a mile above Birmingham, is another good example. It is only 2200′ long, from the spring which feeds it to its mouth at the river, and yet it is powerful enough to keep the grist mill going all the year round. The spring is in the floor of a ravine which is dry higher up. For miles along Pennington ridge back from the river no running water is seen upon the surface, the entire rainfall sinks, pursues underground channels, and issues at this spring. But halfway between the spring and the river a run of water descends from the ridge on the south, and where the two runs join, the surface is strewed with pieces of the curious *Oolitic limestone* which at this horizon in No. II has been found in various parts of the State.

Dry hollow is a synclinal basin of limestone (low in the series), as is shown to be the fact by the dips along Half Moon run in Centre county: 10° (N. W.) where the railroad bends to go down the run; 10° (S. E.) a mile higher up the run where it issues from its narrow gorge through Dry hollow ridge. The fact is also shown by a 24° (S. E.) dip on the railroad 2¾ miles further southwest, at the foot of the steep southeast slope of Dry hollow ridge; and again, by a 13° (S. E.) dip, 3½ miles further south-west, where W M. run issues from Dry hollow ridge.

But Dry hollow ridge is not an anticlinal. It has no N. W. dips on its north-western side anywhere; nor are there any steep S. E. dips which can be supposed to be *N. W. dips overturned* along its north-west flank. On Half Moon run the above-mentioned S. E. dip of 10° is re-inforced by a S. E. dip of 24° half a mile higher up the run, above the forks, and entirely through the ridge; so that it is monoclinal here. In like manner 34°, 22° and 20° (S. E.) are seen along the railroad, and 34° (S. E.) along the common road ½ and 1½ miles from W. M. village. On the Juniata we have seen *Chestnut ridge* monoclinal; and on the map will be noticed dips of 24° (S. E.) at the south-

Fig. 3.


Section Line C.D.
Across Nittany Valley, West of Halfmoon run,
Through the Wrye and Hostler Iron-ore banks,
of Lyon, Shorb and Company.
Soft fossil ore.
Hard fossil.
Crest of Tussey mountain.
Terrace of Tussey
Clinton
Medina
Oneida
Hudson
Trenton
Spruce Creek.
Pennsylvania ore banks
Hostler Bank.
pipe ore
pipe ore
Fossil ore of V.
Scale of Miles.
Scale of Feet.
Pond Bank.
Wrye Banks.
Tide water level.
Mountain.
Bald Eagle
Fossil Ore
Note.
For want of exposures the exact relationships of the Wrye and Pond outcrops with the Hostler and Pennsylvania banks remains doubtful; but their proximity explains the great breadth of the Pennsylvania outcrop. The distance of the latter from the line of Section must also be taken into consideration. JPL.

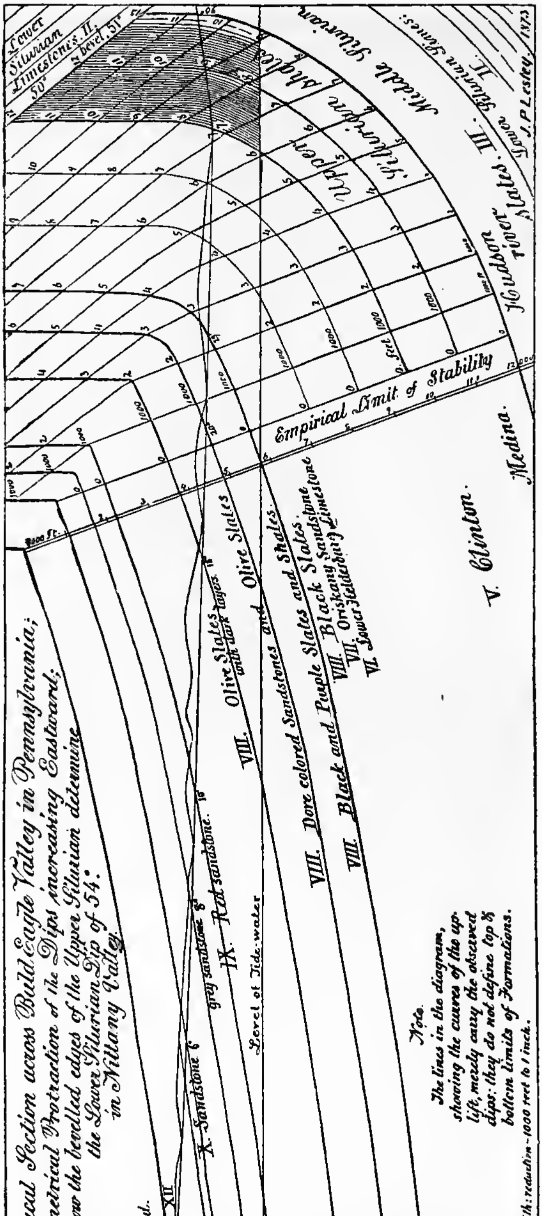
east side of the ridge, 16° (S. E.) in its middle, and 10°, 35° and 37° (S. E.) at its north-west side at Birmingham.

Nittany Valley anticlinal axis runs along northwest of Dry Hollow ridge and probably close to Warrior's Mark village. But its northwest dipping strata are so pressed over and folded under that N. W. dips can scarcely be found. The black slate along the foot of the mountain, opposite W. M. village, stands vertical for half a mile each side of Spring Mount; but the limestones in front of Spring Mount are *overturned* to 60° (S. E.); and up W. M. run-heads they are *overturned* to 45°, 50°, 68° (S. E.) In the other direction, south-west, there is an *overturned* dip of 54° (S. E.) 2½ miles from Spring Mount, at the foot of the mountain; and another of 54° (S. E.) 2½ miles further, and within a mile of the Juniata. But in front of these are *normal* 80°, 60°, and 40° (N. W.) dips along Logan's run, at the foot of the mountain; and *two* ESPECIALLY *valuable* (N.W.) dips of 23° and 27° at the quarry, where the railroad leaves the head of Logan's run, *plainly proving* that *Pennington's ridge actually holds the axis of the great anticlinal*, and also that the course of the axis from Birmingham is slantingly towards the mountain. A dip of 75° (N.W.) ⅝ mile from W. M. village toward the mountain completes the chain of evidence that the line of the arch runs nearly through W. M. village; and, therefore, that *a vast fault must swallow up all the subdivisions of No. II, except the Trenton limestone.*

Some idea of the structure of the valley can be obtained by inspecting a map published with this report, plotted from Mr. Franklin Platt's field-notes during my private survey of the Lyon, Shorb & Co.'s ore lands in 1872.

Mr. Platt's map was drawn in 20′ contour lines, the elevations taken by aneroid barometer, from Mr. Leuffer's railroad line as a base. One line of aneroid observations was carried to the top of Tussey from Pennsylvania furnace; the rest of the mountain being drawn in by rough trigonometrical observations from the Spruce Creek road. The gaps in its terrace are all properly placed, and their characteristic features are given; but slight variations in

Fig. 4.


A geological Section across Bald Eagle Valley in Pennsylvania;
with a Geometrical Protraction of the Dips increasing Eastward;
showing how the bevelled edges of the Upper Silurian determine
the Lower Silurian Dip of 54°
in Nittany Valley.
Allegheny Mountain.
Lowest Coal Bed.
XII
Red Shale. XI
X. Sandstone
grey Sandstone
IX. Red sandstone.
Level of Tide-water
Catskill.
Catskill.
VIII. Olive Slates with dark layers
VIII. Olive Slates
VIII. Dove colored Sandstones and Shales.
VIII. Black and Purple Slates and Shales.
VIII. Black Sandstone
VII. Oriskany Sandstone
VI. Lower Helderberg Limestone
Chemung.
Portage.
Genesee.
Hamilton.
V. Clinton.
Medina.
Empirical Limit of Stability
Upper Silurian
Middle Silurian
Hudson river Slates. III.
Lower Silurian Limestones. II.
Angles
Note.
The lines in the diagram, showing the curves of the up-lift, merely carry the observed dips; they do not define top & bottom limits of Formations.
Scale before Photo-lith: reduction—1000 feet to 1 inch.
J. P. Lesley. 1873

the almost dead-level crest of the mountain could only be indicated. The survey of the Spruce Creek valley was made rapidly and only for the purpose of assigning a proper value to its topographical features, a new township survey by a corps of odometer surveyors being the basis. Here a considerable adjustment had to be made, which renders this part of the map of no authority, as against any geodetic survey; and the whole interval between the mouth of Warrior's run and the river is untrustworthy.

Three sets of aneroid levels were carried from the railroad to the crest of Bald Eagle, and two of them entirely across to the Bald Eagle creek. But the survey along the mountain was not locally complete and accurate enough to allow the topography to suggest any plausible explanation of the geographical structure, except in the most general way.

Ten years afterward, I seized a favorable opportunity, during the progress of the State survey, to obtain the desired representation of the excessively disturbed triangular area between Birmingham and Warrior's Mark.

Messrs. E. B. and O. B. Harden's map is contoured for 20′ elevations above tide, and plotted on a scale of 1600′ : 1″. It shows few dips; but expresses the relief of the surface so well that the exact course of the axis of Pennington ridge can be followed to the west side of Warrior Mark village. The remarkable faults across the mountain have already been described. The Pennington ore banks are included in this area.

The cross sections Figs. 1, 2, 3, here inserted, were made in 1872 after very careful study of the ground; and their essential characteristics still stand good; some of the details require modification; but how the corrections are to be made, does not yet appear.

Fig. 1 I reproduce with some hesitation because it does not represent the usual construction of the river section above Birmingham; does not locate the great axis at Birmingham, or in Pennington ridge, but at the very foot of the mountain, and in the shape of a fault. But in constructing this section I used all the dips which I took along the river at that time; and it certainly seems to state the facts as they exhibit themselves. Other geologists have made different sections; but none of them can be considered demonstrations, so difficult are the exposures to read.

Fig. 2 presents my interpretation of the structure in 1872, along a line (A B) through the Pennington ore banks. In this section, also, I treated the (54°) S. E. dips at the foot of the mountain as *normal* and *not overturned*.

Fig. 3 carries this interpretation as far east as the line C D, which cuts the county line.

Fig. 4. This diagram section is constructed from the dips of the Upper Silurian, Devonian and Coal Measure rocks, observed on a survey of the road from Bald Eagle Furnace up Emig's run and Laurel Creek to the crest of the Allegheny Mountain. The measurement of the curves of the different layers of this upturned mass, taken at every thousand feet, as shown in the diagram, result in giving a slope of 50° to 54° to the bassett edges of the broken mass. It is evident that the upslide of the other section of the broken mass has conformed to this slope, and that the uniform dip of 54° ± observable for miles along the south-east foot of Bald Eagle Mountain (as represented in Juniata Section, and Sections AB and CD) is perfectly explained by the diagram.

It proves that the original fault was in a vertical plane, and not on a slant.

It proves that the lower Silurian Limestone mass has ridden upon this slope to a considerable height, probably several miles, in the air above the present surface.

It illustrates the great erosion of the country, amounting to *thousands of cubic miles* of earth crust, including the coal measures (which are preserved on Broad Top, 20 miles to the southeast,) and gives us the source of the Cretaceous and Tertiary deposits of New Jersey and Delaware.

It accounts for the general S. E. dip across the whole valley, in Tussey mountain, and as far as Huntingdon.

It assures us that the brown hematite ore beds of the district belong to rocks of different ages and are arranged in parallel belts.

It confirms the opinion that the quantity of ore in these


A Study, in 20 foot contour lines, of the Structure and Erosion of a part of the Lower Silurian Iron-ore Region north-east of the Little Juniata River; in Huntingdon and Centre Cos. Pennsylvania.
To illustrate a Report on the Mines of Lyon, Shorb, and Co. of Pittsburg; by J. P. Lesley, Prof. Geol. Univ.y Penn.a
Field-work by Franklin Platt, of Philadelphia.
Tyrone
Scale
Key List of the Iron Ore Mines on this Map.
1. West Pennington.
2. East Pennington.
3. nameless.
4. Beck's.
5. Town.
6. Rumbarger's.
7. Hannah Furnace.
8. Waite's.
9. Braunsteller's.
10. Love-town.
11. Lytle's
12. Mc.Kinney's
13. Hannah F.: No. 2
14. Bull's.
15. Pond. No. 1.
16. Red.
17. California.
18. Reider's.
19. Whorell's.
20. Pond. No. 2.
21. Wrye's.
22. Dixon's.
23. Little Dry Hollow.
24. Dry Hollow.
25. Benn's.
26. Bressler's.
27. Kerr & Breden's.
28. Hostler's.
29. Pennsylvania.
30. Old Seat of H. Fur:
31. Huntingdon Furn:
30. Dorsey Ore Banks
Skeleton Map, giving the names of the principal ridges, valleys and streams of the Ore Region.
Tyrone City
Bald Eagle Mountain.
Pennington Ridge.
Huntingdon Furnace
Spruce Creek.
Terrace of L. Middle Silurian.
Crest of Tussey Mountain
Canoe Valley
Little Juniata R.

belts must bear some relation and be in some proportion to the breadth of the outcrop of the ore-bearing limestones, lengthwise of the valley ; and therefore, that any estimate of quantity of ore we may make by examining diggings, must fall short of the actual amount of ore in the valley.

The *original source* of the brown hematite iron ores of our Lower Silurian limestone valleys has been speculatively sought for without sufficient investigation in the field. Most persons have looked upon them as accidental and local inwashes from unknown sites. Dr. R. M. S. Jackson, an assistant on the geological survey of Pennsylvania in 1838 or 1839 obtained the data necessary for concluding that they were deposits of iron hydrated peroxide set free from limestone rocks during their gradual erosion and dissolution.

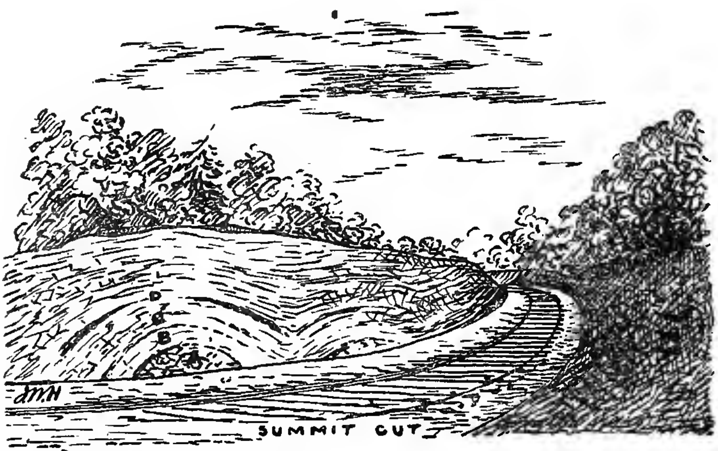
The rocks of the Lower Silurian age were originally sea-muds, composed of rounded grains of dolomite (derived from previously existing Laurentian land,) cemented together with a paste of carbonate of lime. Some of the beds consisted also of rounded grains of quartz. Some of the layers were nearly pure carbonate of lime. All contained a larger or smaller percentage of iron, lead, zinc, and other metals, precipitated either chemically, or by the agency of organic beings, from the solutions of their carbonates, chlorides, &c., in the river and sea-waters.

Buried subsequently beneath at least 16,000 feet of later deposits ending with the coal measures, and remaining wet, their temperature gradually rose to about 400° F. and then slowly fell in proportion to the rate of removal of the overlying formations, through Mesozoic and Tertiary ages ; the process still going on.

Dr. Genth's discovery of the amorphous or gelatinous condition of a part of their silica is thus explainable. Varied reactions must have ensued. The carbonates of lime and magnesia combined as dolomites, which in part crystallized in rhombohedral crystals, the hollow casts of which may be seen in outcrop specimens. Shells of silica, deposited (without crystallizing) around these rhombs, are noticeable. The iron became peroxydized as *fibrous* hematite, and the silica can be obtained by dilute nitric acid also *in the same fibrous form.* All these facts suggest that the *first* formation of the iron ore took place while the rocks were still at a great depth, wet and soft and warm.

But at the end of the coal era the United States rose from the waves and have never been covered by the ocean since that time. The edges of the Bellefonte Fault stood as a mountain range as high as the Alps.

Fig. 5.



Erosion commenced and has continued to the present day, and still goes on. The continent has been gradually worn down to the present surface. Mountains once 30,000 or 40,000 feet are now but 2,000 or 3,000 above sea level.

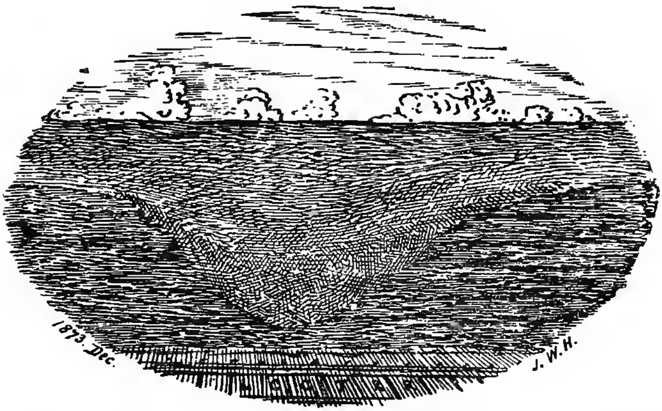
And this slow erosion gives us the *second* part of our explanation of the brown hematite iron ores. It explains the innumerable caverns and sink holes and dry hollows of this Nittany and other limestone valleys. It leads us to expect to find traces of such caverns and widened fissures and sink holes of the last preceding age, filled up with a wash of clay, sand, and iron ore from outcrops lately existing not far above the outcrops which run along the present surface.

Of the different theories in vogue among our iron men each theory has its basis of truth.

Those who contend that the brown hematites lie in pockets are correct; but they must confine the assertion to that part of the ore which now occupies former caverns and fissures and sink-holes.

Those who contend that the brown hematites are surface washes caught by the accidental variations of the earth's surface, are correct; but they must limit the application of

FIG. 6.



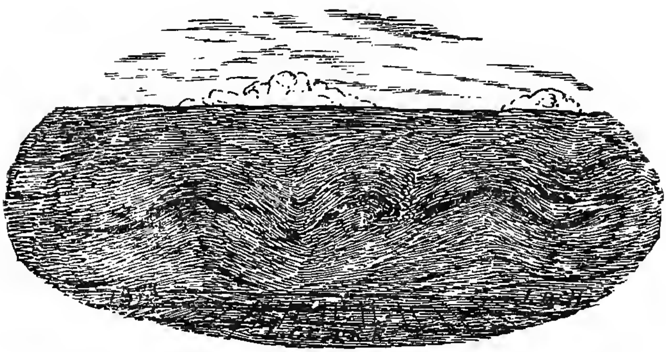
Summit Cut, in siena-colored Wash-Ore, exhibiting erosion (?) & débris of pulverized Calcif: S.S.

their theory to banks which show rolled gravel and rolled ore, and a confused and mingled mass of ore and sand and clay.

But, there are interstratified beds of brown hematite, still in their original places, although not in their original condition, dipping between undissolved limestone and sandstone rocks to undetermined depths, and ranging lengthwise of the district. And this is why the principal ore banks are ranged along geographical lines or belts.

Supposing the cross section along Warrior's Mark run given in Fig. 3 to be correct, it represents *four* ore-horizons, coming to the surface one after the other, their outcrops forming belts along the valley, and their depths beneath the *Slate formation No. III* being about as follows:

Fig. 7.



Summit Cut in Washore with Ore-streaks One foot thick.

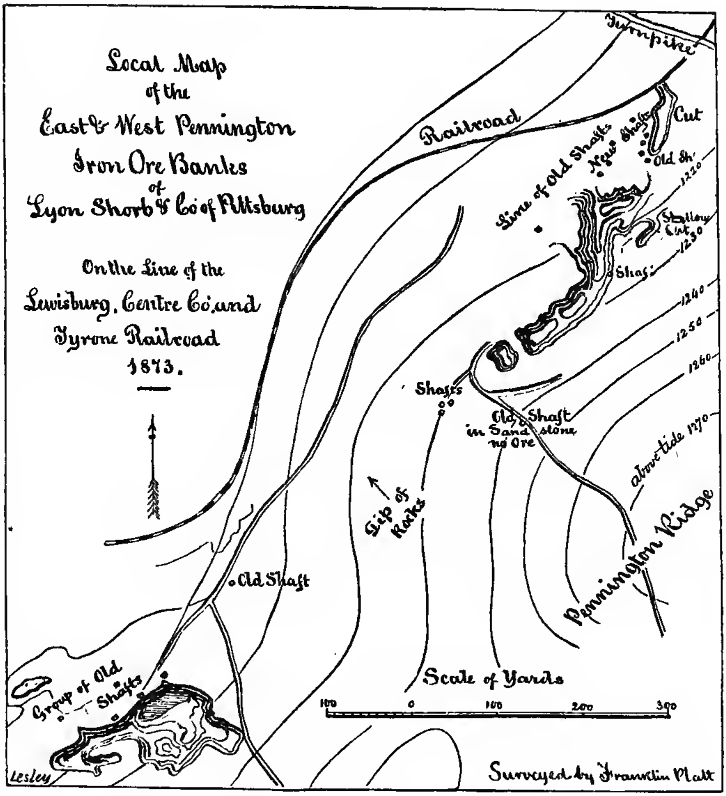
	Feet.
Trenton limestone, &c., 2500′.	
Pennsylvania furance and Cale Hollow ore banks, ...	2500
Interval of limestone, 700′.	
Huntingdon furnace ore banks, ...	3200
Interval of limestone, 550′.	
Pipe-ore range near toll-gate, ...	3750
Interval of limestone, 1500 .	
Pennington, Town, Lovetown banks, ...	5250

The whole subject has seen so amply treated by Mr. d'Invilliers in the Centre county report (T^4) that I will here only give descriptions of the ore banks in Huntingdon county; beginning with the *Pennington ore range,* marked on the map Nos. 1, 2, 3, 4, 5, 6, 7, 8, and 9; and afterwards those of Dry Hollow, Cale Hollow and Huntingdon furnace.

Pennington ore range.

ThePennington ore rocks descend into and beneath Logan's Creek valley, at first slowly, then steeply, at last vertically, and before reaching the surface again on the other side of the little synclinal, are cut off by the great fault, and are sent down by it to a depth of many thousand feet beneath Bald Eagle mountain. On section line C D, Fig. 3, no such structure appears; consequently the little Logan's creek synclinal does not range away north-eastward along the foot, but cuts across more northward into the flank of

Fig. 8.

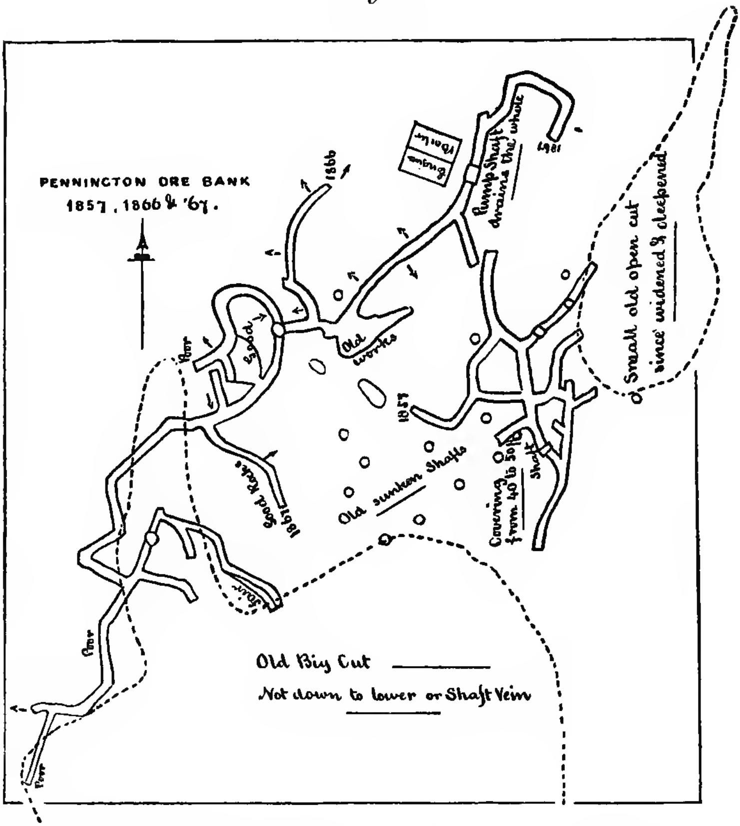


Bald Eagle mountain. As for the Pennington ridge anticlinal, it loses itself in the hill north of Warrior Mark village, and in the great fault further on. Obscure dips of 75° to 80° (N. W.)* are seen in calc. sandstone at 500 yards north-west of the village, and 80° (N. W.) in blue limestone, at 450 yards further up Warrior run; but the universal slant in the country, from here onwards, is south-east; all the outcrops beyond or north-eastward of Warrior Mark village belong to the *south-east* side of Pennington ridge, as will be abundantly evident to any one traveling along the road from Warrior's Mark to Lovetown.

*The cross cleavage of the rocks near the fault makes the direction and strength of these dips doubtful. They look like 30° to 60° (S. E.)

The Pennington ore range is therefore a short one, whereas the next ore range to the south of it runs continuously through Warrior's Mark village and Lovetown for ten miles within the limits of our map. It consists of a line of outcrops commencing about two miles from the Juniata river, and extending two miles to the railroad, a mile west of

Fig. 9.



Warrior's Mark village. The north-west face of Pennington ridge is covered with wash-ore to a variable depth, below which lie sheets, belts, and masses of rock ore, between ribs of still undissolved siliceous limerock. The more argillaceous lime beds have left intercalated sheets of white clay.

No. 1. The Old or East Pennington bank supplied Bald

Eagle furnace with stock for many years. The ore was hauled about four miles over the mountain. It was chiefly got from the large open-cut shown in Local Map, Fig. 8; but also from underground gangways following the ore down the dip (N. W.) beneath a clay covering; and from shafts sunk on that side, tunnels or rooms being driven from the bottoms of the shafts irregularly in every direction at the caprice of uneducated miners, who groped always in the dark, without correct geological ideas to guide them, following what they imagined to be the thickest beds and belts of the best ore, and leaving all the rest to stand and be covered up again by the annual tumbling in of their shallow works. Most of these miners were Irish laborers paid by the ton. Water invariably stopped them, and limited the range of workings to a comparatively narrow belt down hill. The great deposits of ore unquestionably lying to the deep (N. W.) are unexplored. Neither maps nor notes of the old works exist.

Fig. 9 is a reduced copy of maps made by Mr. H. V. Böcking, mining manager of the company, to show the position of shafts and direction of tunnels executed under his direction, in a more systematic way.

At the east end of the Old Bank, Mr. Böcking did much sinking on lower ground. One old shaft which had been abandoned at the depth of 30 feet on account of water, he sunk 30 feet deeper to the sandstone floor of the ore, which drained the mine. A cross cut from this shaft 75 feet long struck the ore descending (N. W.) but where it was nearly level. Galleries were then driven and much ore won in an irregular way. But the heavy spring rains of 1857 filled the works to the top of the shaft. At this time the large deposit at McAtear's (West Pennington) Bank was discovered. In 1865 a new shaft was sunk, in a dry season, a little north of the cave-in works, reaching the bottom of the ore at 45 feet. The shaft was 60 feet deep, and a steam-pump kept it dry by two or three hours' work per day. A good vein of ore had been abandoned (on account of water) in a smaller open cut, near the last-mentioned shaft, with only 3 or 4 feet of dirt covering to the ore.

That the rich deposits of ore in the old open cut pass down north-westward, in irregular but continuous floors and layers between the clays, was proven by gallieries driven by Mr. Böcking west from the pump-shaft, see Fig. 9. He describes these galleries as driven in wavy ore, meeting several good bodies of ore. No pillar mining was done, as the sinkings were merely tentative.

In all this no account is made of anything but the better streaks of hard lump or rock ore, which alone a small charcoal furnace is willing to smelt. Great quantities of salable ore and wash-ore are ignored.

My assistant, Mr. Franklin Platt, obtained the following information on the ground while making his map:

Beginning at the railroad, the first and smaller pit (now filled with water) 70 yards long, by 15 wide and 5 deep, yielded about 5000 cubic yards of wash-ore, without any solid lump ore. Shaft No. 1, sunk near it, (N. W.) is said to have passed through

1. Top wash-ore,	15 feet.
2. Rich lump-ore,	5 "
3. Clay with little or no ore,	25 "
4. Good lump-ore,	15 "

The bottom not reported. Shaft No. 2, (W.) had lean wash-ore on top; clay to 40 feet; good lump-ore thence to bottom at 50 feet.

The main open cut is 230 yards long, with an average width of 35 yards, as shown in Fig. 8; depth from 5 to 8 yards. Wash-ore, sometimes lean, forms the wall of the pit, from the surface to an apparent depth of 15 feet. A shaft midway of the eastern edge, "struck a layer of ferro-manganese ore, 5 feet thick, at a depth of 15 feet."

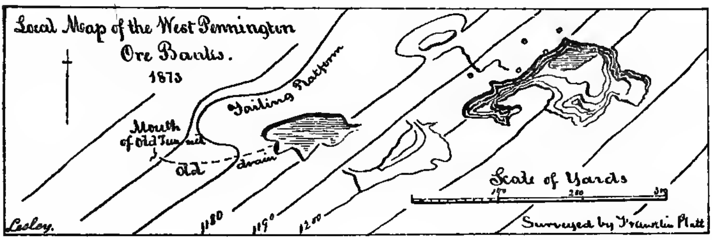
Two thirds of the distance from the southern to the northern end of the pit, a massive crop of half-decomposed calciferous sandrock charged with more or less of ore, juts from the wall, dipping gently north-west.

Some of this rock is genuine iron ore; the rest ferriferous or merely ferruginous sandrock. The excavated ore lay over, under and around this rock, having been freed from other similarly dipping, but more ferriferous and more dissoluble strata.* It is a place where the genesis of our brown hematites may be studied to advantage.

Ore was found in some of the shafts to the south-west of the main open cut.

The whole N. E. and S. W. extent of this uninterrupted expanse of wash ore, from the railway track to the shafts last mentioned, is about 500 yards, and its width, say, 100 yards. A considerable percentage may be too lean to wash.† Estimating the depth of soft and hard ore at 10 yards, we have 500,000 cubic yards. Rejecting one half for leanness, we are safe in supposing 250,000 cubic yards of ore in sight.

Fig. 10.



No. 2. The West Pennington Banks. An interval of half a mile separates this open cut from the East Pennington banks last described.‡ The railroad, curving across a

*The strike of this rock is *across* the open cut, here very narrow. The ore of the northern end of the cut is therefore above these rocks, and that of the southern portion of the cut belongs below these rocks.

†The "black ore," which is very rich, is in some places abundant; in other places it becomes very thin.

‡Mr. Böcking, speaking of this interval, says that after passing a low place at McAtear's, the main body of good ore was discovered in 1857, at the surface, on the ground into which old pits had been sunk, the miners having previously condemned the whole locality. The very rich deposit then discovered lay higher up the slope of the ridge, and had thus been entirely missed.

Mr. Platt remarks: "What the oreginal shape of the ore on the face of this ridge was, it is now hard to say; but the two Pennington ore deposits are at present separate and distinct, not necessarily connected in any way. I presume that the original limits embraced them both, and much of the ore lying between them which is now gone."

This agrees with what is seen at tho Pennsylvania ore banks, to be described hereafter, and it is a strong argument in favor of the wholly outcrop slight hollow in the side of the ridge, see Local Map, Fig. 3, approaches within two hundred yards of the north wall of the excavation, see Fig. 11, which is 180 yards long, by 40 wide on an average, and shows nothing but wash ore on its banks. Its very irregular depth may be called 10 yards; water standing on the floor.

This cut was worked to a depth of 40 feet during seven years, and yielded richly. The first maps are lost. Mr. Böcking's underground works on the north wall, commenced in 1865, are represented by his Local Map, Fig. 12, and thus described by him:

An old whim shaft was pumped out, and pillars robbed. The galleries then caved in, and the work stopped. Ore can still be reached from other shafts, two of which are timbered. One body of ore lies between the old cut and the underground works. It is not very rich, but is "good natured," and mixes well with more refractory ores. Another body of good rich ore remains standing to the deep of the works, and has a heavy covering. Another body of very good ore, fifteen feet thick, occupies a trough below the level of the pump-shaft, estimated at say 500 tons. Shaft 5 has ore around it. Shaft 4 is in a fair vein of rock ore. The deposit at shaft 3 is variable, and part of it stands. Old cuts and pits show that the deposit runs on south-westward.

That the ore extends northwards is shown by the railway cutting 200 yards north of the open cut (see Fig. 10), where ten feet of wash ore is seen overlying white and red clays.

Seventy yards south-west of the main open cut is another, 110 yards long, 15 wide, and 8 deep (13,200 cubic yards), nothing now showing but wash-ore in the side walls. It was originally much deeper, slides having partially filled it.

Three hundred yards west of the main open cut is the Old Philips bank, 100 × 30 × 6 yards (18,000 cubic yards), full of water. It was once deep, and drained by a tunnel,

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character of the brown hematite deposits. On the other hand, the ore has never been properly followed to the deep, and the distance in that direction to which the dissolution of the ferriferous limestone and the precipitation of peroxide of iron has extended is unknown.

the mouth of which is shown on the map (Fig. 10), 140 yards from its west end.

Calling the length of ground occupied by these three open cuts, with their imperfect underground workings, 400 yards, and its breadth 100 yards, and assigning an average depth of ten yards for wash and lump ore, we get an original mass of 400,000 cubic yards, one half of which may be considered rich and accessible enough to work to advantage.

But it must be considered that this Pennington range of deposits shows a much stronger tendency to develop lean layers and sandy masses than the Dry Hollow, Red, or Gatesburg ranges, hereafter to be described. Estimates of the workable quantities are, therefore, hazardous. We are here geologically at the bottom of the limestones, and close on top of the "calciferous sand-rock" formation, which accounts for the tendency to sand-rock and sandy ore exhibits in these banks.

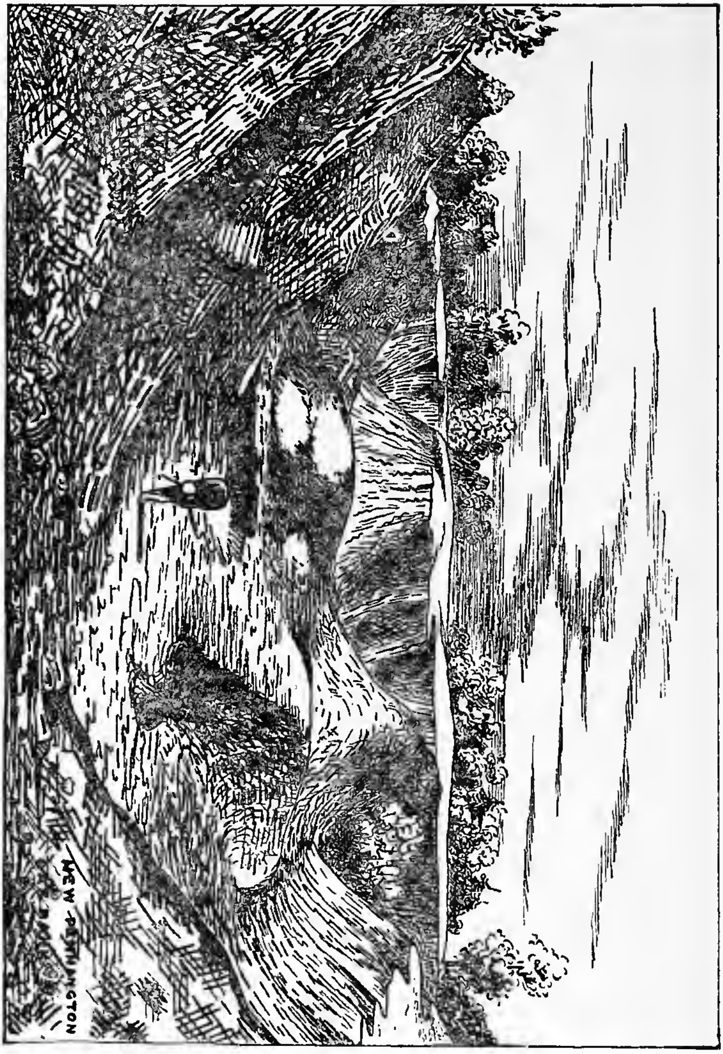
Of the old Phillips bank Mr. Böcking says that it holds purplish easy smelting ore, mixed with clay, and without discernible regular veins. Quantities of wash-ore can be got here; but *dry* screening is impracticable.

This gives the key to the problem of the future. The near presence of the railway makes systematic mining along this range a very different affair from the "ground hogging" of the surface hitherto pursued, unsystematic, wasteful and costly as it of course was. A regular stoping of the deposit on a large scale and the washing of all the ore ground must yield a profitable revenue.

Mr. John W. Harden, an experienced superintendent of mines, considers the extensive dry tailings, which cover the slope to the north of the cuts, capable of being profitably washed, while being got out of the way of future open cuts.

Traditional accounts of such old ore mines as these are to be credited with due caution and large allowances. But they have their value. It is of great importance, then, that shafts of over a hundred feet have been repeatedly sunk along this range, for they are proofs that experience

Fig. 11.



has justified them — proofs that bodies of ore have been found lying very deep beneath the surface. The open cuts exhibited by the maps (Figs. 8 and 10) were once very deep and were stopped by water, *as has been the case with all the ore banks of these valleys.* The miners were always driven from fine beds of rich rock-ore by the influx of water, which they had no adequate machinery to keep under. We can easily believe it, therefore, when we are told that in the Old Pennington bank a floor of masssive rock-ore, from 8 to 16 feet deep, underlies 50 feet of a covering, consisting of wash ore and scattered lump ore, intercalated between white variegated sandy clays, and that in the West or New Pennington banks the deposit consists of a surface soil, with a little ore 5 to 10 feet thick; then wash ore interstratified with layers and masses of white, brown, and red tight clays and loose sands from 50 to 80 feet, and a floor of red rock ore underlying all.

My own belief is that when pumping machinery of adequate power comes to be applied to these deposits, and an approved system of mining adopted, many hundred thousand tons of ore will be raised and sent to the eastern furnaces at a living profit.

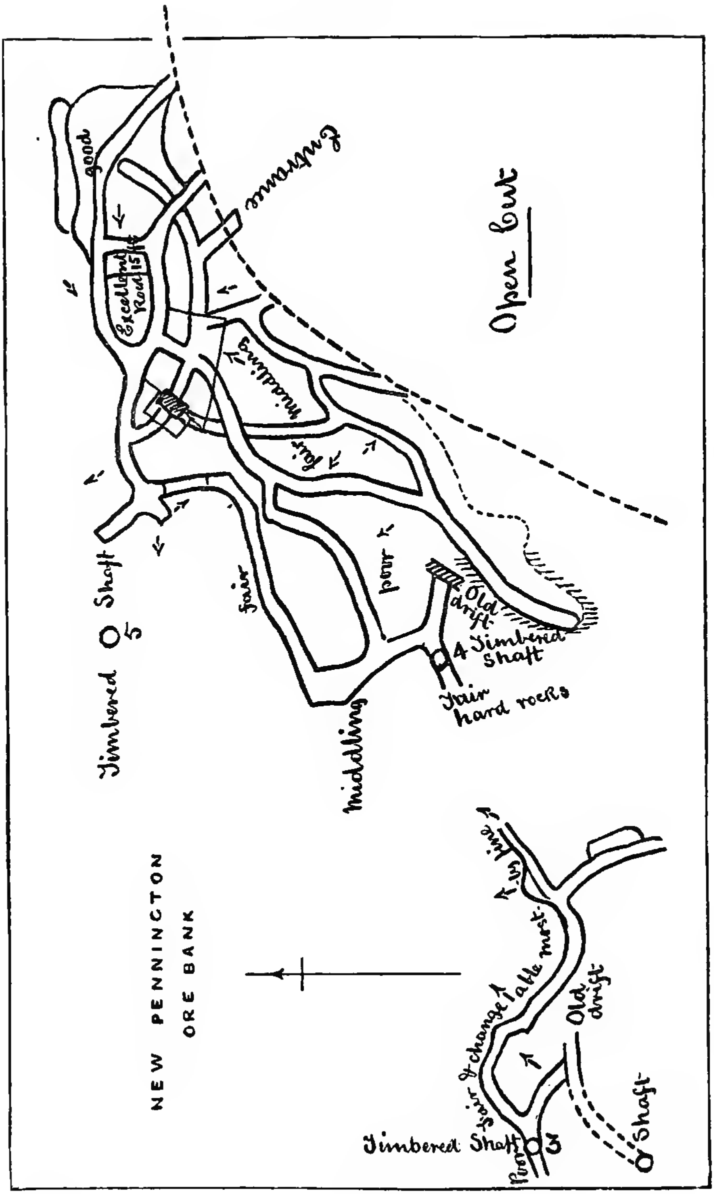
The southwestward extent of the deposits is unknown. But on the south-west of the ravine and hill spur beyond it, a pipe-ore and a good deal of "barren ore" mark the continuation of the *Pennington outcrop* through D. Branstetter's fields, and then across Guyer's farm. It is cut by a gap, and then is again visible crossing Waite's farm, and (on the west land line) reaching to the hill-top. Hence to the Juniata it is hard to trace, but becomes visible again west of the river in Sinking valley.

No. 3. Beck bank (marked "nameless" by mistake in the Key list on the large map).

The eastward extent of the Pennington deposit has not been carefully explored; but at the entrance of a R. R. cut, half a mile east of the Old Pennington bank, Huntingdon furnace mined ore 10 years ago. This bank shows 40×20×5=4000 cubic yards of excavation, with water in the floor, and wash ore walls, rather lean in quality and quantity, as now visible.

No. 4. New Town bank, also called Beck's (and so designated on the large map,) lies 1⅝ miles east of Old Pennington bank, and was worked for Bald Eagle furnace, and abandoned for want of pumps to keep down water, "good

Fig. 12.


NEW PENNINGTON
ORE BANK
Entrance
Open Cut
good
Excellent Rock 15 ft
middling
fair
poor
fair
middling
Timbered Shaft
5
Old drift
4 Timbered Shaft
fair hard rocks
Timbered Shaft
3
Old drift
Shaft
fair & change
table most
T. in line

ore being left standing in the floor." In the woods behind Beck's and Ale's fields, north of it, small shafts were once sunk on fine-sized ore. In Beck's bank wash ore is seen in the walls, showing rather lean. At present, there is not much evidence of the presence of a considerable deposit, and no encouragement is felt for looking for it.

The road to Warrior's Mark village descends to Warrior's run, past Newtown bank, which seems to be the remains of a surface deposit once covering the flat top of the Pennington Ridge anticlinal. It is the only mine on this south-east dipping outcrop that has ever been opened west of Warrior's run. But that the ore belt extends in that direction, towards the Juniata, is proven by the heavy outcrop of ore ground shown on the large map and on Cross-section A B, Fig. 2, 1¼ miles due south of the Old (east) Pennington bank.

The vein of ore pursued by those who worked the New Town bank is described as small and irregular in thickness, and not traced successfully downhill and westward; but much coarse ore covers the ground in Jer. Berk's fields, on which the furnace had no right to enter. Slight shaftings showed small veins of ore. Further west also, in Adelberger's fields, some ore was raised; and outcroppings occur on P. Cooken's farm.

Warrior's Mark and Lovetown Range.

From Warrior's run, north-eastward, we have almost a continuous series of shafts and open cuts for a good many miles, viz:

Old Town bank, (V), is ½ mile east of Warrior run; Romberger's bank, (VI), 1½ miles; Hannah bank, (VII), 1¾ miles; Waite's bank, 2¼ miles; Lloyd Braunstetter's bank, (IX), 2⅝ miles (with pipe ore outcrops to the south of it); Disputed bank, (X), 4¾ miles; Hannah Furnace bank, 5 miles; Hannah Furnace and Beck banks, half a mile north of the last two, and less than a mile west of Lovetown; the pipe ore outcrops, half a mile south of Lovetown; croppings near the saw-mill, 2 miles east of Lovetown; Hannah Furnace bank and Bryan bank, 2⅝ miles east of Lovetown; and the

Curtin bank, 5 miles east of Lovetown and 11 miles from Warrior's run.

The ores of these banks, when rich, are black or dark-colored, much of it of a pitch-like luster, and often inclining to cold-short in quality. Dr. Genth's analyses in my appendix will give their chemical constitution. When lean, they are of a lighter color, brown, or liver-colored, clay predominating over sand in the deposit, as compared with the Pennington ores proper. Some of them may occupy a slightly higher geological position, being still further removed from the upper layers of calciferous sand rock, and lying, therefore, still more in the body of the Trenton group* of limestones.

No. 5. Old Town Banks,† are shown on Local Map, (Fig. 13,); two old open cuts, one on each side of the main road, and groups of shafts, principally north of the road. There is a decided ore-show on the surface for 470 yards. Opposite the new church, an old shaft reached a maximum depth of 110 feet, touching "a vein of ore." (Böcking.) Contradictory accounts are now given of this work. Some say that the quantity of ore was enormous, timbers 30 feet‡ long being used to support the chambers, the ore dipping steeply N. W.; and that massive ore stands in the sides and at the bottom of the deserted mine. Others say that the ore mass, 25 feet thick, descended vertically with undiminished size when the shaft was abandoned. It is may be a deposit in one of the ancient caverns or cross fissures of the limestone formation.

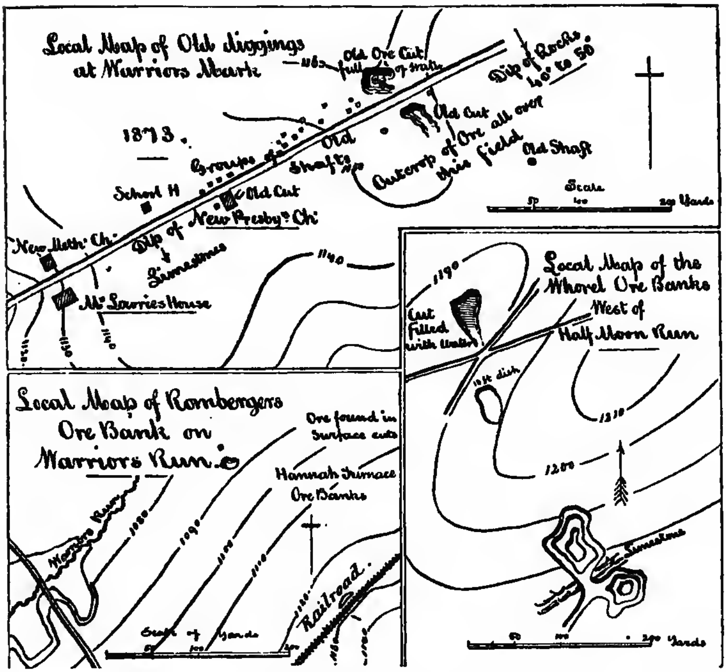
Shafts sunk to depths of 30 and 50 feet sometimes went through clays without ore. Mr. Böcking sunk one 80 feet deep to find a mass of ore said to exist between three old shafts, but found nothing. The surface wash ore is sometimes only 2 or 3 feet deep; in other places 20 feet. No

*See sections A B and C D. The Trenton limestone proper, of the New York geologists, is considered to be the top member of the Trenton group. Our ores are far below it, and in the lower members of the group, viz: the Chazy, Bird's Eye, and Black River limestones.

†Called Town Bank, on the Local Map.

‡The rocks of the neighborhood dip 25° to 35° S. E.

Figs. 13, 14. *Fig. 17.*



estimate of quantity is possible with such information. The visible area measures about 67,500 square yards.*

A little pipe ore has been found higher up the hill north of the road.

Regular and progressive stoping from the south-west, along the belt, may produce large results in the future. But the oreless clay of great thickness intervening between the surface wash and the deep hard ore will make mining expensive.

No. 6. Rumbarger's Bank, (Local Map, Fig. 14,) is an open cut in the south bank of the east branch of Warrior's

*Ore is found in the soil of Petershoff's farm on the south of the Town Banks. There is an old digging on the Hyskel (B. M. Thompson) farm; and further west outcroppings on Thom. Gano's, whose trial pit on a small vein near his orchard was stopped by water; lively outcroppings show in several fields up the slope of Dry Hollow ridge.

Run, the surface of the ground only rising 6 feet above the bed of the stream.

A cross-road separates the excavation into two; that on the southwest, 40 × 40 × 10 yards deep; that on the north-east, 30 × 30 × 10 yards deep; 25,000 cubic yards in all. These pits reached a depth of 40 feet, wholly in wash-ores and clays, without striking solid limestone. The rock ore left in the bottom when the work was drowned out is *reported* to be less abundant than that found above it. But as the ore streaks "dipped fast to the south-east," and the limestone outcrops of the neighborhood dip from 22° to 34° in that same direction, (see Large Map,) good mining will probably yield well. Plenty of good ore has been won here, and nothing but the lack of pumping machinery stopped the winning. Thos. Funk worked the Banks at one time for the Milesburg Company.

The ore belt passes on eastward under Is. Buck's (now Smith's) lands, where Messrs. Green and Barree raised ore, but took no sufficient means for establishing a mine.

Thence it enters and underlies S. Hanna's farm, with its numerous ponds and sink holes, full of promise for the future.

A mine for Bellefonte Iron Works has just been opened (August, 1873,) at a point 300 yards north-east of Rumbarger's Banks, (see Local Map, Fig. 14,) where a very heavy outcrop exists. Every cubic yard is washed profitably. The cut is yet only 4 or 5 feet deep.

As a heavy surface show extends 150 yards beyond Hannah Bank, we have here an area of 450 × 50 = 22500 yards of wash ore of undetermined depth; besides the rock ore undoubtedly existing further down.

Mining and washing will here be cheap, and the railway runs along the hillside at a distance of 200 yards, and at an elevation of 35 feet, (Fig. 14.)

Further on, the surface show is slight, or wholly wanting,† until we reach the next excavation.

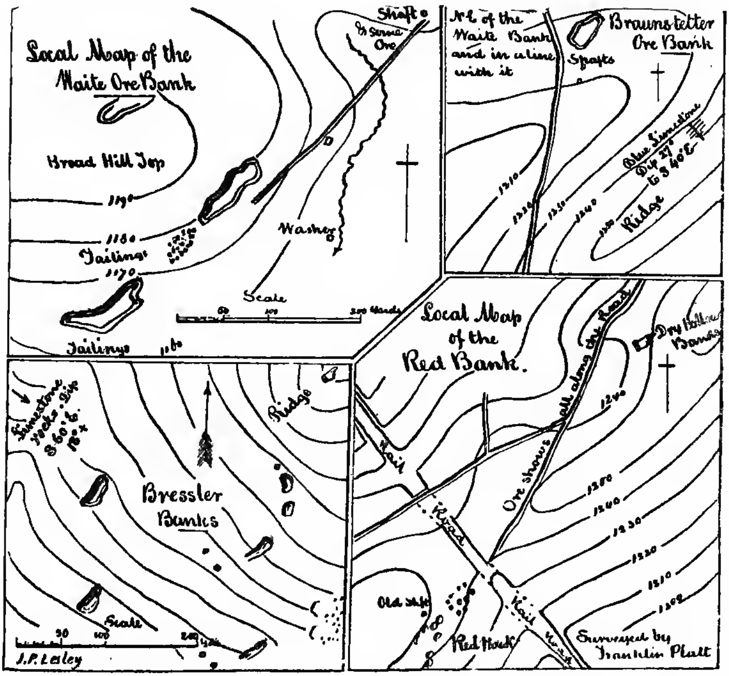
No. 8. Waite Banks, shown in Local Map, fig. 15, con-

†A shallow pit ½ mile from Hannah Bank yielded some ore. The Waite Bank is 400 yards northeast of this shaft.

sist of two pits, 100 × 20 × 7, and 90 × 20 × 7 = 26,000 cubic yards, in size, more than twenty feet depth of good-looking wash ore being seen in the sides and much lump-ore having been won by still deeper shafts in the intervening ground. The entire ore prism must therefore exceed 150,000 cubic yards. The railroad is a mile distant.

No. 9. Branstetter's, or the McGlathery bank, is situated about 1200 yards beyond (N. E. of) the Waite banks, and the interval shows little on the surface; yielded only

Figs. 15, 16. *Figs. 18, 19.*



some lean ore to one or two trial pits. This bank, (see Local Map, Fig. 18,) is only 30×20×10=6000 cubic yards large. It is said to have been worked to a depth of 40 or 50 feet, but is now fallen in and full of water, and no one seems to know much about it. Overlying limestones crop out 150 yards south-east of it, dipping 27° S. 43° E.

Further on is the old Disputed bank, on the high divide, between Warrior and Half Moon waters. Here are several small shallow open cuts and shafts in surface ore, but no deep mining has ever been attempted. The ore seems to dip south, and is sandy. The crop traced westward becomes good and plenty on Jos. Branstetter's farm, who has never made judicious trials of the deposit, and through the hollow leading to Patton's (Waite's) and the Lloyd bank above mentioned.

For *Lovetown banks*, (Nos. 10, &c.,) in Centre county, see Report T[4].

Dry Hollow Range.

No. 20. Pond bank No. 2 is a small excavation 35×10×5=1750 cubic yards, at the head of the hollow, or rather on the divide, where the south branch of Dry hollow begins to descend towards Warrior's run, and alongside of one of the summit cuts of the railroad. Good wash and lump ore show in the walls. No sandy ore is seen. The R. R. cut shows 10 feet of wash ore for a length of 100 yards. Altogether we have here say, 40,000 cubic yards of ore in sight.

No. 21. Wrye bank. The local map, Fig. 23, shows this extensive group of shafts, commencing 450 yards northwest of the railway track, at an elevation of 40 feet above it, and continuing along the road up the slope to an elevation of 100 feet above the R. R., a distance of 400 yards. Over most of this surface the show amounts to little, proving how little we can rely on the surface indications as negative testimony; for these works were extensively driven from 1852 to 1857, and yielded some very rich ore, while the surface showed only poor sandy ore.

There is one open cut, 25×20×10=5000 cubic yards large, showing wash ore in the walls from top to bottom, none of it rich, decidedly sandy, holding iron-stained calc. sandstone masses, as at the east Pennington banks. Very good open ore, bluish, and heavily charged with manganese, occupied the west end of this open cut (Böcking). An old miner reports that in the shafts they went through 26 feet of pretty worthless loose stuff and then worked 18 feet of good lump ore, without getting through; that the shafts up the hill were dry ; those lower down quickly filled with water, and were therefore abandoned, one after another, before they could get out more than 10 or 12 feet of lump ore. What the charcoal furnace miners called worthless is now valuable for hot blast, especially anthracite furnaces, and the whole of this great deposit will be washed and sold. The breadth of the belt of shafted ground is about 100 yards, but must be considered as indefinitely greater along the strike.

I am informed that in these old diggings the body of ore sank to 50 feet beneath the surface and thinned away, but came in thick again lower down, and approached the surface. Two good pillars are known to be left standing in the old works, under a top covering of sand, one at the lower end, the other at the upper end of the works. In the last, solid rich rock ore lies 45 feet beneath the surface. All the shafts are now caved in. The ore layers were traced for several hundred yards eastward by trial shafts.

The appearance of this ore differs from that of the Pond bank No. 2 so much that we should suspect them to belong to a different geological horizon. This suspicion is almost confirmed by the general south-east dip of the outcropping rocks here and there exposed at the surface. This important structural question is clearly expressed by my section C D (Fig. 3,) which passes through these banks. It is quite certain that the rocks which on dissolution delivered these ores, are the mother rocks also of the Kerr and Bredin, Hostler and Pennsylvania furnace ores, to be described hereafter. The great breadth of the Dry Hollow outcrop belt corresponds with that of the localities just named, and I think it pretty evident that we have here two horizons of lower Silurian ore-bearing limestones close together.

The old *Sandy bank* is a group of small shallow pits, in very sandy surface ore, but rich and good when washed, on the hill slope, a few hundred yards north-east of the Wrye bank, showing the continuation of the outcrop in the direction of Half Moon run.

In the other direction, the outcrop has been exploited at the old *Pond bank* of Bald Eagle furnace, 500 yards southwest of Wrye bank, and nearly in the bottom of the vale, which deepens rapidly.* It lies close to the foot of Hickory ridge; ore light but good, not sandy, and easy to smelt. A pond, dry in dry season, covers some of the old diggings. Much surface ore covers the neighborhood, and it will hereafter be an important mining ground, with heavy clay cover to the ore, requiring hard pumping.

Top ore of large size abounds around a sink-hole in Isaac Gano's fields, on the north slope of Hickory ridge, a mile S. W. of the pond. The pieces seemed rolled from an outcrop of good ore seen half way up the hill, in the Huntingdon Furnace woods.

At *Simpson's bank* (¾ mile further west) the wash-ore is good and easy to smelt. Whereas at *Andrew's bank*, adjoining, (the Warrior's Mark and Pennsylvania Furnace road separating them,) sandy ore only has been taken from the open cuts, but no shafting done.

Jos. Krider's fields are covered with very rich scattered pieces of ore, some lumps weighing 400 pounds. Attempts to find a bed at a little gap near by, have failed thus far. The shafts were tried in thick woods; others were too low on the hill slope, and encountered only wash ore. There is undoubtedly a heavy rock ore deposit somewhere. Similar shows are again seen half a mile further on (west) opposite the old wash-machine, and Huntingdon furnace has picked off the surface much of this loose block-ore. A small layer was found in two or three shafts, but never followed up to see what would come of it.

No. 22. Dixon's banks are only a few small holes, fallen shut, with a slight sandy ore surface show, 100 yards west of the road, where it crosses the head of the middle branch of the Dry Hollow. Here "a small irregular vein yielded good ore. A little west of it, on a detached knoll, a thicker vein of poorer, flinty ore was found, at the edge of a pond,

* This and the following-named banks are not exhibited on the large map, because not accurately located. Their descriptions I got from Mr. Böcking's notes.

and was thought not to pay for pumping, to get for charcoal furnace use.*

The old *Kelsey Bank* yielded much good ore, years ago, in funnel-shaped pockets, not continuous.

No. 23. Little Dry Hollow Banks (see Local Map, Fig. 14) are near the crest of the low hill dividing the middle from the north branch of the Dry Hollow. No. 1 is a small hole on a small outcrop reported to have yielded six to eight feet of sandy lump-ore, soon running out. No. 2 consists of a group of small pits and trial shafts on a slight outcrop. Some ore was got from shafts A, B, and C. The appearances here are not favorable for future mining prospects.†

No. 24. The Dry Hollow Banks are the central figure in the broad expanse of outcrop which seems to fill the hollow and its three head branches, and to cover the dividing slopes, in many places if not continuously, north of the railway. They are shown in map, Fig. 29.

In the southeast corner of this map the railroad curve ought to have been designated, the distance of the track from the principal excavation A, being less than 400 yards.

The cut on the south side of the township road is pictured by Mr. Harden, in Fig. 28; that on the north of the road in Fig. 30; and the road itself in Fig. 31; the wash-ore in

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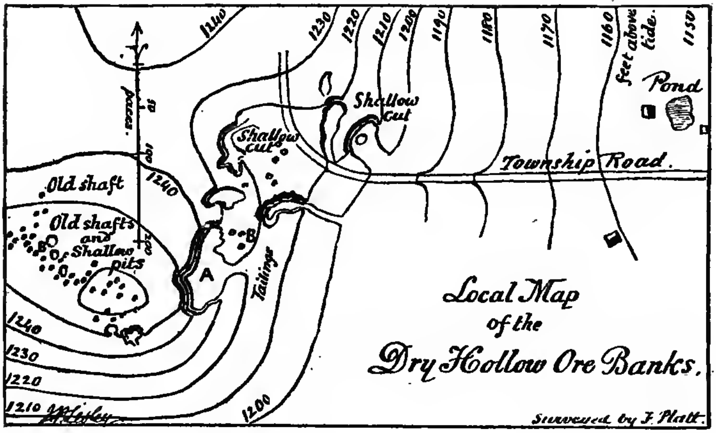
* Mr. Böcking thinks he remembers that this vein had a decided northern pitch, and distinguishes it thus from all the other veins of this range. This must be either a mistake or a mere local accident. Mr. Platt's field notes also mark a doubtful N. 30° W.> 34° dip of the limestones in the through-cut 240 yards north-west of railroad section stake 81–80. But 100 yards N. E. of the same stake, soft rotten limestone strata dip S. 30° E.> 20°. Other railroad exposures show that the S. E. dip dominates the structure. Thus at railroad station 4145, is a through-cut in blue limestone, dipping S. 30° E.> 34° with regular cleavage planes N. 60° W.> 70°; at 4151, a good exposure of limestone gives S. 30° E.> 26°. In railroad cut at 4164, sandy and blue limestone layers seem to dip S. 60° E.>31°; in the cut 180 yards S. W. of railroad 4180, hard, sandy limestones dip S. 45° to 50° E.> 26°.

†Mr. Böcking reported some years ago that these works merely won small veins and top ore, while the body of ore is undoubtedly left under the little ponds, &c., at the foot of the hill. Good ore used to be raised from the Little Dry Hollow bank, but efforts to "recover the vein" some few years ago failed, although the ore here rides to the top of the hill, where it is pipe-ore (as it is also pipe-ore on the northern side of the hill.)

Fig. 29.



the railroad cutting at the curve, south of the banks, is shown in Fig. 32.

The Dry Hollow Bank, ½ mile north of the R. R., 2½ miles E. of Warrior's Mark village, is an extensive system of open cut excavations, from which great quantities of excellent ore have been got in past times. The term "system" is however inapplicable to the process of mining here

Fig. 30.

Part of Dry Hollow Bank. South side of Road.

employed, for it resembles rather the burrowing of animals. No one can estimate how much of the precious ore has been left untouched, for there are neither maps, nor records, nor traditions of the work.

The old miners merely say that the ore runs out against a bank of clay. But such reports are good for nothing; and even if literally true teach nothing, for they are sure

Fig. 31.

Road to Warriors Mark through Dry Hollow Bank.

to relate to single points, and fail of application at others. Fifteen years or so ago, some of the old pillars of ore were taken out by sinking shafts and driving short galleries at a few points. The ore is mostly wash ore, that is fine ore disseminated through clay. The dip is southward (towards the great central synclinal) and deep workings and powerful pumps are needed in future, south of the old shallow surface workings.

From Dry Hollow Summit cut for the railroad to the first shafts, a distance of about 400 yards, there is a decided outcrop. The shafts extend over 200 yards to the edge of the big open cut A, Fig. 29. They seem to have gone down* through wash and lump-ore 60 feet to water, which in all cases stopped the works. The lumps alone were carried to the furnace. The wash-ore was not valued then; now it is merchantable. The sinking was done at random and ore was always got.

* Twenty-five years ago, more or less.

Mr. Platt's estimates on the ground are as follows:

110×40×10	= 44,000	76,000 cubic yards of excavation done.
50×15× 8	= 6,000	
50×15× 6	= 4,550	
60×25×10	= 15,000	
50×10× 5	= 2,500	
100×10× 4	= 4,000	

The main bank A, shows wash-ore of very variable richness from top to bottom, 50 feet. The shafts at B are reported 60 to 70 feet deep, through wash and lump ore. From shaft C, on the roadside, 60 feet deep, 1,600 tons of excellent lump-ore alone were selected for use.

About 300 yards north-east of the banks, the railroad line has exposed a mass of lump and wash ore of excellent quality.

The *Old Red bank* of Bald Eagle furnace is on a continuation of the Dry Hollow deposit south-west, but higher up the hillside. It is shown in Local Map, Fig. 19. Mining was confined to the surface ore which was sandy and without "regular veins;" but no one knows how the deposit of ore is to the deep.

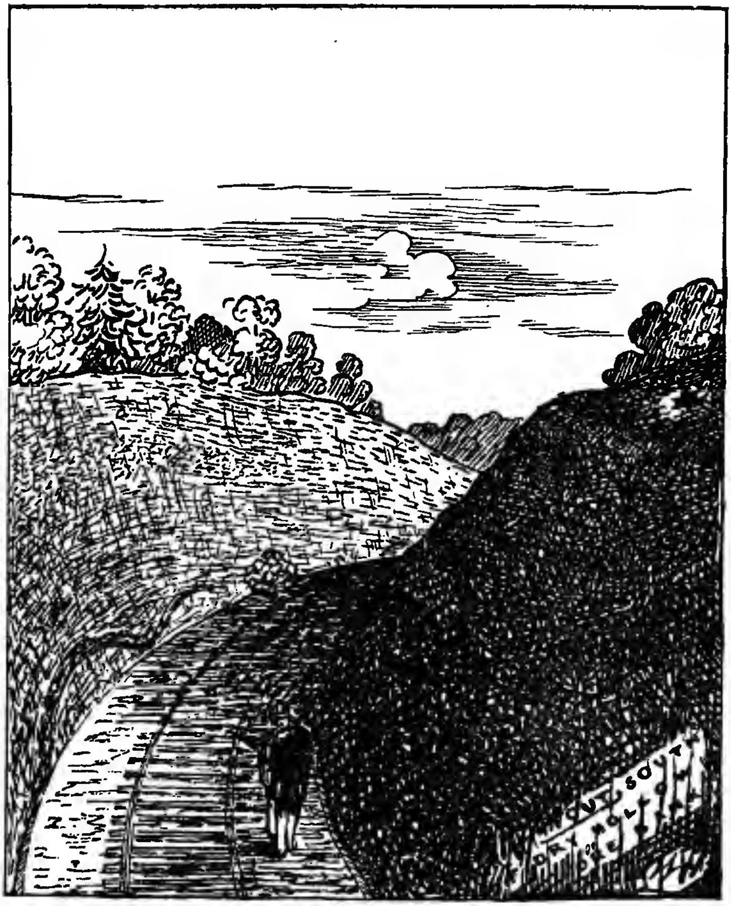
The surface show between the Dry Hollow banks and the Red bank is not so heavy as where the old excavations were made; but the deposit underneath is really continuous and unbroken, as is shown by the cuttings through the ridge made by the railway between the two localities. See Fig. 19.

Here wash-ore has been exposed for 100 to 125 yards along the track; sometimes 10 feet thick resting on clay; sometimes 20 to 25 feet of wash-ore holding larger lumps. The varying thickness of the red clay and ore layers in this cut is an instructive example of what the miners found in their shafts. Some of the lumps weigh 300 to 400 pounds. Very few pieces of silex appear; and on the whole, this deposit looks freer from silica than any other in the valley. Little or no soil covering exists.

The Red Bank pits and shafts are very numerous, and all shallow. The ore when smelted alone, at Bald Eagle furnace, made first-class iron.

From the south-west end of the Red bank to the north-east end of the Dry Hollow bank is about 1000 yards. The breadth is 200 (say 150) yards. The worked depth (to water) varies from 20 feet at Red bank to 100 feet at Dry Hollow bank. Taking an average of 10 yards, we have 1000×150×10=1,500,000 cubic yards of wash and lump ore. Discard one half of the leaner interval between, and allow one ton to the yard in consideration of the size and quantity of

Fig. 32.



lump ore, and we have 750,000 tons. In our ignorance of the condition of things where the water stopped the old fashioned rude mining, it is impossible to say how near this estimate approximates accuracy.

No. 25. Bean bank lies a mile to the S. W. of the Dry Hollow bank, where many tons of surface lump-ore were scratched out and sent to Huntingdon furnace; as was done in other places along this part of the range on the south slope of Dry Hollow ridge. No attention was paid to the great body of wash ore forming the deposit, and no effort to mine to the deep. A vast body of ore ground awaits future exploration and excavation, within a mile of the railroad. Quartz occurs in this ore bank.

No. 26. Bressler bank (see Fig. 16) is a collection of small holes, on the north-west side of the ridge, in a ravine descending to the east branch of Warrior's Run, and distant from the railway half a mile. About 2500 cubic yards of excavation seem to have been made in past years. The pits are fallen in, showing sandy wash ore in their sides. Eight feet of lump ore is reported as mined in this locality. No geological indications of the structure appear.

This completes all I have to say here of the Dry Hollow outcrop. For, although ore has been found further south-west along the south side of the ridge towards Warrior's Run, no mining has been done; and the Old Seat bank, (No. 37,) is so out of line with the Banks above described, that it may be left for notice in connection with the ores west of Warrior's Run. But I shall describe, further on, the continuation of this range where it crosses Warrior's Mark Run and at the Huntingdon Furnace and Dorsey Banks.

I pass over, therefore, to the Cale Hollow (Kerr & Bredin, Hostler and Pipe-ore) banks further south-east.

The Cale Hollow Range.

Cale Hollow is divided from Dry Hollow by Hickory Ridge, as shown in the large map; and its ores lie in a deeper and narrower synclinal than the ores in the gentle and wide synclinal of the Dry Hollow as shown by section CD. They are, however. ores once carried by the same limestone strata, and ought therefore to be of the same general character. It is therefore remarkable that so little pipe ore has been found in Dry Hollow, while an abundance of pipe ore characterizes the Cale Hollow banks.

No. 27. Kerr & Bredin Bank, (see local map, Fig. 24, and wood cuts 33, 34, 35,) is a small excavation of about 5000 cubic yards, showing in its walls lump and wash ore, 25 feet deep. Much of the wash ore seems leaner than in other banks. A shaft has been sunk for exploration in the bottom of the old cut, and the report of it is favorable to future mining on a systematic scale. (See Fig. 35.)

The ore from this bank won for itself a high reputation at the furnace. It was called "gun metal ore," and was said to bear a striking resemblance to the Bloomfield ore of Morrison's Cove, south of Hollidaysburg, in Blair county, from which was made by preference the ordnance of the United States Army during the civil war.

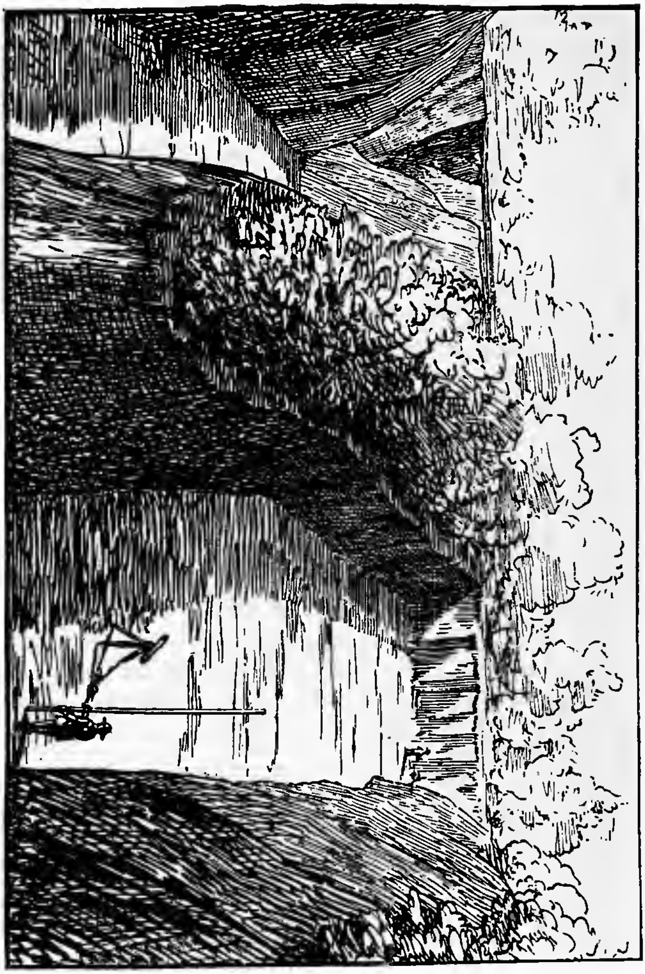
Dr. Genth's analysis of the Kerr & Bredin ore, given below, when compared with Dr. Otto Wuth's analysis of Bloomfield ore, made June 9, 1871, compare as follows:

	Kerr & Bredin.		*Bloomfield.*
Ferric oxide,	70.67	Perox. Iron	78.63
Manganese oxide,	0.36	Manganese	0.29
Cobaltic oxide,	trace		——
Alumina,	3.91		2.50
Magnesia,	0.26		0.38
Lime,	trace		0.34
Phosphoric acid,	0.19		0.134
Silicic acid,	5.48		7.02
Quartz,	6.80		——
Water,	12.33		10.71

The extra quartz determined by Dr. Genth diminishes the percentage of iron oxide in his specimens, and reduces the percentage of iron from 55.04 (Wuth) to 49.47 (Genth.) Otherwise the ores are strikingly alike.

The *Kerr & Bredin bank* lies at the foot of the south slope of Hickory ridge, one mile W. N. W., of the Hostler bank. In a dry autumn Mr. Böcking was directed to sink south of the old cut, and to mount a pump. He reported a 12-inch "vein of ore" at 40 feet, and water at 44 feet. A

Fig. 33.



Part of the Kerr and Bredin Bank, sketched by J. W. Harden.

tunnel-way was commenced in the direction of the old cut, which caved in, and the works were stopped.

The continuation of these ores along the foot of Hickory ridge, on the north side of Cale hollow, is proven by a range of "lively outcroppings." In some places the surface is sufficiently rich wash-ore. One or two pits (Bronstetter's) were worked, for Huntingdon furnace, 1½ miles west of the Kerr & Bredin bank, in "an irregular vein."

FIG. 34.

North-eastward the ores continue to show themselves to Half-moon run, where "pipe-ore" is marked upon the large map. See Little bank, below.

From a small cut at Eyer's, on the east side of Half-moon run, pipe-ore was raised many years ago. The limestone rocks at Eyer's house, 100 yards south of the spot, dip to the S. 30° E.>21°.

Another old pipe-ore locality shows now fair ore on the surface, near two small trial pits.

No. 28. Hostler bank (see local map, Fig. 26, and wood cut, Fig. 36) occupies the northern slope of the Spruce Creek anticlinal ridge, as a large open cut, from which the ore was in old times hauled to Pennsylvania furnace, two miles due east of it.

The recorded history of this important mine reveals the following features: Wherever the diggings were made they went down through "pipe" wash-ore which was occasionally mixed with lump-ore, to depths of 60 and 65 feet, in all the shafts.

One of these shafts passed through this wash-ore 65 feet, and then passed through a stratum of solid limerock, varying in thickness from 10 inches to two feet. Below this

Fig. 35.

A Section at Kerr & Bredin Ore Bank.

limestone lay lump "pipe" ore, into which the shaft was sunk 6 feet further, and then the flow of water stopped its further descent.

From the bottom of the shaft a five inch auger hole was then drilled through a continuous bed of pipe ore to an additional depth 39 of feet.

The percentage of iron in the pipe ore is uniform ; or varied only by the chemist's including in his analysis adherent or inclosed clay.

It is a constant feature of the Pipe ore banks of the southern range that they do not furnish the "lean-ores," so-called, which are met with in the banks opened along the more northerly and geologically lower outcrops of the "Barrens" in this valley. It has been the uniform experience at the Pennsylvania, Hostler, and other Pipe ore banks that shafts and borings have always passed through lump-ore, after having been sunk or drilled below water level. But as pumping apparatus on a sufficient scale has never been applied to such deep shafts and borings, they have in no case passed entirely through the deposit of lump ore, the thickness of which is therefore still a matter of conjecture.

I give the history of these operations as an evidence of the insufficient extent to which the development of this iron ore district has been carried; to show that only its surface has been scratched, but its deposits not mined. Regular, systematic, efficient operations are yet to be begun.* They await the completion of the railroad and that demand for large quantities of ore from distant furnaces which is already become so urgent. The underground drainage all through the valley is immense, and the largest bodies of ore, and especially of pipe ore, can only be won with heavy pumping and systematic stoping.

The Hostler open-cut bank must be sunk in air to the lower ores, and through them to the bottom floor of all; then with powerful pumps to keep the water down, the clay stripping above can be washed, and the heavy face of

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* Written in 1872.

ore below can be stoped and the top stuff thrown back into the abandoned ground as the ore-face advances. As Mr. Böcking justly remarks, "35 feet of ore will pay well for stripping 65 to 75 feet" of clays above it. He adds, and I agree with him heartily: "The time for shallow digging and ground-hogging is pretty well past in these barrens, and the exploration of the richer banks may in future require preparations that will take some capital, and may need in some cases two or more years before yielding a return."

The Hostler Bank excavations measure about 120×50×10= 60,000 cubic yards. The ore lies like that to be described in Pennsylvania Furnace Banks,* as a mass of clay and wash-ore separated by ribs of undecomposed limestone. The walls are about 30 feet high, but the steep north-west dip of the measures prevents this figure from being used as a datum of calculation. It only shows in a general way the depth below the sod to which the weathering action has gone, *as exposed by the miners.* The lately sunk shafts passed alternate soft beds of ore and hard ribs of limestone, all on a steep dip; 38° to the N. 35° W. In a shaft at the north-west end of the open cut they went down through 75 feet of wash-ore ground before striking the solid limestone rocks and water.

It is impossible from such data to estimate the future yield at this locality, but the amount of ore to be won must be great. Nor is it confined to the neighborhood of the old works. The ore belt runs on south-westward for at least five miles.

At the distance of 1900 feet there are somewhat less than twenty old shafts in one group, quite forgotten until recently discovered by Mr. George Lyon. They were mostly shallow pits in the surface of the pipe-ore bearing clays; but some of them look as if they had been sunk to a considerable depth; and their number proves that the search for ore was remunerative even at that day.

This part of Cale Hollow is a wide, flat, slightly undulating, dry vale, every part of which shows a top-dressing

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*See Report T[4] on Centre county.

of fine ore. It is a virgin district. Mr. Lyon sunk one trial-shaft in it, and struck an "ore-vein." There was a similar accidental discovery of another group of five or six pits from which some top-ore had been scraped. I have no

Fig. 36.

doubt that a continuous belt of mining ground runs the entire length of Cale Hollow.

The *Red bank*, $1\frac{3}{4}$ miles from the Hostler, on the same slope of the Spruce Creek Ridge, is old and disused; the ore in the top clays was stripped, but no attempt at deep mining was made. Another old bank in line with it, but across a little ravine issuing from the ridge, furnished some pipe-ore to Huntingdon Furnace. Still further west,* in a similarly situated bank, near Huntingdon Furnace, a vein of good red-short ore was struck, and abandoned on account of water. On working one part of this pit the ore became too sulphurous to use. It will be again referred to after describing Bank No. 29.

The belt of Cale Hollow ores may be traced north-eastward with the same general character.

Little bank, for instance, lies two thirds of a mile northeast (near the Warrior Mark and Pennsylvania Furnace

*$4\frac{1}{3}$ miles from Hostler Bank.

road), 1⅝ miles west of Pennsylvania furnace. Here very rich top-washings cover a high flat area connected with Hickory ridge. Seams of the ore penetrated the limestone rocks all the way down a 40 feet shaft, under which the main body of ore dips northward.

The *Eyer bank* (already mentioned) is an old excavation one mile still further east, on the east side of Half-moon run.

Going on north-eastward across a dividing ridge, the ore appears again along Tadpole run, in Sleepy hollow, and at the head of the Beaver-dams, for a distance of more than a mile. Years ago, some pipe-ore was raised, for Centre furnace, east of B. Crane's, but the surface was merely scratched. At the Pennsylvania furnace old surface-pits, sunk at the Beaver-dams, the body of ore probably lies under the bed of the run and would require heavy pumping.

The "dry hollow" which carries the Valley of Tadpole run on in a straight line north-eastward, and is a geological prolongation of Cale hollow shows plenty of out-croppings of ore, just as Cale hollow does, and the ore is of the same kind—pipe-ore. In fact the ore belt continues to McAllister's and the School-house cross-roads, eight miles north-east of the Hostler bank, and far beyond the limits of my large map. All this however is in Centre county.

Between McAllister's and Pinegrove Mills, the country spreads out into a plateau two or three miles wide, through which runs the Brush Valley anticlinal. Here, far beyond the east limit of my map, are the

Old Weaver banks; two open-cuts and several shafts near them, abandoned years ago. No systematic mining was attempted in that early day, the work being done by the farmers. Tradition speaks of "ore veins" being reached, but probably too well watered for the natives to cope with them. "The ore lying around the holes is not a regular pipe-ore, but is mixed with liver-colored ore, and reported red-short." We have here, then, ores not belonging to the Hostler and Pennsylvania Pipe-Ore Bank system connected with the sandstone of the anticlinal, that is, ores belonging to the underlying limestone.

Down Spruce creek.

The Pennsylvania ore banks are described in Report T[4] on Centre county. The ore here obtained has been so abundant that no explorations of note have been made along Spruce creek. A few trial pits were sunk near the school-house, and near Mr. Geo. Lyon's mansion south of the turnpike. Large pieces of pipe-ore lie in the east corner of Mr. F. Lyon's fields at the foot of Tussey mountain. Ore has been noticed in Mr. Stewart Lyon's north fields.

All the above are on the south slope of the anticlinal of Brush valley, facing Tussey mountain. The anticlinal may be studied where the limestone rocks are seen dipping both ways (N.W. and S. E.) in the end of the hill at the furnace, and in the railway rock-cuts as the line makes its semicircle down Half Moon run and up Spruce creek and Tadpole run.

Three miles further down Spruce run, a pipe ore bank was commenced on the south slope of the anticlinal, to supply works erected at the mouth of Spruce creek, for a patent process to convert the ore directly into wrought iron; but the patent process failed and the mine was never worked. It sufficed to show that the ore belt or outcrop follows the ridge along the north side of Spruce creek towards the Juniata, but coalesces with that of the Cale Hollow, or north dip, beyond Huntingdon furnace, and sinks beneath the surface, for no trace of it is found in the Little Juniata River section, where the Canoe Valley anticlinal may be seen replacing this of Brush valley.

Huntingdon furnace district.

Returning thus to Warrior's Mark run, and the neighborhood of Huntindon furnace, I have little to add to finish this report, except concerning an ore belt, west of the run, on the south slope of the ridge, in line with the Dry Hollow banks. But before speaking of it, I shall give the following *section up Warrior's Mark run:*

At the mouth of Cale hollow, in the north dipping rocks of the Spruce Creek Ridge anticlinal, and 150 yards east of the mill-dam, or a mile east of Huntingdon furnace, there is marked on the map an old pipe ore bank, now fallen in. Lime rocks here dip N. 30° W. >50° ; but, by the road-side 300 yards to the west-south-west, only 38° ; and in the hill-side 650 yards to the west-north-west, 12° in the other direction S. 30° E. The Old Seat bank, No. 30, is 1100 yards distant (up Warrior's run towards the N. N. W.) from this old bank. The Cale hollow is thus seen to be synclinal, and, allowing for the different strength of dips observed, there can be no reasonable doubt that the same ferriferous lime rocks outcropping here crop out also at the Old Seat bank ; and I have so drawn the section A B.

The ore at this old bank is reported to have been extraordinarily charged with sulphur, but I could not learn exactly in what form.

No. 30. The Old Seat bank, on the east bank of Warrior's run, 2⅓ miles below where the railway crosses the run, (at Warrior's Mark,) is an old open cut with ore in its floor, abandoned many years ago for want of pumping machinery of adequate power. What little liver-colored ore is visible, looks lean, and much flint lies about. The area of the cut may be 4000 square yards. Water stands in it to within 10 or 12 feet of the top. It has been worked to a depth of 40 feet. About 30,000 cubic yards of ore-ground have been taken out. Although much liver-colored ore like Pennington ore lies about, no pieces of sandstone are visible ; but a good deal of flint is among the ore, as at Pennsylvania furnace bank. Not much surface ore shows in the neighborhood.

In the gap of Dry Hollow ridge, 600 yards higher up the run, lime rocks crop out dipping also S. 30° E. >9°, and 300 yards further, sandy limestones, S. 30° E. >10°. 500 yards further up the run pipe ore is reported, plowed up in the fields. This belongs to an ore-bearing strata about 700 feet lower in the formation than the ore horizon at the Old Seat bank. The dip is continuous and equable ; *there can be no mistake.* 500 yards still further up the run, at the forks of the road, still lower sandy lime rocks are seen dipping the same way, S. 30° E. >13°. Other exposures occur in this interval, dipping also S. 30° E. >13°. No dips are noticed in the next 1000 yards, to the toll-gate and cross-roads and forks of the creek; but there is no reason to doubt that a south-east dip fills the interval, becoming ever more gentle.

Five hundred yards south-west from the toll-gate, and 50 yards off the road (towards the north-west) on land 70 feet above the water, is an old deserted pipe ore bank 50 × 10 yards. This lies just 1000 yards due north-west of the pipe ore last mentioned as plowed up in the fields; and if a continuous south-east dip of 10° be *supposed*, we should find in it an evidence of a *third and still lower pipe ore horizon*, 550 feet below the second and 1250 feet below the first, or Old Seat ore horizon. But it would be very unsafe to consider this the simple state of the case. The place where ore was "plowed up over a space of 600 yards" is worthy of a thorough investigation, but the surface show is slight. The other locality where lumps and pipes of solid ore were got 25 years ago from the open cut and underground works, is reported to be rich still. None of its wash ore was taken away.

This place is very important. It proves conclusively that pipe ores occupy a *geological* range of at least 1250 feet of the Lower Silurian formation. And these exhibitions on Warrior's Run connect the rich Dry Hollow group of banks already described, with the Huntingdon furnace and Dorsey group next to be described.

The toll-gate is only 800 yards down the run from where the railway crosses it. And the south-east dipping Beck and Town Bank ores (Nos. 4 and 5) are only 400 yards further up. The Beck and Town ore horizon therefore underlies the toll-gate ore rocks (unless there be some concealed disturbance in the interval) at a *geological* depth of at least 1200 feet, and probably 1500 feet. For there are 20° dips (to the south-east) in the railway cut, and 35° dips in Warrior's Mark Village. If I am anywhere near the truth, the Pennington Range ore horizon (Beck's, Town, &c.) underlies the Cale Hollow Pipe Ore horizon at a *geological* depth of 2500 to 3000 feet; which may well explain their different qualities. And this result is in harmony with features of my cross-sections AB and CD.*

No. 31. Huntingdon Furnace banks. These lie along the southerly slope of a prolongation of Dry Hollow ridge, west of Warrior's run, and within a circle swept around Huntingdon furnace with a radius of two miles, as shown on the land-map. The Dorsey banks are outside this circle, but are excavated in the same belt of outcrop. The outcrop is very broad because, as we have just seen along Warrior's run, the south-east dip is very gentle, about 10°. This has allowed a very large dissolution of the ore-bearing rocks.

The *Wilson bank* is two miles west of Warrior's run. No ore has been found in this interval, the slopes being sandy. Here limestone begins to come in, overlying the sandstone, and ore-bearing clays take possession of the surface. This sandstone has been mistaken for the Calciferous sandrock; but must be one of the numerous intercalations of sand in the great limestone series.

The *Keefer banks* follow, in the next half mile, and, although exhausted as to the wash ore of the outcrop, can be mined to the deep if proper pumping apparatus be mounted to keep the underground water down.

Fig. 44 gives a local map of these excavations, which

*The Pennington and Lovetown ores being on the some geological horizon, and there being a breadth of limestone outcrop (dipping S. 30° E. > 50°), between Lovetown and the Bellefonte fault at the foot of Bald Eagle Mountain, at least 700 yards broad, we have about 5000 feet of Lower Silurian measures visibly exposed underneath the Cale Hollow (= Pennsylvania Furnace Bank) ore horizon. Adding to this the 2500 feet of limestones between Pennsylvania Furnace bank and the foot of Tussey, and we have a total thickness of Lower Silurian Limestones from the bottom of No.III (the Hudson River Slate) down to the jaw of the Bellefonte Fault, of 7750 feet; a very great thickness; but quite in harmony with all that we know of the Trenton, Black River, Bird's Eye, Chazy and Calciferous in the Great Valley of Reading, Harrisburg, Chambersburg, Winchester and Knoxville. This, so far as I know, is the first approximately accurate measurement of these formations in mass south of their New York outcrops, which are very thin in comparison with these. (Written in 1872.)

severally measure as they come in order along the line of Mr. Platt's survey:

a.	*	130 × 30 × 8	=	31,200 cubic yards.
b.	*	160 × 35 × 8	=	44,800 "
c.	†	40 × 25 × 10	=	10,000 "
d.	‡	120 × 40 × 8	=	38,400 "
e.	§	100 × 40 × 8	=	32,000 "
f.	§	30 × 30 × 5	=	4,500 "
Total excavation, say,				161,000 cubic yards.

No. 32. Dorsey banks, see Fig. 44.

These works lie just outside the two mile circle around Huntingdon furnace stack (see Land-line map), and are used for Barree Forge, distant three miles due west on the Little Juniata river; the nearest distance to the river by the township line in a south-west direction being two miles.

There is first an open cut on the south side of the road, see Fig. 44, measuring 65 × 25 × 6 = 9750 cubic yards of excavation, with wash ore in the walls. Then, a shallow open cut, ten or twelve feet deep, 75 × 30 × 4 = 9000 cubic yards, the floor being everywhere wash ore.

The main bank, in the south-west corner of Fig. 44, is divided by a slide of the south-east wall into two open cuts, 200 × 70 × 15 = 210,000 cubic yards, with wash ore walls and floor (now generally 30 feet deep), but excavations have been made much deeper.

From the north-easternmost Huntingdon furnace diggings to the last Dorsey digging is a stretch of about 2000 yards, with ore-shows filling up the intervals between the banks. There is a maximum breadth of 500 yards. But if half that be adopted for an estimate, we have an area of wash ore here equal to 100,000 square yards, in all respects like that of the Dry Hollow Bank district (on the same

* These lie south of the road, on the large map. Eight yards is taken as the average depth of both, but they may have been worked deeper. Wash ore forms the walls.

† Also south of the road and beyond the limits of Fig. 44.

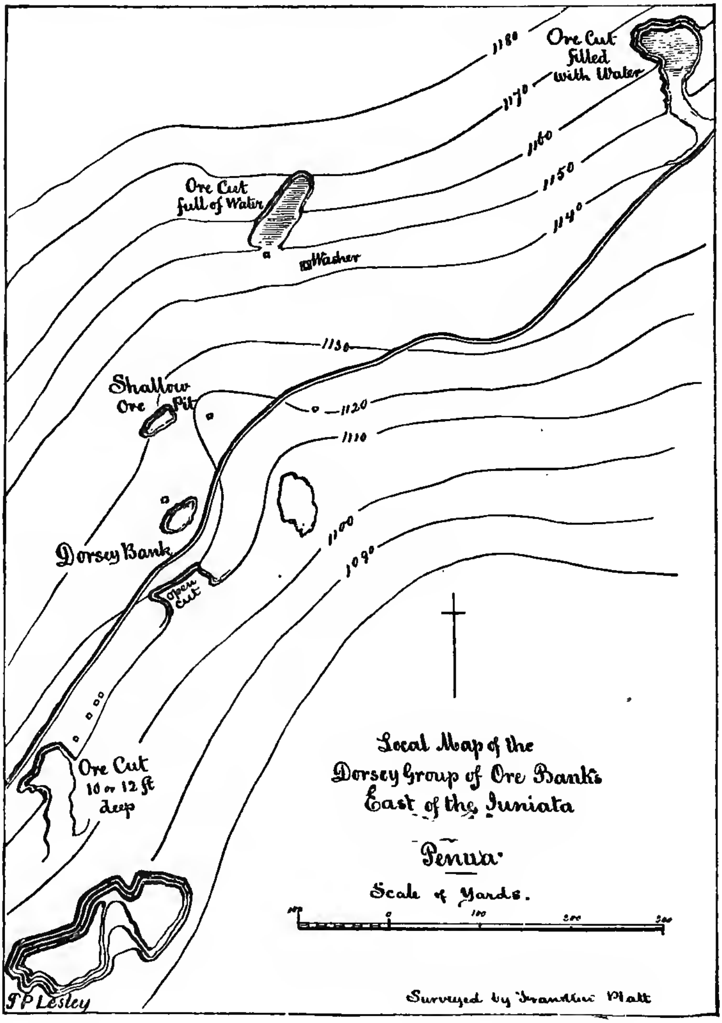
‡ North of the road, at the north-east corner of Fig. 44. It has not been worked for years. Wash ore forms the walls.

§ North of the road, and of the Dorsey bank, Fig. 44. Both have fallen shut. Wash ore forms the walls.

range) described above, and representing, at least, one or two millions of cubic yards of ore ground, besides whatever deeper deposits of pipe ore exist.

As in Dry hollow, so here much lean ore is mingled with the rich, and much dead stripping will be required in places.

Fig. 44.



There is this distinction: The ore of the Barrens, that is the liver-colored and more sandy ore, ranges along the north-western side of the belt of outcrop, up the hill-side; pipe ore characterizes the down hill, or south-eastern side of the outcrop. The main bank is wholly in the top or wash ore covering, and has merely revealed the principal deposit of rich rock ore and pipe underlying it. Those who worked the pit describe a layer of ore 6 to 8 feet thick as apparently creeping downhill, overturned, and covering itself. What this description means I do not know. The ore makes excellent iron.

Analysis by Dr. F. A. Genth.

No. 1. East Pennington bank.

The greater portion of 13 specimens, received for examination, was compact, dull, of various shades of brown, and had like No. 1 an admixture of dark-brown pitchy ore; other portions were porous and had the cavities lined with botryoidal fibrous brown limonite; others were stalactitic. Some of the ore had lost a part of its water of hydration, and had changed into turgite and even into hematite. Many of the pieces showed a considerable admixture of manganese minerals, such as wad, minute quantities of pyrolusite and perhaps psilomelane; some contained a large quantity of rounded grains of quartz.

An average of the whole showed the following composition:

Ferric oxide,	=	65.88	=	44.77 Metallic iron.
Manganic oxide,	=	6.00	=	4.18 Metallic manganese.
Cobaltic oxide,		0.34		
Alumina,		trace.		
Magnesia,		0.26		
Lime,		trace.		
Phosphoric acid,		0.22	=	0.097 Phosphorus.
Silicic acid,		6.38		
Quartz,		7.87		
Water,		13.05		
		100.00		

100 iron and manganese contain 0.197 phosphorus.

No. 2. West Pennington bank.

Five specimens were submitted for examination. The ore was mostly of various shades of yellowish brown to dark hair-brown, and without luster; in some was an admixture of a dark blackish brown ore with subconchoidal fracture and a resinous luster; some portions had a slight waxy luster, others were earthy and dull. It was amorphous, but in places the cavities were lined with a coating of brown fibrous limonite. On being breathed upon, it developed a strong argillaceous odor.

An average of the five specimens contained:

Ferric oxide,	=	70.93	=	49.65 Metallic iron.
Manganic oxide,	=	0.38		
Cobaltic "		trace.		
Alumina,		2.81		
Magnesia,		0.14		
Lime,		0.08		
Phosphoric acid,		0.37	=	0.16 Phosphorus.
Silicic acid,		4.38		
Quartz,		7.91		
Water,		13.00		
		100.00		

100 iron contains 0.32 phosphorus.

No. 6. Rumbarger bank.

A sample of ore was taken from a pile alongside of the Bank. It is mostly amorphous and compact, also somewhat porous, and has the cavities lined with a thin coating of fibrous limonite; the cavities are also coated with red ocher and at times with yellow ocher.

The composition was found to be as follows:

Ferric oxide,	=	74.16	=	51.91 Metallic iron.
Manganic oxide,	=	trace.		
Alumina,		3.06		
Magnesia,		0.24		
Lime,		trace.		
Phosphoric acid,		0.36	=	0.158 Phosphorus.
Silicic acid,		6.11		
Quartz,		3.94		
Water,		12.13		
		100.00		

100 iron contains 0.30 phosphorus.

No. 21. Wrye bank.

Five specimens received. The ore is amorphous, porous, and scoriaceous. Some of the cavities are lined with a thin coating of fibrous ore. The more compact pieces contain a large admixture of rounded quartz grains.

An analysis of an average sample gave :

Ferric oxide,	=	77.00	=	53.90 Metallic iron.
Manganic oxide,		0.36		
Cobaltic oxide,		trace.		
Alumina,		2.15		
Magnesia,		0.14		
Lime,		0.15		
Phosphoric acid,		0.19	=	0.08 Phosphorus.
Silicic acid,		2.60		
Quartz,		5.53		
Water,		11.88		
		100.00		

100 iron contains 0.15 phosphorus.

No. 24. Dry Hollow bank.

Amongst the eight specimens received for examination was one of a beautiful variety of fibrous limonite ; the fibers are of about one inch in length, also divergent and radiating; color dark brown, luster silky ; the other ores were both compact and porous amorphous brown limonites, some with the cavities lined with fibrous ore, others having them filled with ocherous clayish ores. Some of the pieces give a strong argillaceous odor, when breathed upon.

a. Pure Fibrous Limonite.

Ferric oxide,	=	83.13	=	58.19 Metallic iron.
Manganic oxide,	=	0.15		
Alumina,	=	0.74		
Magnesia,		0.09		
Lime,		trace.		
Phosphoric acid,		0.50	=	0.22 Phosphorus.
Silicic acid,		2.47		
Water,		12.92		
		100.00		

100 Iron contain 0.37 phosphorus.

b. Average of the Eight Specimens.

Ferric oxide,	=	75.90	=	53.13 Metallic iron.
Manganic oxide,	=	0.16		
Cobaltic oxide,	=	trace.		
Alumina,	=	2.44		
Magnesia,		0.20		
Lime,		trace.		
Phosphoric acid,		0.54	=	0.24 Phosphorus.
Silicic acid,		2.74		
Quartz,	=	7.84		
Water,		10.18		
		100.00		

100 iron contain 0.45 phosphorus.

No. 24. b. Red Bank of Dry Hollow.

An examination of six specimens, showed the general character of the ore to be amorphous, of a dark brown color, and compact; some pieces have cavities lined with yellowish brown and dark brown fibrous limonite; others have rounded quartz grains disseminated through the mass. A portion of the ores has lost part of the water of hydration. The cavities and fractures are frequently coated or filled with a brownish red ocherous ore.

An average sample of the whole contained:

Ferric oxide,	=	80.34	=	56.24 Metallic Iron.
Manganic oxide		0.52		
Cobaltic oxide,		trace.		
Alumina,		1.66		
Magnesia,		0.13		
Lime,		trace.		
Phosphoric acid,	=	0.49	=	0.215 Phosphorus.
Silicic acid,		3.18		
Quartz,		2.63		
Water,		11.05		
		100.00		

100 iron contain 0.38 phosphorus.

No. 27. Kerr and Bredin bank.

The three specimens received show the ore to be mostly amorphous and compact, and of various shades of brown, also earthy; some parts are porous and the cavities lined with fibrous limonite, sometimes in botryoidal forms. On being breathed upon, develops a strong argillaceous odor.

The average of the samples contained:

Ferric oxide,	=	70.67	=	49.47 Metallic iron.
Manganic oxide,		0.36		
Cobaltic oxide,		trace.		
Alumina,		3.91		
Magnesia,		0.26		
Lime,		trace.		
Phosphoric acid,	=	0.19	=	0.08 Phosphorus.
Silicic acid,		5.48		
Quartz,		6.80		
Water,		12.33		
		100.00		

100 iron contain 0.16 phosphorus.

No. 28. Hostler bank.

One specimen of so-called "pipe ore." Amorphous, compact, and earthy, brown to yellowish brown. Porous. Stalactitic. Coated with yellowish and reddish ocherous ore.

The analysis gave:

Ferric oxide,	=	78.58	=	55.01 Metallic iron.
Manganic oxide,		0.08		
Alumina,		0.88		
Magnesia,		0.54		
Lime,		0.30		
Phosphoric acid,	=	0.36	=	0.158 Phosphorus.
Silicic acid,		4.25		
Quartz,	=	2.60		
Water,	=	12.41		
		100.00		

100 iron contain 0.28 phosphorus.

*Old Cut north of Gatesburg.**

A peculiar looking amorphous ore, of a brown and yellowish-brown color, uneven to subconchoidal fracture, dull or of slight waxy luster, inclining to resinous. It has a strong argillaceous odor when breathed upon.

The composition of the one specimen, which I received for examination, was found to be:

*Mr. Platt's Station 568.

Ferric oxide,	=	71.63	=	50.14 Metallic iron.
Manganic oxide, } Cobaltic oxide, }	=	0.53		
Alumina,		4.63		
Magnesia,		0.37		
Lime,		trace.		
Phosphoric acid,	=	1.67	=	0.73 Phosphorus.
Silicic acid,		3.69		
Quartz,		4.64		
Water,		12.84		
		100.00		

100 iron contain 1.43 phosphorus.

General remarks.

The amount of metallic iron in the calcined ores is as follows:

No. 1.	East Pennington bank,	51.49 per cent.
No. 2.	West Pennington bank,	57.07 per cent.
No. 6.	Rumbarger bank,	59.08 per cent.
No. 11.	Lytle bank,	65.30 per cent.
No. 14.	Bull bank — *a*, fibrous ore,	66.25 per cent.
No. 14.	Bull bank — *b*, average,	59.41 per cent.
No. 15.	Pond bank, No. 1,	63.14 per cent.
No. 16.	Red bank, No. 1,	50.46 per cent.
No. 19.	Whorrel bank,	55.64 per cent.
No. 21.	Rye bank,	61.17 per cent.
No. 24.	Dry Hollow bank—*a*, fibrous ore,	66.82 per cent.
No. 24.	Dry Hollow bank—*b*, average,	59·15 per cent.
No. 24*b*.	Red bank of Dry Hollow,	63.23 per cent.
No. 27.	Kerr and Bredin bank,	56.43 per cent.
No. 28.	Hostler bank,	62.80 per cent.
No. 29.	Pennsylvania bank—*a*, averge,	64.67 per cent.
No. 29.	Pennsylvania bank—*b*, pipe ore,	66.71 per cent.
No. 29.	Pennsylvania bank—*c*, sandrock,	33.44 per cent.
Ore from Old Cut N. of Gatesburg,		57.52 per cent.

All these ores were examined for sulphur and sulphuric acid, but not a single one gave a decided reaction for either. They were also examined for titanium, chromium, vanadium, and other metals, but with negative results.

Their only constituent, which has an injurious effect upon the quality of the iron produced from the same, is phosphoric acid; most of them, however, contain it in too small a quantify to be of much harm. Only two of the samples contain it in a larger proportion.

For better comparison, I will arrange the amounts of phosphorus which would be contained in 100 parts of iron, provided no loss of either would be sustained:

Fibrous ore of Bull bank,	0.06	Phosphorus.
Pipe ore of Pennsylvania bank,	0.10	Phosphorus.
Average ore of Pennsylvania bank,	0.12	Phosphorus.
Pond bank, No. 1,	0.127	Phosphorus.
Wrye bank,	0.15	Phosphorus.
Kerr and Bredin bank,	0.16	Phosphorus.
Red bank, No. 1,	0.195	Phosphorus.
N. E. or Upper Pennington bank,	0.197	Phosphorus.
Average of Bull bank,	0.20	Phosphorus.
Lytle bank,	0.278	Phosphorus.
Hostler bank,	0.28	Phosphorus.
Rumbarger bank,	0.30	Phosphorus.
S. W. or Lower Pennington bank,	0.32	Phosphorus.
Fibrous ore of Dry Hollow bank,	0.37	Phosphorus.
Red bank of Dry Hollow,	0.38	Phosphorus.
Sandrock of Pennsylvania bank,	0.39	Phosphorus.
Dry Hollow bank,	0.45	Phosphorus.
Whorell bank,	0.87	Phosphorus.
Old cut N. of Gatesburg,	1.43	Phosphorus.

Of all the ores submitted for examination only two appeared to be in a sufficient state of purity to throw light upon their constitution, as they were crystalline, and free from visible impurities. For this reason they were examined separately.

Taking into consideration only their principal constituents, viz: Ferric oxide, Silicic acid and water, the question arises, in which form the silicic acid is present, as it is undoubtedly in chemical combination with the ferric oxide and *not* in the form of a mechanical admixture of sand. If pieces of these fibrous limonites are placed into strong chlorhydric acid, all the ferric oxide will be extracted, and the silicic acid will remain in the shape of the original pieces, of a snow-white color and fibrous structure. The only hydrous ferric silicates, which are known, are Anthosiderite and Degerœite. The former is a crystalized mineral, which has a composition, represented by the formula $2Fe_2O_3, 9SiO_2+2H_2O$. It is very probable that, although observed in its pure state only at one locality, it occurs frequently as an admixture with other iron ores.—If we calculate for the 3.98 per cent of silicic acid in the fibrous mineral from Bull Mine, the requisite quantities of ferric oxide and water, we find 2.36 per cent of ferric oxide and 0.26 per cent of water, making an admixture of 6.60 per cent of anthosiderite. The atomic ratio between the remaining 79.12 per cent. of ferric oxide and 13.64 per cent of water is 1 : 1.53 or very near 2 : 3, showing the hydrous ferric oxide to be limonite = $2\ Fe_2\ O_3,\ 3\ H_2\ O$.

If in the same manner we examine into the composition of the fibrous mineral from the Dry Hollow, the 2.47 silicic acid require 1.46 per cent ferric oxide and 0.17 water, giving an admixture of 4.10 per cent of anthosiderite.—The atomic ratio between the remaining 81.67 per cent of ferric oxide and 12.75 per cent of water is 1 : 1.4, which also shows the ferric hydrate to be limonite, which, however, has already lost a small part of its water.

The above analyses show besides the mechanically admixed rounded grains of sand, which I distinguish as "quartz," a considerable quantity of silicic acid, which is in chemical combination, probably as a hydrous ferric oxide. But as it is impossible to say what the true character of this mineral may be, whether anthosiderite, or degerœite a silicate of the composition $Fe_2\ O_3,\ 2SiO_2+3H_2O$ or a species not yet known in its pure state, suffice it to say that all these ores are mechanical mixtures of limonite with hydrous ferric silicate and minute quantities of hydrous ferric phosphates, perhaps dufrenite or cacoxenite; some of the ores contain besides these, small quantities of manganese ores, mostly the so-called "bog-manganese" or wad, but also pyrolusite and silomelane.

It is a very remarkable fact that, although these iron ores are, to a great extent at least, the result of the decomposition of limestones and by them precipitated, that almost the entire amount of lime has been washed out of them and only traces are remaining; of the second constituent of the limestones, the magnesia, a somewhat larger quantity is left behind, owing undoubtedly to the lesser solubility of its carbonate in carbonic acid water.

Analyses of limestones.—Of the limestones only a few typical varieties have been more fully investigated, especially those from the Hostler and Pennsylvania banks.

No. 1. Limestone at head of Hostler bank.

It has a fine crystalline granular structure and is mottled, whitish, and gray; the surface is coated with ocherous argillaceous iron ore.

A pure specimen from which the iron had been carefully removed, contained:

Carbonate of iron,	=	0.80	=	0.39 Metallic iron.
Carbonate of manganese,	=	0.19	=	
Carbonate of magnesia,	=	35.19	=	16.76 Magnesia.
Carbonate of lime,	=	59.44	=	33.28 Lime.
Quartz and silicic acid,		3.84		
Alumina,		0.54		
		100.00		

The atomic ratio between magnesia and lime is 1:1.4, which is the composition of some of the "pearlspar" varieties of dolomite.

No. 2. Limestone in Hostler bank.

It lies four feet thick over 33 feet of pipe ore. It has an ash-gray color and a very fine grain, which is hardly perceptible to the naked eye; very friable. Its composition was found to be:

Carbonate of iron,	=	0.50	=	0.24 Metallic iron.
Carbonate of manganese,	=	0.24		
Carbonate of magnesia,	=	42.52	=	20.25 Magnesia.
Carbonate of Lime,	=	51.82	=	29.02 Lime.
Quartz and silicic acid,		4.33		
Alumina,		0.42		
Water,		0.17		
		100.00		

The atomic ratio between magnesia and lime is 1:1, which shows it to be a true dolomite.

No. 3. Upper limestone from Pennsylvania bank.

Dark-gray compact, slightly crystalline. The analysis gave the following results:

Carbonate of iron,	=	1.31	=	0.63 Metallic iron.
Carbonate of manganese,	=	0.18		
Carbonate of magnesia,	=	3.98	=	1.90 Magnesia.
Carbonate of Lime,	=	72.67	=	40.69 Lime.
Quartz and silicic acid,		18.05		
Alumina,		3.81		
		100.00		

The atomic ratio between magnesia and lime is 1 : 15.

No. 4. Limestone in the Pennsylvania bank.

Pale ash gray, very finely crystalline, rough to the touch like rotten stone, very friable and easily falling to powder.

Its composition was found to be:

Carbonate of iron,	=	0.45	=	0.22 Metallic iron.
" " manganese,	=	0.06		
" " magnesia,		42.39	=	20.19 Magnesia.
" " lime,		51.25	=	28.70 Lime.
Quartz and silicic acid,		5.03		
Alumina,		0.82		
		100.00		

The atomic ratio between magnesia and lime = 1 : 1 shows it to be a true dolomite.

Another Variety of Limestone in the Pennsylvania bank.

Yellowish gray, soft, rotten, feels rough to the touch, sandy; crystalline; has a laminated structure. Its analysis gave:

Carbonate of iron,	=	1.18	=	0.57 Metallic iron.
" " manganese,		trace.		
" " magnesia,		35.51	=	16.91
" " lime,		45.73	=	25.61
Quartz and silicic acid,		15.83		
Alumina,		1.75		
		100.00		

The atomic ratio between magnesia and lime = 1 : 1.08 proves it also to be a true dolomite.

It is remarkable that the limestones and dolomites, of which I give the analyses, contain almost the entire amount of silicic acid as quartz, only a small quantity is present as soluble silicic acid and in combination with alumina. If the limestones and dolomites are dissolved in acid, the quartz remains often as a scoriaceous mass or in irregular sandy but not rounded or water-worn grains; sometimes it forms large coherent slaty masses in the limestone, frequently filled with minute cavities, previously occupied by rhombohedral crystals of dolomite. Similar pieces found in the Pennsylvania bank are white, like porcelain and show the same cavities of rhombohedral crystals. Other varieties of limestone in the Pennsylvania bank have a still greater admixture of quartz and are a real calciferous sand rock.*

Analysis of Pennsylvania Pipe, and Pennington Ore. †

3, Devonshire Terrace, Kensington, London, W.,
January 5th, 1871.

DEAR SIR.—Herewith I beg to forward you the results of my analysis of the two samples of ore, marked, respectively, "Pipe ore," and "Pennington bank."

The whole of the samples were intimately pulverized together in each case; they contain:

	Pipe ore.		*Pennington bank.*
Silica,	10.84		5.42
Peroxide of iron,	73.18		79.05
Protoxide of iron,	.75		
Alumina,	2.51		1.29
Oxide of manganese,	traces.		.11
Carbonate of lime,	.20		
Carbonate of magnesia,	1.20	Magnesia.	.11
Phosphoric acid,	.17		.04
Combined water,	9.09		10.57
Moisture,	1.81		3.55
Sulphur,	.05		
	99.80		100.14
Metallic iron,	51.81		55.34
Metallic iron, exclusive of water,	58.25		64.35

Both these samples are rich iron ores, sample "Penning-

* These analyses summed up about 100, most of them a little above, one or two a little below, but all within the limits of unavoidable error; for better comparison I thought it advisable to calculate them for 100.00, from the actual result obtained. (F. A. Genth.)

†These analyses by an English chemist of well known reputation, especially entrusted by Mr. Bessemer with his numerous and important analyses, is here added for comparison.

ton bank" being nearly pure brown hematite. The pipe ore is a harder ore than "Pennington bank" ore.

I consider both samples of ore adapted for the manufacture of Bessemer pig.

Believe me to remain,

Yours, very faithfully,

EDWARD RILEY, F. C. S.,

Metallurgist, Analytical and Consulting Chemist

Analysis of "Pipe Ore," "Kerr & Bredin," and Pennington Bank Ores, by Ch. Aldendorf, Sub-Director of the George-Marien Hutte High Furnaces, March 9, 1872.

		Pipe ore.	Kerr & Bredin.	Pennington.
Water, ...		11.190	10.540	12.340
Insoluble residue,	$Si\ O^2$, Al^2O^3,	5.120	13.400	5.450
Oxide of iron,	F^2O^3.	82.050	73.560	79.450

		Pipe ore.	Kerr & Bredin.	Pennington.
Alumina,	Al^2O^3, . .	1.650	2.840	3.096
Oxide manganese,	Mn^2O^3, . .	0.270	0.190	0.440
Chalk,	CaO, . . .	0.370	0.460	0.440
Magnesia,	MgO, . .	trace.	trace.	trace.
Phos. acid,	$P.O^5$, . .	0.080	0.280	0.064
Sulphuric acid,	$S.O.^3$, . . .	trace.	trace.	trace.
		100.730	101.270	101.280
Per cent. metallic iron, . . .		57.435	51.492	55.615
Phosphorus in 100 iron, . . .		0.061	0.238	0.053
Per cent. iron, excluding water,		64.150	56.075	62.540

"The Pipe and Pennington ores, if melted together, would make a very superior Bessemer iron. The Kerr & Bredin *alone* an inferior Bessemer iron. A separate analysis, however, of Kerr & Bredin shows that its phosphorus is concentrated in the clay thereto attached, and it may be that this ore may be made available for Bessemer pig, by proper treatment before smelting."

Analyses of limestones by Otto Wuth, chemist, Pittsburgh, Pennsylvania.

1. From a quarry near the furnace — a gray crystalline stone:

Silicic acid,	5.08
Alumina,	1.34
Carbonate of iron,	.69
Carbonate of lime,	91.53
Carbonate of magnesia,	1.31
Sulphate of lime,	trace.
Organic matter,	.05

2. From Ore Bank Railroad cut—a partly crystalline drab-colored stone:

Silicic acid,	4.93
Alumina,	.24
Carbonate of iron,	.87
Carbonate of lime,	84.66
Carbonate of magnesia,	8.98
Sulphate of lime,	.11
Organic matter,	.21

Practical value of the ores.

The experience of 60 years has demonstrated the exact values of the brown hematite iron ores of all the lower Silurian valleys of Pennsylvania: on the Lehigh; in the Great or Cumberland valley; in Kishicoquillis valley; in Morrison's Cove, Canoe, and Nittany valleys.

The general resemblance of ores from all the banks is striking. The local variations are still more striking. The key to those variations was only got when the true geological theory of structure was studied out. But it is still a perplexing question why red-short, cold-short, and neutral ores should lie so near each other. There is scarcely an ore bank in Pennsylvania in which the chemist will not find some infusion of sulphur and phosphorus. But some ores have been so slightly charged with one or other, or both of these elements, that they rank in the first class.

Others are so heavily charged that they are useless for Bessemer work; take a low rank as anthracite or coke iron ores; and only make good pig-metal when smelted in small quantities, with charcoal and a feeble cold-blast.

This is especially true of those of the lowest geological horizon or oldest in age, belonging to rocks of Potsdam age, rocks which rise upon the flanks of the South Mountain. Fortunately, these ores nowhere reach the surface in Nittany valley, being buried in the jaws of the Bellefonte fault. Even the Pennington horizon is too high for these ores.

The consequence is, that most of the ores of the district under notice here yield a practically neutral ore and make the best possible iron in cold-blast charcoal furnaces, and good iron with the hot-blast, and mineral fuel. The appended analyses of Dr. Genth will make this fact evident.

Phosphorus, however, is found in all known Silurian brown hematite ores (with some rare exceptions) in quantity enough to prevent the manufacture of steel. But in some cases mixture with other ores will rectify the ore. In other respects, the percentage of phosphorus is too small to do hurt. Dr. Genth's analyses will give the figures in this case also.

The reputation of Pennsylvania iron was greatly made at Pennsylvania furnace. Its quality could not be surpassed. Neither the oldest Swedish, nor the best English, when English iron was still good, nor the more recent magnetite pig-metal of Lake Champlain and Missouri, have excelled it; and it shared this reputation with furnaces smelting similar ores.

There are parts of the deposit in almost every bank, which are sandy and lean. These have been hitherto fastidiously rejected by the charcoal coal-blast furnaces of the district. Such ores are, however, in demand for our anthracite and coke furnaces, and the ever-increasing market for them will require the mining of the whole. I believe that carefully selected ore from these banks will even furnish iron fit for Bessemer use.

Probable Quantity of Ore.

Estimates of the quantity of Brown Hematite Ores are among the most uncertain of all earthly things. Hence I give special statements of the size of excavation and prisms of ore ground in sight for each of the ore banks, in the chapter of this Report devoted to their local description.

The surface ore wash is of various depths from 1 to 30 feet. The breadth of surface covered is sometimes but a few yards; sometimes several hundred yards. Intervals occur where all traces of surface ore vanish from the belt.

The thickness of the underlying clays varies from a few feet to a hundred and more. Sometimes these clays are loaded with scattered pieces of ore, fine or coarse; at others they do not show a trace of ore. Sometimes the mass of clay is interstratified with layers of rock ore yielding richly.

The rock-ores and pipe-ores, bedded or in packets, under the clays are also excessively irregular, and nothing but actual mining can teach us the quantities concealed.

But any one who reads carefully the following descriptions of the ore banks taken up in succession, must arrive at the conclusion, that the Railway line connecting the ore deposits of Nittany Valley with Western Pennsylvania over Tyrone, and with Eastern Pennsylvania over Lewisburg, will have within the limits of my map, at its command for freight to distant iron works, many millions of tons of prepared ore of the choicest character.

One of the most noticeable features in the iron history of this district (and of other similar) has been denials of the existence of any ore just where the deposits were proved by subsequent diggings to be most copious, and predictions of the speedy exhaustion of ore banks which steadily grew in magnitude and richness as the excavations spread. The history of Pennsylvania Furnace Bank affords a notable instance, and not an isolated one.

There are not less than 100,000 linear yards of ore belt on my map. If the ore were continuous, and only 50 yards wide by 10 deep, we should have 50,000,000 cubic yards of ore ground. If only one tenth of this were ore, we have 5,000,000 cubic yards of ore. It only needs to look at the number, breadth and depth of the diggings, and their distribution on the map, and to remember that none are noted there but the principal cuts; that large spaces of ore belt have for various reasons never been explored; that in some the ore is seen going down to unknown depths; and that in all the banks water has stopped work—to appreciate the inadequacy of the above calculation.

Letter respecting Nittany Valley ores, by E. V. d'Invilliers, Philadelphia, May 18, 1885.

In response to your request that I should forward to you any notes relating to the structure and present condition of the ore banks in the Nittany valley of Huntingdon county, collected during a hasty reconnoissance of Warrior's Mark and eastern Franklin townships early in the present month, May, 1885, I beg leave to respectfully submit the following items, which you may use as you see fit, for incorporation in the forthcoming Huntingdon county report:

Structure. In my Centre county report T[4], pages 32–34, I described the Nittany valley, along the Centre-Huntingdon line, as being composed of *three* (3) anticlinal ridges, which I have named from north southwards: 1. *Chestnut* or *Buck ridge*, from 1½ to 2 miles south of Bald Eagle mountain; 2. *Gatesburg ridge*, 1½ miles further south; and finally, 3. *Sand* or *Tadpole ridge*, about 1½ miles still farther south, whose south-east flank faces Tussey.

The first of these, *Chestnut ridge*, I depicted (see section page 38) as an *overturned* anticlinal, with rather gentle south-east dips on its south flank, but steep and overturned dips on its north flank, along the deeply eroded Stormstown valley. It was in this part of the region that I got my lowest rocks, and consequently the greatest thickness to No. II, in all about 6000′+. I met with no serious difficulty in identifying this Chestnut Ridge axis with the Sand Ridge * (or main axis) of the valley in Marion and Walker townships, east towards Clinton county, though between Huntingdon county and this place the axis sinks to a point south of Bellefonte, being beautifully displayed in a regular and gentle arch, with dips of 6° in limestone, near

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*Not to be confounded with *Sand* or *Tadpole* ridge of Ferguson township.

the *Crust bank* south of Fillmore, and finally elevating the sandy measures low down in No. II, just east of the Spring-Marion township line.

Having thus traced it through Centre county eastward, I see but one difficulty in tracing it westward through Huntingdon, and identifying it with the *Sinking Valley* axis crossing the Little Juniata near Birmingham, viz: the comparatively gentle south-east inclination of a group of dips (45°, 50°, 60°, 68°) noted on your contour line map, along the headwaters of Warrior's Mark run, north-east of the village of that name, and dips of 20°, 22°, and 34° along the L. & T. R. R. south and east of the village, all of them *north* of my axis.

To your interpretation of this part of the valley, as given in your report to Lyon, Shorb & Co., I am disposed, in view of my preference for the *overturned* rather than the *faulted* structure, to suggest the following changes:

1. The extension of the Sinking Valley anticlinal, which is well marked as far east as the Pennington ore banks, eastward from Pennington to join my Chestnut Ridge axis, placing it *south* of Warrior's Mark village, and through that group of mines south-east of Warrior's Mark, known as the Bressler, Bean, Dry Hollow, and Little Dry Hollow banks, and between the latter and Lovetown.

2. The abolishment of the little Logan Creek synclinal trough.

From where this axis crosses Warrior's run, it begins to lift the lower sandy measures of No. II to daylight, until the maximum elevation of the arch is reached just east of the Centre county line and north of the Juniata Mining Co.'s bank. Consequently we should expect to find a close relationship between the ores of these Huntingdon county banks (Bressler, Bean, Dry Hollow, etc.) and those of Juniata and Scotia in Centre county—occurring in practically the same rocks. And such is really the case. The axis, sinking westward, naturally allows of higher limestone measures riding over its crest, and precisely similar results are obtained in consequence at the Pennington ore banks to those enumerated in the case of the Pond bank in Centre county (page

192, T⁴) situated just at the edge of the "Barrens" and just where the sinking anticlinal receives some layers of siliceous limestone, itself related to the lower part of the series of No. II.

This axis crosses the Little Juniata at Birmingham in a course of N. 45° E., according to Mr. Platt in Report T, page 87, and it may be said to keep this general direction to a point south of the Pennington ore banks. It then shifts 10° or 15° more to the east (and in view of the remarkable changes in the course of this and other axes in Huntingdon, this view is plainly admissible) its course will be almost a direct one N. 60–65° E. into Centre county. And in so doing it conforms to the next anticlinal, further south to be immediately described.

3. Passing to the consideration of the *Gatesburg anticlinal* and its identification in Huntington county, I have already stated that in Centre county it is situated about 1½ to 2 miles south of the Chestnut ridge, and it is so indicated on your contour line map of the Lyon, Shorb & Co. lands. There appears to be no difficulty in identifying this axis with Hickory ridge of Huntingdon, plainly marked where it crosses Half Moon run, 2 miles north of its junction with Spruce creek.

Between this anticlinal and the first one described, is the Dry Hollow synclinal.

As was the case in Centre county, this Gatesburg-Hickory Ridge axis is quite subordinate in Huntingdon county, dying rapidly east and west from Half Moon run, and carrying on its crest a second, but *higher*, sand-rock series than that of Chestnut ridge, as shown in my section T⁴, page 38. How far west it may be traced in Huntingdon county, I am unable to state, but it is probably lost before reaching Warrior's run; certainly no evidence of it exists along the Little Juniata, though it is probable that the Old Seat, Huntingdon furnace and Dorsey ore banks owe their existence above water level to its influence. Economically considered however, it is of little importance in either county, the higher limestones in the synclinals on both sides of it, carrying most of the ore.

4. The *Tadpole* or *Sand Ridge* axis of Centre county is evidently the eastern extension of the *Spruce Creek* anticlinal of Huntingdon. It is a regular arch, with about equal dips in both directions, and showing very little if any sandstone along its crest in Huntingdon county. It keeps almost a direct line of N. 55-65° E. from the river for 3 or 4 miles into Centre county; but west of the river it is bent sharply to the south, if it is to be connected at all with the Canoe Valley axis.

On its crest, north of Pennsylvania furnace, the limestone is about 3500′ below No. III at the base of Tussey mountain, and it is in this range of the upper measures of No. II that most of the pipe ores of the region are mined.

The development of the ore territory through this portion of Huntingdon county during the past ten years has been insignificant, when compared to the extent of favorable ground.

There are several reasons for this state of affairs, among which may be mentioned the lack of home furnaces and local consumption; the superiority and cheapness of the lake and foreign ores which compete with these hematites and pipe ores in the great iron centers of the State; the general dullness of the iron trade and the excessive royalties demanded by the owners of ore territory.

All through this valley, in both Huntingdon and Centre counties, the bulk of the land or mineral right is owned or controlled in large blocks by various corporate bodies, counteracting the possibility of getting any very advantageous leases, the contracts of the large companies all being made on the basis of 50 cents per ton royalty, with an additional clause providing for a minimum yearly output.

The most northern range of ore in the valley, the *Pennington—Lovetown* belt, is unrepresented by a single active operation to-day. The old banks are all fallen in and present a very dilapidated appearance, and very little ore has been shipped from them during the past ten years.

Beginning at the Pennington banks, about 2½ miles west of Warrior's Mark, the range can be traced with more or less interruption all along the slopes of this ridge and anticlinal 10 miles to the Lovetown bank of the Dunkirk Mining Company in Centre county. At present the ore in the Pennington bank lies deep, and it would be costly to raise, though in close proximity to the railroad.

The ore has been tested to about 60′ by shafts, with 30′ of wash ore already mostly robbed, and reports of 15′ of good lump ore in the bottom under 25′ of heavy clay.

The ore is a heavy liver-covered hematite, and in general mining will not average over 40 per cent of iron and with about 0.15 per cent phosphorus. Passing to the south side of the ridge, 500 yards east toward the summit of the Warrior's Mark road, the *Ale farm* shows some good and heavy crop ore; but it has never been prospected.

Beck's (*Jos.*) farm extends from here to the railroad crossing at the sand quarry. It has a fair showing of surface ore, and near the north-east point of the hill about 1600 tons of good hematite were raised. The country around here is sandy and offers little or no encouragement for a profitable operation.

The old *Town bank*, ½ mile east of Warrior's run, has changed but little in the past 10 years, showing numerous cuts and shafts on either side of the road, with the characteristics of an irregular deposit, 2 to 20 feet deep of wash ore, and with a very limited outcrop.

Addelman's farm, next east, was never worked, but shows a good body of wash hematite, confined to the flat between the railroad and public road.

Rumbarger's (*O. S.*), about 1 mile east of the village, shows a filled up water pit, in which the workings are said to have reached 40 feet in wash ore and clay, from which a considerable quantity of ore was raised by the Milesburg Iron Company.

There is an excellent quality of wash hemitite showing through about 10 acres of ground here, an analysis of which shows a very good percentage of iron. The deposit is shallow.

The *Conrad farm*, next east, shows about the same quality of ore through 3 acres in the flat, with a circular pit, marking the site of an old operation from which some good hematite was raised

The *Hanna farm* (*Saml.*), from which some 500 tons were raised for a Clinton county firm, continues this surface cropping eastward to the Pennsylvania furnace road. The ore looks very clean, and the topography is favorable for a good wash through 2 or 3 acres. From here eastward into Centre county more or less indications of ore mark this deposit through the farms of Henderson, Waite, Patton, Wrye, Mingle, Braunstetter, Stevens and Beck, though the crop is weak and surface flinty.

Henderson has recently raised some ore from high up in the limestone ridge; but the bulk of the ore is to be looked for lower down along the flat and ravine. The stripping is light here (5′—10′) and but very little rebellious and stiff clay is reported, with good prospects for lump ore at moderate depths. Mining and washing would be comparatively cheap here, and the railroad is only about 250 yards distant.

In the *Waite* farm, the cove becomes rather contracted, and the ore rides rather higher on the two ridges, especially to the north around the old *Waite bank*. Ore from this farm has been shipped in considerable quantities to Graff, Bennet & Co., Barre, and Johnstown, by the reopening of the old bank. This farm was shafted considerably by parties in the interest of the Messrs. Carnegie, though it is claimed that their shafts were not very judiciously located, and none of them over 20 feet deep. Some little pipe ore is mixed with the hematite along the south side of the stream, where indeed most of the surface show occurs. No systematic work has been done eastward to the Centre county line, the ore being inaccessible and lying under considerable cherty cover.

The central belt of the county, extending from the L. & T. R. R. 2 miles east of Warrior's Mark into Centre county, has been recently acquired by the Powel interests, who by purchase of the Schoenberger interests and a tribute of 25 cents per ton to Lyon, Shorb & Co., have tied up about 3300 acres of ground, comprising the site, of the Bressler, Bean, Dry Hollow, Dixon, Wrye, Whorrel and Reider openings.

Their principal opening is at the Dry Hollow bank, on the south slope of the anticlinal, where some excellent ore is being won. The measures here are the same sandy limestones which form the "Barrens" of Centre county, and the ore closely resembles that raised from similar horizons at the Juniata and Scotia mines

I made no detailed examination in this territory, though I heard excellent reports of both the quantity and quality of ore being mined.

South of the Dry Hollow synclinal, bearing this group of mines in its trough, the Hickory Ridge anticlinal shows a broad roll of sandy limestone measures, slightly higher strata than those comprising the first anticlinal, and singularly barren of ore. On its south slope it carries however the old *Kerr & Bredin* bank, whose ore won for itself quite a reputation in former days.

This bank has been long abandoned, and is apparently a circular pit of hematite ore, more closely related to the Dry Hollow range in its characteristics than to the pipe ore deposits of the true limestone. Similar ores are mined in Centre county, at the Pond and Lambourne banks. About 5000 or 6000 cubic yards of ground have been excavated, and the deposit tested by shafts to about 50 feet. Probably the last trial work done here was performed by Mr. James Pierpoint for the Celtic Iron Co., who estimated its contents at about 80,000 tons and reported the deposit as being pot-shaped, deep in the center and shelving rapidly toward the rim of the pit.

More or less outcroppings show east to Half Moon run; but they are so largely mixed with disintegrated sandstone as to be nearly worthless as indications of the true ore body.

The *Hostler ore bank* consists of two large open cuts on the *south* side of Cale Hollow and on the *north* flank of Spruce Creek anticlinal. It is about 2 miles from the

Pennsylvania Furnace (Bryson) bank, whose pipe ore it closely resembles, which was to be expected from its occurrence in precisely similar limestone rock, about 2500 feet below No. III slates. The surface wash revealed the presence of fine pipe ore mixed with a little lump, to a depth of from 50 to 60 feet, at which depth limestone was struck dipping N. W. There is little or no refractory clay found in this bank, a feature of most of the pipe ore deposits, and but little lean ore in consequence. Future mining though at this point will be comparatively expensive, as most of the wash has been removed, necessitating the mining of the deeper ore in sitû.

I believe there is quite a body of good pipe ore in this bank, but it must be won by the patient and slow pick and shovel process necessarily pursued in all similar deposits.

On the chemical erosion of the Nittany Valley limestone, by Prof. A. L. Ewing.

A paper read before the A. A. A. S., 1884, entitled:—

An attempt to determine the amount and rate of chemical erosion taking place in the limestone (Calciferous to Trenton) valley of Centre county, Pa., and hence applicable to similar regions throughout the Appalachian regions.

In the following results the nature of the case precludes the idea of even a close approximation to accuracy. It is claimed, however, that these determinations form a more reliable basis than mere estimates.

The method pursued is as follows: The amount of water flowing from a given hydrographical basin in the region under question is determined by taking the cross-section and velocity of the stream draining it. The amount of solids in the water is determined by evaporation. These data, with the area of the basin, form the basis of calculation.

The region selected is that of the Spring Creek basin, which forms a considerable portion of the limestone region of Centre county.

The measurements were made above the old dam below Bellefonte and below the entrance of all visible tributaries from the valley.

That a fair conception of the region may be had, a brief explanation of its geology is necessary. It forms a part of Nittany Valley, which valley, known by different names, extends through a considerable portion of the Appalachian region. It consists of the remains of a great anticlinal fold which, had it not been eroded away, would form an immense mountain-like plateau over 20,000 feet above its present height. As it is, the floor of the valley is composed of the upturned edges of the lower Silurian limestone, eroded through a thickness of 6000 feet.

The valley is flanked on either side by the overlying

Medina sandstone, which forms monoclinal ridges from 600 to 1000 feet above its floor.

The great amount of erosion that has taken place here is an interesting geological topic. That in early geological times it was due mainly to mechanical agencies caused by the steeper declivities is undoubtedly true. The present topographical features however, cannot be explained without considering the excessive chemical erosion of the limestone. This I believe is the opinion of all geologists who have visited the region. The water from the limestone contains a large amount of calcium and magnesium salts. That from the State College well gives .2273 grains per liter of solids, over 80 per cent of which is calcium and magnesium carbonates. Sink-holes, caves, &c., are common as in other limestone regions. Still I am not aware that any attempts have been made to determine the amount of erosion taking place by this process; hence the following is submitted:

Average width of stream where the measurements were taken, 22.86 metres, (75 ft.) Depth, average of six measurements across the bed of the stream, .823 metres, (2.7 ft.) This gives as the cross-section of the stream 18.81 m^2., (202.5 sq. ft.) Allowance was made in these determinations for obstruction from weeds, &c.

The velocity of the stream was determined by floating surface particles and by floating a long bottle weighted with shot, at various depths from .3 m. to .75 m., (the greatest depth of the stream being 1 m.) The velocity of the stream was found to be 994.776 m. per hour, this giving 18.712 m^3. as the amount of water removed per hour. The water shows on evaporation, average of two tests, 155.3 grains per m^3. giving 2,905,974 grains as the amount of solids removed per hour, or 25,456,560 kilos per annum. As the area of limestone drained by Spring creek is about 100 sq. m., this gives 255,654 kilos of solids as the amount removed per annum per square mile. This is equivalent to 282 tons.

A portion of the water carried off through Spring creek however falls not upon the limestone area considered above, but upon the mountains bordering the valley. Probably one fourth of the water considered above falls upon the mountains. To show that the main part of the solids comes from the limestone, however, I had specimens of the water, as it flows from the mountains, evaporated. An average of two tests gave 16.5 gr. per m^3. or a little over one tenth of the amount found in the water as it flows from the valley.

Thus not more than $\frac{1}{40}$ of the solids in Spring creek water probably comes from the mountains. Making this correction, it still leaves 275 tons per square mile as the amount annually removed in solution. A closer approximation could bemade by continuing observations similar to the above through a period of time, say for one year. To get the amount of water carried off in a year this would be necessary.

Yet it is evident that the amount of solids carried away in solution is much more constant than the amount of water flowing through the stream, as in times of freshet or excessive flow there is a larger proportion of surface water, while in times of diminished flow, a relatively larger portion of the water reaches the stream through underground drainage and must contain more solids.

Hence the above number, 275 tons per square mile, may be taken as a fair approximation to the amount of material actually removed per annum in this and similar regions.

According to the above determinations, and assuming that the solids removed have a specific gravity of 2.8, we get, as the cubic contents of the mass removed from the entire basin, 9,130.5 m^3, or 91.3 m^3 per square mile per annum. Making the deduction as before of $\frac{1}{40}$ for the amount brought from the mountains, and conceiving the remainder to be spread evenly over the surface, it would form a layer $\frac{1}{29173}$ of a metre in thickness. Hence, to lower the surface to the extent of 1 metre by this process, would require 29,173 years, or about 9,000 years to remove one foot from the surface.

It is safe to assume that had the rocks of this region been similar to those of the bordering mountains in their nature and power to resist dynamical agencies, we should have in place of Nittany valley a mild anticlinal plateau somewhat above the mountains in elevation; say 1000 feet above the present height of the valley.

The erosion in the valley then in excess of that along the mountains has been mainly chemical, and at least 1000 feet of limestone have been thus removed. A simple further deduction shows that accordingly Nittany valley has been 1,000,000 years in process of formation.

The limestone erosion could not begin before the latter stages of the Mesozoic era, possibly not before the Cenozoic era, as sufficient time must have elapsed subsequent to the carboniferous age to erode all formations of the Palæozoic era above the Trenton limestone. One million years seems not inconsistent with other estimates of geological time; still these calculations respecting time are an after-thought and supplementary to the main point intended to be shown in this paper, viz: the rate and amount of chemical erosion of limestone.

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THE PUBLICATIONS

OF THE

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

FROM 1874 TO 1885.

Reports have been issued by the Board of Commissioners, and the prices thereof fixed in accordance with the law authorizing their publication, as follows:

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B. Report on the MINERALS of Pennsylvania, by F. A. Genth; and on the hydro-carbon compounds, by S. P. Sadtler. With a reference map of the State. 8°, pp. 206, 1875. Price in paper $0 50, postage $0 08; in cloth $0 75, postage $0 10.

B 2. Report on the MINERALS, by F. A. Genth, continued from page 207 to page 238. 8°, in paper cover, pp. 31, 1876. (Bound with B.)

M. Report of CHEMICAL ANALYSES in 1874-5, in the Laboratory at Harrisburg, by A. S. McCreath. 8°, pp. 105, 1875. Price in paper $0 50, postage $0 05.

M 2. Report of CHEMICAL ANALYSES in 1876-8, by A. S. McCreath: Classification of coals, by P. Frazer; Fire-brick tests, by F. Platt; Dolomitic limestone beds, by J. P. Lesley; Utilization of anthracite slack, by F. Platt; Determination of Carbon in iron or steel, by A. S. McCreath. With one folded plate (section at Harrisburg) and four page plates. 8°, pp. 438, 1879. Price $0 65, postage $0 18.

M 3. Report of CHEMICAL ANALYSES in 1879-80, by A. S. McCreath. With a reference map of 93 iron ore mines in the Cumberland valley. 8°, pp. 126, 1881. Price $0 40, postage $0 10.

N. Report on the LEVELS above tide of railroad, canal and turnpike stations, mountain tops, &c., in and around Pennsylvania, in 200 tables, by C. Allen. With a map. 8°, pp. 279, 1878. Price $0 70, postage $0 15.

O. CATALOGUE of specimens collected by the survey (No. 1 to No. 4,264) by C. E. Hall. 8°, pp. 217, 1878. Price $0 40, postage $0 10.

O 2. CATALOGUE (continued from No. 4,265 to No. 8,974); also catalogue of fossils (pp. 231 to 239.) 8°, pp. 272, 1880. Price $0 40, postage $0 12.

O 3. CATALOGUE (continued from No. 8,975 to No. .) 8°, pp. , 1885. Price $, postage $. (*Waiting to go to press.*)

P. Report on the COAL FLORA of Pennsylvania and the United States, Vols. 1 and 2, (bound together,) by L. Lesquereux. 8°, pp. 694, 1880. Price $0 80, postage $0 28.

P. Report on the COAL FLORA of Pennsylvania and the United States, Vol. 3, with 24 double page plates (lithographed) of coal plants, to accompany P. Vols. 1 and 2. 8°, pp. 283, 1884. Price $1 20, postage $0 18.

(P.) ATLAS of 87 double page plates (lithographed) of coal plants, to accompany P. Vols. 1 and 2. 8°, 1879. Price $3 35, postage $0 22.

P 2. Report on Permo-Carboniferous plants from W. Va. and Greene county, Pennsylvania, by W. M. Fontaine and I. C. White. With 38 double page plates (lithographed) 8°, pp. 143, 1880. Price $2 25, postage $0 17.

P 3. Description of *Ceratiocaridæ*, by C. E. Beecher ; and of *Eurypteridæ*, by James Hall. With 8 plates. 8°, pp. 39, 1884. Price $0 60, postage $0 07.

Z. Report on the TERMINAL MORAINE across Pennsylvania, by H. C. Lewis; including extracts from descriptions of the Moraine in New Jersey, by G. H. Cook, and in Ohio, Kentucky, and Indiana, by G. F. Wright. With a map of the State, 18 photographic views of the moraine, and 32 page plate maps and sections. 8°, pp. lvi and 299, 1884. Price $1 40, postage $0 17.

GRAND ATLAS, Div. I, Pt. I, 1885, port-folio containing maps of 56 counties and parts of counties (scale 2 miles to 1 inch) on 49 sheets (26″×32″). The maps of the remaining counties will be published in Part II. These maps are duplicate prints on heavy paper of the county maps contained in the reports of progress. Price $7 25, expressage from Harrisburg, $

ANTHRACITE REGION.

A 2. Report on the causes, kinds, and amount of WASTE in mining anthracite, by F. Platt ; with a chapter on METHODS of mining, by J. P. Wetherill. Illustrated by 35 figures of mining operations, a plan of the Hammond breaker, and a specimen sheet of the maps of the Anthracite coal fields. 8°, pp. 134, 1881. Price $1 10, postage $0 12.

AC. Report on MINING METHODS, &c., in the anthracite coal fields, by H. M. Chance. Illustrated with 54 plates and 60 illustrations in the text. 8°, pp. 574, 1883. Price $1 40, postage $0 25.

AC. ATLAS containing 25 plates illustrating coal mining, to accompany Report AC, by H. M. Chance. 8°, 1883. Price $1 40, postage $0 12.

AA. First report of progress of the anthracite survey ; PANTHER CREEK BASIN, by C. A. Ashburner ; with a determination of the latitude and longitude of Wilkes Barre and Pottsville, by C. L. Doolittle ; and a theory of stadia measurements, by A. Winslow. 8°, pp. 407, 1883. Price $0 58, postage $0 18.

(AA.) ATLAS of SOUTHERN anthracite field, Part I, containing 13 sheets: 3 mine sheets, 3 cross section sheets, 3 columnar section sheets, 1 topographical map sheet, and 1 coal bed area sheet, relating to the PANTHER CREEK BASIN ; 1 general map of the anthracite region, and 1 chart of anthracite production from 1820 to 1881. 8°. 1882. Chas. A. Ashburner, Geologist in charge ; A. W. Sheafer and Frank A. Hill, Assistant Geologists. Price $1 50, postage $0 12.

(AA.) ATLAS of WESTERN MIDDLE anthracite field, Part I, containing 11 sheets: 4 mine sheets between Delano and Locust Dale, 3 topographical sheets between Quakake Junction and Mount Carmel, and 4 cross section sheets. 8°,

NOTES.—Single sheets of the Anthracite Survey, with the exception of those in the Panther Creek atlas, can be purchased by addressing Chas. A. Ashburner, Geologist in Charge, 907 Walnut street, Philadelphia. See page 9.

1884. Chas. A. Ashburner, Geologist in charge; A. W. Sheafer and Bard Wells, Assistant Geologists. Price $1 65, postage $0 11.

(**AA.**) ATLAS of NORTHERN anthracite field, Part I, containing 6 mine sheets between Wilkes Barre and Nanticoke, 3 cross section sheets, and 4 columnar section sheets. 8°, 1885. Chas. A. Ashburner, Geologist in charge; Frank A. Hill, Assistant Geologist. Price $, postage $.

(**AA.**) GRAND ATLAS, Div. II, Pt. I, 1884, port-folio containing 26 sheets (26″×32″) as follows: 13 sheets Atlas Southern Anthracite Field, Part I, 11 sheets Atlas Western Middle Anthracite Field Part I, 1 sheet photo views of plaster models in Western Middle and Southern Fields, and 1 specimen sheet Report A 2. Price $4 25, expressage from Harrisburg $.

For anthracite coal in SULLIVAN county, see G 2.

For Conglomerate beds near Carbondale, Pittston, &c., see G 5, G 7.

For Utilization of anthracite slack, see M 2.

For single sheets see page 9.

BITUMINOUS COAL FIELDS AND SURROUNDING AREAS.

H. First report on CLEARFIELD and JEFFERSON counties, by F. Platt. With 8 maps, 2 sections, and 139 cuts in the text. 8°, pp. 296, 1875. Price unbound $1 50, postage $0 13 (*For second report see H 6, H 7.*)

H 2. Report on CAMBRIA county, by F. & W. G. Platt. With 4 maps and sections and 84 cuts in the text. 8°, pp. 194, 1877. Price $1 00, postage $0 12.

H3. Report on SOMERSET county, by F. & W. G. Platt. With 6 maps and sections and 110 cuts in the text. 8°, pp. 348, 1877. Price $0 85, postage $0 18.

H 4. Report on INDIANA county, by W. G. Platt. With a colored geological county map and 87 cuts in the text. 8°, pp. 316, 1878. Price $0 80, postage $0 14.

H 5. Report on ARMSTRONG county, by W. G. Platt. With a colored geological county map, and 58 cuts in the text. 8°, pp. 338, 1880. $0 75, postage $0 16.

H 6. Second report on JEFFERSON county, (*See H above,*) by W. G. Platt. With a colored geological county map, and 57 cuts in the text. 8°, pp. 218, 1881. Price $0 60, postage $0 12.

H 7. Second report on CLEARFIELD county, (*see H above,*) by H. M. Chance. With a colored geological county map, an outcrop map of the Houtzdale basin, and 58 cuts in the text. 8°, pp. 197, 1884. Price $0 85, postage $0 11.

I. Report on VENANGO county, by J. F. Carll. The geology around Warren, by F. A. Randall. Notes on the comparative geology of N. E. O., N. W. Pa. and W. N. Y., by J. P. Lesley. With one small map of the Venango oil region; one small map of the region south and east of Lake Erie; one long section of the rocks at Warren; and 7 cuts in the text. 8°, pp. 127, 1875. Price in paper, $0 60, postage $0 05.

I 2. Report of oil well records and levels in VENANGO, WARREN, CRAWFORD, CLARION, ARMSTRONG, BUTLER, &c., by J. F. Carll. 8°, pp. 398, 1877. Price $0 60, postage $0 18.

I 3. Report on the VENANGO, WARREN, CLARION, and BUTLER OIL REGIONS; descriptions of rig, tools, &c.; survey of the Garland and Panama conglomerates, &c.: discussion of preglacial and post glacial drainage; by J. F. Carll. With 23 page plates, and an atlas. 8°, pp. 482, 1880. Price (of volume and atlas together) $2 30, postage $0 30.

(**I 3.**) ATLAS of 22 sheets. Map of Venango county, colored geologically; map of lower oil field (Butler, Armstrong and Clarion) in 2 sheets; 3 local contour maps at Franklin, Titusville, and Spring creek; two maps of N. W. Pennsylvania showing the past and present drainage; long section across W. Pennsylvania; vertical section of the formations from the Upper Coal Measures down to the bottom of the Devonian; diagram map and section of Third sand; profile section from Meadville, S. W.; 5 sheets of grouped oil well sections; 5 sheets of working drawings for well boring, &c.; diagram of daily rate of drilling six wells at Petrolia. (*Sold only with the report.*)

I 4. Report on WARREN county, by J. F. Carll. With a colored geological county map, a map of the Warren oil region, and 2 sheets of oil well sections. 8°, pp. 439, 1883. Price $1 12, postage $0 20. (*Note. The first 147 pages of this book contain oil well records; see under Petroleum Fields below.*)

J. Report on the OIL REGION, by H. E. Wrigley; map and profile of line of levels through Butler, Armstrong, and Clarion, by D. J. Lucas; map and profile of Slippery Rock creek, by J. P. Lesley. 5 maps and sections, a plate and 5 cuts. 8°, pp. 122, 1875. Price in paper $0 75, postage $0 06.

K. Report on GREENE and WASHINGTON counties, by J. J. Stevenson. With two county maps. (Showing the calculated local depths of the Pittsburg and Waynesburg coal beds beneath the surface,) and 3 page plates of general sections. 8°, pp. 419, 1876. Price, in paper, $0 65, postage $0 16. (*Note.—Since the publication of this book, two colored geological county maps have been published, and will be found in pocket of volume K 3 described below.*)

K 2. First report on FAYETTE, WESTMORELAND, and S. E. ALLEGHENY counties, (*i. e.* west of Chestnut ridge,) by J. J. Stevenson. With 3 colored geological county maps, and 50 cuts in the text. 8°, pp. 437, 1877. Price $1 40, postage $0 20.

K 3. Second report on FAYETTE and WESTMORELAND counties, (the Ligonier valley,) by J. J. Stevenson. With 4 page plates, and 107 cuts in text. 8°, pp. 331, 1878. Price $1 40, postage $0 16. (*Note.—In a pocket in this volume will be found the colored geological maps of Greene and Washington counties, alluded to above.*)

K 4. Pt. I, Report on the MONONOAHELA river COAL MINES, from the West Virginia State line to Pittsburgh, (including some on the Youghiogheny and other streams,) by J. Sutton Wall. With a map of the region in a pocket, 12 heliotype pictures, and 26 page plates. 8°, pp. 231, 1884. Price $1 15, postage $0 14.

L. Report on the YOUGHIOGHENY coke manufacture, by F. Platt; Notes on the coal and iron ore beds, by C. A. Young; Report on methods of coking, by J. Fulton, (*See G* below;) Report on the use of natural gas in the iron manufacture, by J. B. Pearse and F. Platt; The Boyd's hill gas well at Pittsburg, by J. P. Lesley. With a map of the coke region, two folded plates of coke ovens, and page plates and cuts in the text. 8°, pp. 252, 1876. Price $1 00, postage $0 13.

Q. Report on BEAVER, N. W. ALLEGHANY, and S. BUTLER counties, by I. C. White. With 3 colored geological county maps, and 21 page plates of sections. 8°, pp. 337, 1878. Price $1 40, postage $0 20.

Q 2. Report on LAWRENCE county, and special Report on Correlation of the Pennsylvania and Ohio coal beds, by I. C. White. With a colored geological county map, and 134 cuts in the text. 8°, pp. 336, 1879. Price $0 70, postage $0 15.

Q 3. Report on MERCER county, by I. C. White. With colored geological county map, and 119 cuts in the text. 8°, pp. 233, 1880. Price $0 60, postage $0 11.

Q 4. Report on CRAWFORD AND ERIE counties, by I. C. White. With two colored geological county maps, and 107 cuts in the text. Also, a Report on a preglacial outlet for Lake Erie, by J. W. Spencer. With two maps of the Lake region. 8°, pp. 406, 1881. Price $1 17, postage $0 18.

R. Report on McKEAN county, and its geological connections with Cameron, Elk, and Forest counties, by C. A. Ashburner. With 33 page plates of vertical and columnar sections, pictures of Rock city and Olean conglomerate, Wilcox and Kane spouting wells, map of Howard Hill coal field, &c., and an atlas of 8 sheets. 8°, pp. 371, 1880. Price of Volume and Atlas together $1 70, postage $0 22.

(R.) ATLAS for McKean county of 8 sheets:—Colored geological county map; three topographical maps; of Buffalo Coal Company tract, Alton coal basin, and Potato Creek coal basin; map of McKean oil district; one sheet of columnar sections between Bradford and Ridgway; and 2 diagram sheets of the Well account and Production account in the Bradford district. (*Only sold with Report R.*)

R 2. Part II, Report on township geology of CAMERON, ELK AND FOREST counties, by C. A. Ashburner. (*To appear about March 15, 1885.*)

(R 2.) ATLAS for CAMERON, ELK AND FOREST counties, of 11 sheets (*published November, 1884, in advance of the report*):—3 colored geological county maps; 1 anticlinal and synclinal map; 1 topographical map McKean county; 2 tract maps Forest and Elk counties; 1 map Straight Creek coal basin; 2 sheets oil well sections; and 1 sheet coal sections. Price $0 65, postage $0 08.

V. Report on N. BUTLER county; and (Part 2) special report on the Beaver and Shenango river coal measures, by H. M. Chance. With a colored geological map of N. Butler; a contour local map around Parker; a map of the anticlinal rolls in the 6th basin; a chart of the Beaver and Shenango rivers; profile section from Homewood to Sharon; Oil well records and surface sections; and 154 cuts in the text. 8°, pp. 248, 1879. Price $0 70, postage $0 15.

V 2. Report on CLARION county, by H. M. Chance. With a colored geological county map; a map of the anticlinals and oil-belt; a contoured map of the old river channel at Parker; 4 page plates, and 83 cuts in the text. 8°, pp. 232, 1880. Price $0 43, postage $0 12.

For the coal basins of BRADFORD and TIOGA counties see report G.

For the coal basins of LYCOMING and SULLIVAN see report G 2.

For the coal basins of POTTER county see G 3.

For the coal basins of CLINTON county see G 4.

For the coal in WAYNE county see G 5.

For the East Broad Top coal basin in HUNTINGDON county see F.

For the mountain coals in BLAIR county see T.

For the Broad Top coal measures in BEDFORD and FULTON counties see T 2.

For the coal basins in CENTRE county see T 4.

For coal analyses, see M, M 2, M 3.

For classification of coals, see in M 2.

For coal plants, see P, P 2.

For fossil crustaceans in coal slate, see P 3.

PETROLEUM AND GAS.

See reports I, I 2, I 3, I 4, and J under Bituminous Coal Fields.

See L, for the Pittsburgh gas well, and the use of gas in the iron manufacture.

See Q, Q 2, Q 3, Q 4, for references to oil rocks in Beaver, Lawrence, Mercer, Crawford, Erie, and S. Butler counties.

See K for the Dunkard creek oil wells of Greene county.

See R, R2, for descriptions of oil rocks in McKean, Elk, and Forest counties.

See V, V 2, for notes on the oil rocks of N. Butler, and Clarion counties.

See H 2 for oil boring at Cherry Tree, Cambria county.

See G 5 for oil boring in Wayne county.

NORTH-EASTERN AND MIDDLE PENNSYLVANIA.

(*Palæozoic formations from the Coal down.*)

D. First report on LEHIGH county iron mines, by F. Prime. With a contour line map of the ore region, and 8 page plates. 8°, pp. 73, 1875. Price in paper $0 50, postage $0 04.

D 2. Second report on LEHIGH county iron mines, by F. Prime. With a colored geological contour line map of the iron region, (in 4 sheets,) a colored geological contour line map of the Ironton mines, 4 double page lithograph pictures of Limestone quarries, and one page plate of *Monocraterion.* 8°, pp. 99, 1878. Price $1 60, postage $0 12.

D 3. Vol. 1. Report on LEHIGH and NORTHAMPTON counties. Introduction, by J. P. Lesley; Slate belt, by R. A. Saunders; Limestone belt and iron mines, by F. Prime; South mountain rocks, by F. Prime and C. E. Hall. With 3 lithograph pictures of quarries, 4 pictures of triangulation stations, 14 page plates of sections, and an atlas of maps. 8°, pp. 283, 1883. Price $0 65, postage $0 13. (*Note, for atlas see below.*)

D 3. Vol. II, part I. Report on BERKS county, (*South Mountain belt,*) by E. V. D'Invilliers. With 10 page plates of sections and Indian relics, and 3 pictures of rock exposures. 8°, pp. 441, 1883. Price $0 55, postage $0 18. (*Note, for atlas see below, as before.*)

(**D 3.**) ATLAS: One colored geological map of *Lehigh* and Northampton counties, (*one sheet*); one colored geological contour line map of Southern Northampton county, (*six sheets*); a contour line map of the mountains from the Delaware to the Schuylkill, (*eighteen sheets*); a colored geological contour line index map to the 22 sheets, (*one sheet*); and 4 sheets of maps of Iron mines. Price of Atlas $2 80, postage $0 17.

D 5. ATLAS of colored geological county maps of CUMBERLAND, FRANKLIN, and Adams, (*three sheets*); and first instalment of contour line map of the South mountains, Sheets A 1, A 2, B 1, B 2, (*four sheets,*) by A. E. Lehman. Price of Atlas $1 25, postage $0 08.

F. Report on the JUNIATA RIVER district in MIFFLIN, SNYDER and HUNTINGDON counties, by J. H. Dewees; and on the Aughwick valley and East Broad Top region in HUNTINGDON county, by C. A. Ashburner. With colored geological maps of East Broad Top R. R. and Orbisonia vicinity (2 sheets); Three Springs map and section (2 sheets); Sideling Hill creek map and section (2 sheets); and Isometric projection at Three Springs (1 sheet); six folded cross sections and 22 page plates of local maps, and columnar sections. 8°, pp. 305, 1878. Price $2 55, postage $0 20.

F 2. Report on PERRY county, (*Part I, geology,*) by E. W. Claypole. With two colored geological maps of the county; 17 geological outline township maps as page plates; and 30 page plate cross and columnar sections. 8°, pp. , 1884. Price $, postage, . (*In press, October, 1884.*)

G. Report on BRADFORD and TIOGA counties, by A. Sherwood; Report on their coal fields (including forks of Pine creek in Potter county), by F. Platt; Report on the COKING of bituminous coal, by J. Fulton. (*See L above.*) With 2 colored geological county maps, 3 page plates, and 35 cuts in the text. 8°, pp. 271, 1878. Price $1 00, postage $0 12.

G 2. Report on LYCOMING and SULLIVAN counties: field notes by A. Sherwood; coal basins by F. Platt. With 2 colored geological county maps (of Lycoming and Sullivan), a topographical map (in two sheets) of the Little Pine creek coal basin, and 24 page plates of columnar sections. 8°, pp. 268, 1880. Price $1 06, postage $0 14.

G 3. Report on POTTER county, by A. Sherwood. Report on its COAL FIELDS, by F. Platt. With a colored geological county map, 2 folded plates, and 2 page plates of sections. 8°, pp. 121, 1880. Price $0 58, postage $0 08.

G 4. Report on CLINTON county, by H. M. Chance; including a description of the Renovo coal basin, by C. A. Ashburner; and notes on the Tangascootac coal basin, by F. Platt. With a colored geological county map, 1 sheet of sections, local Renovo map, 6 page plates, and 21 sections in the text. 8°, pp. 183, 1880. Price $1 05, postage $0 12.

G 5. Report on SUSQUEHANNA and WAYNE counties, by I. C. White. With a colored geological map of the two counties, and 58 cuts in the text. 8°, pp. 243, 1881. Price $0 70, postage $0 12.

G 6. Report on PIKE and MONROE counties, by I. C. White. With two colored geological county maps, (1 sheet Pike and Monroe, and 1 sheet Wyoming,) a map of glacial scratches, and 7 small sections. Report on the Delaware and Lehigh water gaps, with two contoured maps and five sections of the gaps, by H. M. Chance. 8°, pp. 407, 1882. Price $1 15, postage $0 15.

G 7. Report on WYOMING, LACKAWANNA, LUZERNE, COLUMBIA, MONTOUR, and NORTHUMBERLAND counties, (*i. e.* the parts lying *outside* of the anthracite coal fields,) by I. C. White. With a colored geological map of these counties, (in two sheets,) and 31 page plates in the text. 8°, 464, 1883. Price $0 85 and postage $0 20. (*Note.—The colored geological map of* WYOMING *county is published in G 6.*)

S. Report on the Seven mountains in HUNTINGDON, UNION, AND SNYDER counties, by C. E. Billin. With a colored geological contour line map of the mountains (1 sheet); maps of the fossil ore outcrops, and Stone mountain fault; and colored geological cross sections, (2 sheets.) 8°, pp. , 1885. Price $, postage $. (*In press.*)

T. Report on Blair county, by F. Platt. With 35 cuts in the text, and an Atlas of maps and sections, (See below.) 8°, pp. 311, 1881. Price *with atlas* $4 55, postage $0 28.

(T.) ATLAS of colored geological contour line map of Morrison's cove, Canoe valley, Sinking valley, and country west to the Cambria county line, (14 sheets); Index map of the same (1 sheet); colored sections, (2 sheets.) 8°, 1881. (Note.—*The Atlas is not sold separately.*)

T 2. Report on BEDFORD and FULTON counties, by J. J. Stevenson. With two colored geological maps of the two counties. 8°, pp. 382, 1882. Price $0 80, postage $0 20.

T 3. Report on HUNTINGDON county, by I. C. White. With a colored geological map of the county; and numerous sections. 8°, pp. , 1885. Price $, postage $. (*In press.*)

T 4. Report on CENTRE county, by E. V. D'Invilliers; also, special report by A. L. Ewing; and extracts from report to Lyon, Shorb & Co., by J. P. Lesley. With a colored geological map of the county, 13 page plates of local maps and sections, and 15 cuts in the text. 8°, pp. 464, 1884. Price $0 80, postage $0 19.

See also report on the line of the Terminal Moraine, Z.

SOUTH-EASTERN PENNSYLVANIA.

C. Report on YORK and ADAMS counties, by P. Frazer. With one folded map of a belt of York county through York and Hanover, 6 folded cross sections, and two page plate, microscopic slices of dolerite. 8°, pp. 198, 1876. Price in paper $0 85, postage $0 10. (*Note.—The colored geological county map of* YORK *is published in the* ATLAS *to C 3.*)

C 2. Report on YORK and ADAMS counties, (South Mountain rocks, iron ores, &c.,) by P. Frazer. With one general map of the district; 10 folded cross sections; and 5 page plates. 8°, pp. 400, 1877. Price $1 25, postage $0 12. (*Note.—The colored geological county maps of* ADAMS *is published in* D 5.)

C 3. Report on Lancaster county by P. Frazer. With nine double page lithographic views of slate quarries, and Indian-pictured rocks; one plate of impressions on slate and one page plate microscopic section of trap; and an atlas. 8°, pp. 350, 1880. Price of report and atlas $2 20, postage $0 25.

(C 3.) ATLAS of 13 sheets:—Colored geological map of YORK county; colored geological map of LANCASTER county; Susquehanna river section (Sheets 1, 1A, 2, 2A, 3, 4); Lancaster section; Pequea section; Muddy run section; Chestnut-hill mines; Gap nickel mine. (*Note.—Atlas sold only with report.*)

C 4. Report on CHESTER county; General description, pp. 214, by J. P. Lesley; Field notes in the townships, pp. 215–354, by P. Frazer. With a colored geological county map, a photographic view of contorted schists, and 12 page plates. 8°, pp. 394, 1883. Price $0 75, postage $0 18.

C 5. Report on DELAWARE county, by C. E. Hall. With a colored geological county map; a contour line map around Media; 30 photographic page-plate views of granite quarries, Kaolin pits, &c., and 4 page plates of altered micas. 8°, pp. , 1885. Price $, postage $. (*Partly printed; but publication delayed.*)

C 6. Report on PHILADELPHIA and the southern parts of MONTGOMERY and BUCKS counties, by C. E. Hall. With a colored geological map of the belt of country between Trenton and Delaware county (in 3 sheets); a sheet of colored cross-sections, and 24 cuts in the text. 8°, pp. 145, 1882. Price $1 65, postage $0 13.

E. Part I of (historical introduction to) a report on the AZOIC rocks, by T. S. Hunt. 8°, pp. 253, 1878. Price $0 48, postage $0 12.

VOLUMES PUBLISHED AND ON SALE, MARCH 1, 1885.

A.	D 2.	H 7.	P atlas.
A 2.	D 3, Vol. I.	I.	P 2.
AC.	D 3, Vol. II, part I.	I 2.	P 3.
AC atlas.	D 3 atlas.	I 3.	Q.
AA.	D 5 atlas.	I 3 atlas.	Q 2.
AA atlas (1.)	E.	I 4.	Q 3.
AA atlas (2.)	F.	J.	Q 4.
Grand atlas, Div. II, Pt. I.	G.	K.	R.
	G 2.	K 2.	R atlas.
Grand atlas, Div. I, Pt. I.	G 3.	K 3.	R 2 atlas.
	G 4.	K 4, Pt. 1.	T.
B.	G 5.	L.	T atlas.
B 2, (exhausted.)	G 6.	M.	T 2.
C.	G 7.	M 2.	T 4.
C 2.	H.	M 3.	V.
C 3.	H 2.	N.	V 2.
C 3 atlas.	H 3.	O.	Z.
C 4.	H 4.	O 2.	——
C 6.	H 5.	P, Vols. I, II.	75.
D.	H 6.	P, Vol. III.	

Other reports of the Survey are in the hands of the State Printer and will soon be published.

SINGLE SHEETS ANTHRACITE REGION.

In order to make the results of the survey in this region immediately available, 200 copies of each sheet (size 26×32 inches) will be sold singly as soon as printed. Remittances* for the same and communications respecting the Anthracite Survey should be addressed to

CHAS. A. ASHBURNER, *Geologist in Charge,*
907 Walnut street, Philadelphia.

General Map Anthracite Coal Fields, scale $\frac{1}{300000}$ths of nature (about $4\frac{3}{4}$ miles to one inch) showing the outlines of the coal basins and outlets to market; with list of working mines during 1882 and 1883 with their annual production,

Printed on light paper, ... Price $0 11
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Printed on light paper with counties colored, ... Price $0 13

Geological and Mine Sheets, scale 800 feet to 1 inch $\frac{1}{9600}$ths of nature, showing the geology, mine workings, and the shape of the floor of the coal beds by contour curve lines 50 feet vertically apart.

DELANO SHEET[1], Western Middle Field, in vicinity of Delano and East Mahanoy City, ... Price $0 22

SHENANDOAH SHEET[1], Western Middle Field, in vicinity of West Mahanoy City, Shenandoah, and Gilberton, Price $0 26

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SHEET No. I, WESTERN MIDDLE FIELD[1] } in vicinity of Delano and Mahanoy City, ... Price $0 11

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1. Contained in Atlas W. M. A. F. Part I.
2. Contained in Atlas N. A. F. Part I.
3. Contained in Atlas E. M. A. F. Part I.
4. Contained in Atlas S. A. F. Part I.

Cross Section Sheets contain vertical cross sections, scale 400 feet to 1 inch, $\frac{1}{4800}$ths of nature; reference maps scale 1 mile to 1 inch, $\frac{1}{63360}$ths of nature; &c.

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SHEET NOS. I, II and III, SOUTHERN FIELD[4],	25 sections; through collieries L. C. and Nav. Co., between Mauch Chunk and Tamaqua, (See foot-note, page 4.)	

Columuar Section Sheets contain sections showing thickness and character of coal measures, scale 40 feet to 1 inch, of coal beds scale 10 feet to 1 inch, &c., &c.

SHEET NO. I, NORTHERN FIELD[2],	contains sections at Bennett, Pine Ridge, Enterprise, Henry, Wyoming, Oakwood, Prospect, Conyngham, Baltimore, Diamond, Hollenback, Laurel Run, Mineral Spring, and Red Ash collieries, ...	Price $0 11
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SHEET NO. III, NORTHERN FIELD[2],	contains sections at Maltby, Forty Fort, Harry E, Black Diamond, East Boston, Kingston, Mill Hollow, Plymouth, Boston, &c., collieries, ...	Price $0 11
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Other Anthracite sheets are in the hands of the State Printer and will soon be printed.