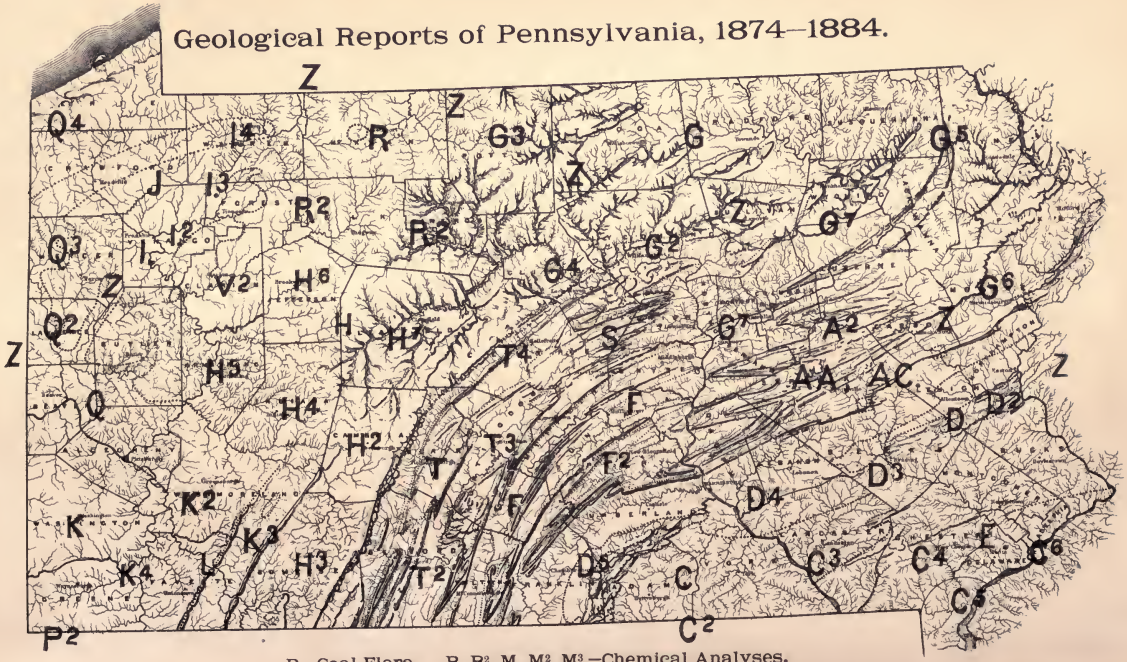
PRESTON E. CLOUD, JR.



P.—Coal Flora. B, B², M, M², M³,—Chemical Analyses.
N.—Levels. O, O²,—Catalogue of Specimens.

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

REPORT OF PROGRESS.

T.

THE GEOLOGY OF CENTRE COUNTY,

BY

E. V. d'INVILLIERS.

APPENDIX A.

EXTRACTS FROM REPORT TO LYON, SHORB & CO.,

By J. P. LESLEY.

APPENDIX B.

OBSERVATIONS ON THE GEOLOGICAL FORMATIONS.

By A. L. EWING.

WITH A COLORED GEOLOGICAL MAP OF THE COUNTY; AND PAGE PLATES OF LOCAL SKETCH MAPS, CROSS SECTIONS, COLUMNAR SECTIONS, ETC.

HARRISBURG:
PUBLISHED BY THE BOARD OF COMMISSIONERS
FOR THE SECOND GEOLOGICAL SURVEY.
1884.

Entered, for the Commonwealth of Pennsylvania, in the year 1884, according to acts of Congress,

By WILLIAM A. INGHAM,
Secretary of the Board of Commissioners of Geological Survey,
In the office of the Librarian of Congress, at
WASHINGTON, D. C.

Electrotyped and printed by
LANE S. HART, State Printer,
Harrisburg, Pa.

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LETTER OF TRANSMITTAL.

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 to the Board, for publication, a carefully written and as I think accurate report on the geology of Centre county, by Mr. E. V. d'Invilliers, whose excellent topographical and geological work in Berks county was published last year (see D. 3, Vol. 2, part 1.)

The preparation of a report on Centre county was undertaken early in the history of the Survey, but was again and again interrupted by events incident to all such undertakings, where the geological facts are of a difficult kind, and mineralogical interests are of unusual importance.

The coal measures of Centre county have been carefully examined and described by Mr. d'Invilliers, and references made to the work done in Clearfield county by Mr. F. Platt in 1874, and by Dr. Chance in 1873, and published in Reports H and H'.

The iron ore mines of Centre county have been visited and described at four different times by Mr. F. Platt, by Mr. A. S. McCreath, by Mr. W. G. Platt, and by Mr. d'Invilliers, as well as by myself, by the late Mr. J. W. Harden, and by Prof. A. L. Ewing, of the State Agricultural College.

The facts thus obtained have been used by Mr. d'Invilliers in this report.

In Appendix A will be found my own notes and sketches, Dr. Genth's analyses, and Mr. Harden's observations.

In Appendix B will be found Prof. Ewing's report.

An Index of personal and place-names and of notable geological facts and fossils is appended. The pressure of duties connected with the publication of current reports has prevented me from preparing a special geological index.

The large colored county map has been constructed by Mr. d'Invilliers, with his usual patient attention to details, out of the best materials at command, some of which in the western townships are new. A portion of Clinton county has been added to the map to show the geological structure of the Nittany valley region. The district bordering on Mifflin and Union counties has been colored in accordance with the still unpublished survey of the Seven Mountains, by Mr. Billin.

In this map for the first time three tints have been employed to distinguish the three sub-divisions of No. IV, (Upper, Middle, and Lower,) the Medina white, the Medina red, and the Oneida gray sandstones. This was needful for bringing out the peculiar topography of the Centre county Silurian mountains.

The small map printed on page 352, containing the Pennsylvania, Lovetown, and some other ore banks, is part of my map of 1873–'4, the whole of which will be given in the forthcoming report on Huntingdon county (T ,) together with Mr. E. B. Harden's beautiful contour-line map of the Bald Eagle mountain and Logan's Run valley, along the Little Juniata from Tyrone to Birmingham.

The six transverse sections of Nittany valley given by Mr. d'Invilliers on pages 28, 34, and 48, show the anticlinal structure of the central ridge, or Barrens, with the pronounced tendency towards vertical (or overthrown) northwest dips on the Bald Eagle Mountain side. Much additional information respecting the faulted condition of that side of the fold is desirable. Prof. Ewing's notes of the outcrops around Scotia bear upon this point; and the data to be published in the Huntingdon county report will include an interesting exhibition of three cross-faults which throw the mountain to an extent equal to its width.

Prof. Ewing makes an important addition to our knowledge of the outcrop of the Oriskany sandstone No. VII

along the Bald Eagle valley. He describes, on page 430, a projection of this outcrop above the surface at a point several miles further south-west than any observed by Mr. d'Invilliers. It illustrates the excessively irregular character of this curious formation—one especially interesting to business men for furnishing the best deposits of glass-sand, and to systematic geologists as the accepted horizon of separation between the Devonian and Silurian systems; an arrangement too convenient for many reasons to be abandoned, however strange and even improbable it may seem that a radical change in the order of creation should have occurred without leaving a more visible trace than merely a thin archipelagic sand-bank deposit like the Oriskany. We can only conjecture that movements took place in distant regions of the globe great enough to change the condition of oceanic sediments everywhere, and thereby to change the living population of the world's waters.

Professor Ewing's graphic description of the iron ore deposit on Sinking creek in Potter township (page 418) will arrest the attention of mineralogists. I cannot but regard it as an excellent illustration of the probable correctness of the explanation which I ventured to suggest in 1879, on page xvii of the preface to Report QQ. An unlooked for addition to the argument there presented is made by the accident of finding one pipe of ore embedded at an angle to all the others. As I regard the ordinary pipe ore as converted stalagmite, I must regard this exceptional pipe of ore as a fallen stalactite similarly converted.

J. P. Lesley.

Philadelphia, 1008 Clinton Street.
June 12, 1884.

LETTER OF Mr. E. V. D'INVILLIERS.

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

DEAR SIR: I have the honor to submit to you my report on Centre county, together with a map of the whole county, geologically colored to show the areas of the Palæozoic rocks within its border lines.

Centre is the largest county in the State, containing more than 1200 square miles of surface; and its series of rock formations extend downwards from No. XIII, the Lower Productive coal measures, through the Sub-carboniferous, Devonian, and Silurian systems, nearly to the bottom of the great Magnesian limestone formation No. II. As I was allowed only six months (from July to December, 1883) for field work, my report will show that it had to be principally expended upon districts known to be of prime importance in respect to their mineral value.

The township maps at my command were, as usual, very defective. Some of the errors were corrected, and some new features added; but many inaccuracies undoubtedly remain, especially in the mountain townships.

In prosecuting my survey I met with the heartiest cooperation from the citizens of the county everywhere, and I owe it to their assistance that my report is as complete as it is. I wish to thus publicly tender my thanks to all, and especially to Messrs. Robert, George, and Abraham Valentine, the Hon. A. G. Curtin, A. G. Curtin, Jr., Mr. Andrew Brockerhoff, Mr. John D. Shugert, Mr. C. T. Alexander, Mr. James L. Somerville, Mr. A. H. Bell, Mr. G. W. Jack-

son, Mr. D. G. Bush, and Dr. Fairlamb, of Bellefonte; to Mr. Frank McCoy, of the Milesburg Iron Works; to Mr. James Pierpont, of the Juniata Mining Company; to Mr. Cameron Burnside, of Howard; Col. G. H. Platt, and Mr. Mark Hopkins, of Peale; Messrs. Frank Wilcox, and W. J. Jackson, of Powelton; Mr. J. H. Holt, and Dr. M. S. Stewart, of Moshannon; Mr. John T. Thompson, of Lemont; Col. James P. Coburn, of Aaronsburg; Hon. J. Devens, of Hublersburg; Messrs. Philip Collins, and W. G. Platt, of Philadelphia; Messrs. Peter Cameron, and Robert Ramsey, of Snow Shoe; Messrs. Theodore and George Boak, of Pine Glen; Messrs. S. S. Blair, and W. Reed, of Tyrone; and Mr. C. S. d'Invilliers, of Philipsburg.

I am, sir, very respectfully yours,

E. V. D'INVILLIERS,

Philadelphia, 711 Walnut street.
June 1, 1884.

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List of Illustrations.

CENTRE COUNTY.

Chapter I.

Geographical Description.

Centre County is appropriately so called, for it occupies the centre of the State, surrounded by Clearfield on the north-west; Clinton, Union, and Snyder on the north-east and east, Huntingdon on the south, and Blair on the south-west.

It was set off in 1800 from Mifflin and Lycoming counties, with the following boundary lines:

* "Beginning opposite the mouth of Quinn's run, on the West Branch of the Susquehanna; thence a straight line to the mouth of Fishing Creek; thence to the north-east corner of Miles township, including Nittany valley; thence by the north-eastern boundaries of said township to the summit of Tussey's mountain; thence by the summit of said mountain, by the lines of Haines township in Northumberland, Potter township in Mifflin, and Franklin township in Huntingdon county, to a point three miles south-west of the present line between Mifflin and Huntingdon counties; thence by a direct line to the head of the south-west branch of Bald Eagle creek; thence a direct line to the headwaters of the Moshannon; thence down the same to the Susquehanna to the place of beginning."

Several modifications in boundary lines have taken place since 1800.

* History of Centre and Clinton counties by J. B. Linn, 1883, page 34.

The western and north-western boundaries, being the Moshannon creek and the river down to the mouth of Jews, run, need no remark.

But the various changes brought about by the successive partitions of the *original* Northumberland county from 1772 have modified its north, east, and south lines considerably.

Thus in 1839, the townships of Bald Eagle, Lamar, and Logan were transferred to Clinton county, while the previous creation of Huntingdon, Mifflin, Lycoming, and Union counties had its effect in further changing the outline of Centre county.

The eastern boundary, between Centre and Union and Mifflin counties, was not definitely fixed until the survey of 1871, and is now eighteen miles and forty perches long. The Huntingdon county line was determined in 1801, and that of Blair county in 1848, both of which were finally fixed by surveys of 1876.

Centre county has an irregular lozenge shape with its longest ends pointing N. E. and S. W. Its area, according to H. Gannett, Top. tenth census, is 1,230 square miles, thus showing it to be the largest county in the State. It is divided nearly in half by the Bald Eagle valley, which forms a marked topographical feature between the Bald Eagle mountain and the great Allegheny mountain plateau.

Twenty-five townships sub-divide the county and are arranged somewhat as follows:

Burnside.
Curtin.
Rush. Snow Shoe. Liberty.
Taylor. Worth. Huston. Union. Boggs. Howard.

Marion.
Half Moon. Patton. Benner. Spring.
Walker.
College. Miles.
Ferguson. Potter. Gregg. Haines.
Harris. Penn.

Eleven townships lie north, and fourteen south of the Bald Eagle mountain, which divides the county in a line about N. 56° E., and S. 56° W.

Burnside, Rush, Snow Shoe and Curtin are essentially

mountain townships, and within them is to be found all the coal occurring in the county.

Taylor, Worth, Huston, Union, Boggs, Howard, and Liberty form the Bald Eagle valley and the rounded slate and sandstone ridges south of the Allegheny escarpment.

Their southern border lines mark the crest of the Bald Eagle mountain.

Half Moon, Patton, Benner, Spring, Marion, and Walker occupy a similar position on the *south* side of this prominent dividing ridge, and make up portions of the Nittany limestone valley and the whole of the slate belt stretching along the south base of the mountains from Huntingdon to Clinton county.

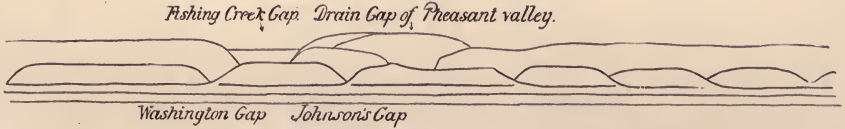
Benner, Spring, and Walker townships have for their south boundary lines the crest of Nittany mountain, another marked topographical feature, extending from the Clinton county line as far west as Lemont, in College township.

College, Ferguson, and Harris townships comprise the limestone area of the combined Nittany and Penn's valleys, the two latter riding up on the crests of the Tussey mountain on the south.

Potter, Gregg, Miles, Penn, and Haines (5 in all) constitute the region of Brush and Penn's valleys and such portions of the Seven mountains as are within the county.

SECTION ALONG THE NITTANY VALLEY ANTICLINAL
Reproduced from First Survey Report.

NITTANY MOUNTAIN AND TERRACE, AS SEEN FROM BALD EAGLE MOUNTAIN.
Reproduced from First Survey Report.



Chapter II.

Towns; Streams; Railroad levels.

The first settlement within the present boundary of Centre county seems to have been on Bald Eagle creek, not far from the mouth of Spring creek, near the present site of Milesburg.*

This was before the organization of the county.

In the year of incorporation, 1800, Centre county had a population of 4112, which increased in 30 years to 19,028.

In the year 1839 Clinton county was created, which of course, robbed Centre of a portion of its population, so that the census of 1840 shows a total of only 20,492.

The increase in the next decade was slight, as in 1850 the population numbered but 23,355. In 1860 it was 27,000; in 1870, 34,418, while the returns of the 10th census, in 1880, give a total of 37,921.

The first post-office in the county was established at Milesburg in 1797. Bellefonte Forge (now Valentines & Co.) was erected in 1798.

Bellefonte, the county seat, was laid out in 1795, and was so named from the beautiful spring within its limits which is the present source of its water supply. It was made a borough in 1806, two years after which the water-works came into existence in a rude form—the water being conveyed through the town by means of wooden troughs. At present, the water is forced up to the reservoirs on the hill, to an altitude of 196 feet, through a six-inch iron pipe 1900 feet long. The reservoirs have a capacity of 300,000 gallons. The estimated discharge of the spring per minute

*Linn's History of Centre County, p. 12.

is 14,600 gallons, so that some idea may be formed of the supply of this large pool.

Other places of size and importance in the county are Philipsburg, Snow Shoe, Unionville, Milesburg, Howard, Eagleville, Spring Mills, Millheim, Aaronsburg, and Boalsburg.

The industries most nearly affecting the people are those of coal and iron mining, farming, saw and grist-mills, and to within a comparatively recent period, lumbering.

The chief of these is, of course, agriculture, considering the amount of capital involved.

Streams.

With but few exceptions the entire drainage of the county is *eastward* into the Susquehanna river at Lock Haven.

The five townships of Potter, Gregg, Miles, Penn, and Haines are chiefly drained by tributaries of Penn's creek, which flows south-east into the Susquehanna near Selinsgrove south of Sunbury, in Snyder county.

Taylor, Half Moon, and Ferguson are drained south into the valley of the Juniata, the former by branches of Little Bald Eagle creek, into the river at Tyrone ; the two latter by the Half Moon and Beaver run branches of Spruce creek into the Juniata at Spruce creek, in Huntingdon county.

The Moshannon creek, dividing Centre and Clearfield counties along three fourths of its western border, is the principal feature of the map. Its general course from the Blair-Cambria-Clearfield corner to the West Branch of the Susquehanna south of Karthaus Landing is about N. 30° E. and 30 miles long in an air line. But its almost endless windings and deviations through the First Coal Basin at Osceola and Philipsburg and the conglomerate hills bordering the Rush-Snow Shoe lines, considerably modifies this statement both as to course and distance.

Its meanders however, have been carefully reduced from topographical maps of the Pennsylvania railroad from original railroad surveys of Messrs. Paul White and C. S. d'Invilliers, so that an accurate representation of this great

stream is, for the first time I believe, laid down upon the map accompanying this report.

Its principal tributaries in this county are the Mountain Branch, Trout Run, Cold Stream, Six Mile run, Black Bear run, and the Little or Black Moshannon, all having their rise in the Allegheny mountains in Rush township, and flowing northwards.

The Black Moshannon alone leaves the township, making a wide detour into Snow Shoe towards the village of Moshannon and emptying into the main stream at the Iron Bridge crossing of the Philipsburg and Snow Shoe road.

Additional streams in Burnside township are the Seven Mile run, Miles and Pine runs, Sterling run, Spruce run, Bougher run, Moore's run, Field's run, Yost's run, Burn's run, and Jews' run, all of which, except Seven Mile run, drain directly into the West Branch of the Susquehanna, which forms the remaining part of the county's western border.

Seven Mile run, with its several branches, drains a part of the north side of the Snow Shoe coal basin. The other streams just enumerated all have their rise in the high barren country, accented by the anticlinal axis dividing the Snow Shoe coal basin from that at Karthaus, which axis is identical with the *Hyner anticlinal* of Clinton county and the *First* or *Laurel Hill axis* of Clearfield county, dividing the *first* and *second* coal basins.

Beech creek drains the rest of the Allegheny coal field in Centre county and both from the number of its branches and the vast amount of territory it waters, it is scarcely second in importance to the Moshannon.

Heading in the Allegheny mountains south of Snow Shoe village, it flows north-east to the Snow Shoe-Curtin line, and then south-east to its confluence with the Bald Eagle creek at Beech Creek village, forming the divide between Centre and Clinton county for the last 8 or 10 miles of its course.

About 5 miles east of Snow Shoe, Beech creek divides into *north* and *south* forks.

The former, heading well up into Snow Shoe township,

drains the coal basin north and south through Pine run, Cherry run, and Little Sandy.

The south fork, rising west of the Snow Shoe summit of the Allegheny mountains, drains a rocky and barren country, and practically limits the southern extension of the Snow Shoe coal basin as far as its intersection with the main stream south of Cato.

Increased considerably in size, Beech creek further receives from the highlands of the Pine Glen-Hyner Axis on the north, the waters of Big Sandy and its tributary Beauty run, Wolf run, Panther run, Eddy Lick, Two Rock and Three Rock runs, and just outside the county the waters of Big run, which takes its rise in upper Curtin.

From the south Beech creek receives Logway run, a small stream which heads up in the little Cato coal field; Counsel run, which again limits the Beech creek coal basin on the south; and finally Hayes run, which, with its numerous offshoots, drains all that portion of the Allegheny plateau in Curtin township.

The wilderness through which this stream formerly found its passage is being gradually changed by the rapid progress of the Beech Creek, Clearfield and South Western railroad, whose trains will no doubt be carrying a large proportion of the county's material wealth before this article finds its way into print.

Its graded line now (Jan., 1884,) hugs the many windings of this wild stream from Beech Creek village on the east through Snow Shoe to the headwaters of its north branch.

There it seeks the channel of the Little or Black Moshannon to the mouth of Rock run in Rush township when, turning westward and crossing the Briartown summit, it gradually descends to the waters of the Big Moshannon and on to Philipsburg.

This important railroad line will have a great effect on the county's industries. Much of it is already ironed, and passing as it does through a region hitherto almost devoid of wagon-roads, its power as a developing agent may be imagined.

In its course through the county it twice pierces the hills.

The first tunnel is at the "Hog Back," Curtin township, 300′ long, from portal to portal, on a 5° curve, and driven through the white Pocono sandstone No. X, which there forms the precipitous hillsides of Beech creek. The second or Moshannon tunnel, in Rush township, is just south-east from the new town of Peale. This tunnel is 1250′ long on a tangent, and was completed very rapidly owing to its location in the upper sandstone members of XII, which are here shaly and carry a small and worthless coal bed.

In addition to these, this railroad has many deep cuts in the coal measures and underlying sand rocks, the chief of which is the big cut north-west of Snow Shoe at the crossing of the Pennsylvania railroad and Karthaus pike at Askey's summit.

Bald Eagle creek, both from its importance to the county at large and the rich agricultural country it waters, is probably the most significant stream in Centre county.

Heading in Taylor township, in the extreme western part of the county, this creek takes a N. 60° E. course through the Bald Eagle valley, hugging close to the north base of the Bald Eagle mountain, receiving the waters of Beech creek at the Clinton county line, and finally entering the Susquehanna river below the town of Lock Haven.

From the north, it drains the entire region occupied by the Upper Silurian and Devonian measures of the Allegheny "foot hills" aggregating many thousands of acres of good, arable farm land. Chief among its tributaries from the north are *Vaughan's* and *Sparrows' Runs*, in Taylor township; *Laurel Run* and numerous smaller streams in Worth; *Williams' Run*, *Mud Lick*, and *Laurel Run* in Huston; *Dick's Run*, *Dewitt's Run*, *McCormick's Run*, and *Free Run* in Union; *Wallis Run*, rising partly in Union and partly in Boggs; *Moose Run*, *Holt's Run*, *Antis Run*, and *Dowdy's Run* in Boggs; *Bullet Run*, *Green*, *Canoe*, and smaller streams in Howard, and finally *Marsh Creek*, heading chiefly in Boggs, flowing parallel to Bald Eagle creek through Curtin, and then turning S. E. through Liberty to the parent stream at Eagleville.

This latter is by all odds its most important tributary.

Rising in the red Catskill rocks of Boggs township, and receiving *Wensel's Run* in Curtin, and *Confer Creek* in Liberty, it waters a vast territory of mountain agricultural land, finally eating its way through the soft slate hills of Liberty and creating a considerable amount of good bottom land near its confluence with Bald Eagle creek. While its flow is gentle, owing to its easterly course through a gradually falling country, it is an important stream to this sparsely populated region, and everywhere presents a charmingly peaceful contrast to the wild hills which enclose it. Almost all the other streams just named have a general southerly course. They are individually unimportant as water courses, though, from the soft and pliable nature of the country through which they flow, create marked features in the topography and are striking illustrations of the great erodng power of flowing water.

Their headwaters generally mark the *transition beds* of the two chief mountain rocks—the red Catskill No. IX and white Pocono sandstone No. X.

Mountain roads are built up almost every one of these ravines, and some few pass over the Allegheny summit into the coal region beyond.

The drainage of Bald Eagle creek from the *south* is even more important, for it comprises, through *Spring Creek*, *Buffalo Run*, *Fishing Creek*, and their branches, fully two thirds of the beautiful and highly cultivated Nittany valley.

First among these in the order named is *Spring Creek*, a water supply of the greatest importance to the agricultural and manufacturing interests of the community.

Heading in the Seven mountains west of Churchville or Tusseyville, in Potter township, and receiving accessions from numerous small streams around Tussey Knob, in Harris, it flows west and north through Harris, College, Benner, and Spring townships, finally bursting through the Bellefonte Gap in the Bald Eagle mountain, and entering the Bald Eagle creek at Milesburg, in Union township, twelve or fifteen miles from its source. Its junction with the Bald Eagle creek marks the site of the old "Bald Eagle's Nest"—

the home of a noted Indian warrior. The stream had its name as early as 1776. Its chief tributaries proceeding southwards from its mouth are—

1. *Buffalo Run*, heading in the south flank of the Bald Eagle mountain, in the western corner of Patton township, flows N. E. parallel to the mountains through Patton and Benner townships ten miles to its intersection with Spring creek at the town of Bellefonte.

It established the line of the recently constructed Bellefonte and Buffalo Run railroad from Bellefonte to the horse-shoe curve at Benner Waddle's—an important feature in the future development of this prolific ore country and one of incalculable benefit to the farming interests of this section.

2. *Logan's Branch*, a rapidly flowing stream rising in the valleys of Nittany mountain at Pleasant Gap and in McBride's Gap in Benner, takes a northerly course through Spring township to the main stream at Bellefonte.

Both of its initial branches sink at the junction of the limestone and slates along the north base of Nittany mountain, but in its short surface flow of about three miles south of Bellefonte it has a fall of 125′, furnishing excellent power for several important industrial works, among which may be mentioned Hume's grist mill, Mann's axe factory, a wire factory to the north of this, Valentine's Bellefonte forges and rolling mill, and the large Bellefonte car works.

The eroding power of this stream is well seen in traveling along the Centre Hall pike south of Bellefonte, the road running in a ravine from 100′ to 125′ below the limestone crests which form the true valley plain.

Some of the deepest rocks in the county are exposed along this creek at the beautiful anticlinal arch about one mile south of the town.

3. *Slab Cabin Branch*, which takes its rise in a gap of Tussey mountain south of Pine Grove Mills in Ferguson township—which is at the divide between the waters of the Juniata and Susquehanna—sinks in the limestones for a half a mile and then flows north-eastwardly through College township to Spring creek at Houserville, 1½ miles north-west

of Lemont. It waters a splendid farming country, though devoid of importance as a water-power.

4. *Cedar Creek*, a stream of interest to the people of lower Penn's Valley, rises in two branches in Potter township near the Harris line; flows south-west through the latter for about 4 miles to Spring creek at Oak Hall Mills. Its waters are entirely confined to a limestone country and furnish power for the Linden Hall and Oak Hall Mills.

These four branches, with the main creek, pass through or are contiguous to the following prosperous villages: Linden Hall, Boalsburg, Shingletown, Pine Grove Mills, Centre Furnace, Lemont, Agricultural College, Houserville, Pleasant Gap, Roopsburg, Bellefonte, and Milesburg, and watering as they do, five of the principal valley townships, their importance in the drainage of the county can be well understood.

Bald Eagle creek receives several other additions from numerous small streams in the Bald Eagle hills, none of any importance however, except the two creeks which gap the mountain ridge at Curtin and Howard.

These two streams both head in Marion township between the "Sand Ridge" and Bald Eagle mountain, and while they were undoubtedly of far greater size and influence in past geological age, as is witnessed by the erosion of their two gaps, they are at present of but little importance.

Little Fishing Creek, while not attaining anything like the importance in this county that the main branch does in Clinton—which with its numerous affluents drains Sugar valley, Lower Nittany valley and the whole plateau of IV and V known as the Big Mountain before cutting through the picturesque and wild Mill Hall Gap—is still a stream of great interest to the people of Walker township.

The main stream rises in Green valley in Nittany mountain, flows east, then north, creating the Hecla Furnace gap in that mountain before entering the limestone plain of Nittany valley between Zion and Hublersburg.

Flowing thence east, it receives several small streams from the mountain and finally leaves the county at Washington Furnace.

The chief tributaries it receives from Nittany mountain valleys, south in the great Madisonburg Gap, are known as *Bear Run*, rising on the west in the Medina Sandstone at Markle and Lee's Gaps; *Dry Run* coming from the small valley of red Medina Shale and SS. between the prongs of the double Medina mountain, south of the Miles township line; and *Musquito Run* entering from the south-east.

These three streams make a considerable body of water, and conjointly they are daily wearing down the great gap still deeper.

Already they have created the wildest and most beautiful gorge in the county and formed a natural means of communication between the people of Penn's valley and those of lower Nittany valley.

The whole topography of this lower end of the valley is greatly furrowed, the erosion of the streams being aided by the greater dip of the limestone, as well as its more sandy character.

The drainage of the remainder of Nittany valley on the west is, as has been already stated, southward into the valley of the Juniata and is confined to the two townships of Half Moon and Ferguson.

The chief agent of drainage here is *Half Moon Run*, which rising in the slates and sandstones along the south flank of the Bald Eagle mountain around Stormstown, cuts successfully through the three anticlinal ridges of the Barrens:—*Chestnut or Buck Ridge; Gatesburg Ridge and Tad Pole* or *Sand Ridge*, and leaves the county in Ferguson Township near the Pennsylvania Furnace. Here it meets the *Beaver Branch* which, issuing from the beautiful Rock Spring at the base of Tussey mountain two miles east of Pennsylvania Furnace, grooves its way through the magnesian limestones along the south flank of Tad Pole ridge to Spruce creek.

The Penn's valley country, comprising the region of the Seven mountains, and the rolling valley and mountainous country between them and Nittany mountain on the north shows but one artery of drainage—that of *Penn's Creek*

and its numerous branches, all converging about the Mifflin County line.

Penn's Creek proper rises in numerous small springs in the middle red Medina valley of Nittany mountain, south of Hecla Gap in Gregg Township. Sinking in the limestone of Brush valley south of J. White's house it issues again in the beautiful Penn's valley cave—one of the numerous limestone caverns that mark these Siluro-Cambrian valleys.

Its waters are collected in Mr. Long's saw-mill dam after leaving the cave, and then traverse the synclinal slate belt of Brush mountain, where several smaller streams join it. Crossing the succeeding anticlinal in the limestone of Penn's valley and furnishing power to several grist mills, it passes Spring Mills and the slate synclinal of eastern Egg Hill, over the George's valley anticlinal to the base of the Seven mountains, where it is turned at right angles to the east and enters Penn township.

From here its course is mainly an easterly one to Coburn station on the Lewisburg and Tyrone railroad, everywhere skirting the base of the mountains and practically marking the division line between the slates and limestones.

At Coburn station it receives Pine creek from the north and taking a south-easterly course it gaps the mountain, crosses the head of the little slate valley south of Beaver Dam tunnel—called by the Dutch "Lechathal" or Lick valley—and enters Haines township on the east.

Leaving the slate valley at Fowler's, on the L. and T. R. R., it again gaps a mountain of Oneida No. IV before crossing the eastern edge of the Poe valley, finally leaving the county through a beautiful gorge in the Medina white sandstone of Paddy's mountain.

Its course through Mifflin and Snyder counties to the river at Selinsgrove is through a most picturesque part of the State, twice gapping the White Mountain synclinal knob, flowing thence through the valley of the middle red Medina as far as Laurelton, where it turns still more to the east and finally gaps Jack's mountain. From Spring Mills, in Centre county, to Laurelton it marks the course of the Lewisburg and Tyrone railroad, and is the only stream that

may be said to cut through the various mountain ranges of Centre, Mifflin, and Snyder counties. Scenery of surpassing and varying grandeur everywhere characterizes its course, and its power as an erosive agent is paramount to any other stream in the region.

Among the most important of its tributaries in Centre county are—

1. *Sinking Creek*, which, rising in the extreme south corner of Harris township in the remarkable "Bare Meadows," 2200′ A. T., encircles a dying anticlinal knob of Oneida IV, and flows N. E. out of the township through George's valley. Coursing through the No. III slate of this valley, with numerous additions from mountain rivulets, it enters the limestone of the "Loop" south of Tussey knob, in Potter township.

Keeping a N. E. direction, it cuts across the synclinal slate belt of Tussey Knob and Egg Hill, with the addition of Laurel run, entering from the south from the mountain region about Thick Head.

After meandering through this slate valley, furnishing power for the Collyer, Lukenbach, Sinking Creek and Red Mills, and receiving an important addition from the mountain region south of Potter's Mills, it enters the limestone area of Penn's valley at the Sinking creek ore bank, 1½ miles east of Centre Hill, and skirts the north flank of Egg Hill to Spring Mills, where it joins Penn's creek.

In its flow of about 14 miles from the "Bare Meadows" to Spring Mills, it shows a fall of about 1100 feet, draining an extensive area.

The little limestone valley of the "Loop" widening N. E. and known as George's valley, is drained directly into Penn's creek about 2 miles south-east of Spring Mills

This stream is swelled by numerous branches from Egg Hill on the north, and from the south it drains Confer and Triester valleys within the mountain area.

At Coburn Station Penn creek receives also

2. *Pine Creek* which, with its main branch *Elk creek*, drains almost the entire area of Haines and Miles townships.

Pine creek may be said to head in *Pine Creek Hollow*,

between Brush and Stone mountains in Haines township, close to the Union county line.

Flowing S. W. through this narrow slate valley and receiving from Brush mountain on the north small streams from Panther Gap, Big Gap and Bear Gap, and from Stone mountain on the south Little Gap and Whitmer runs, it enters the limestone area of upper Penn's valley at Hosterman's saw-mill, about 7 miles east of Aaronsburg.

Turning south, it almost immediately enters the slate synclinal of Stone mountain, crossing which it receives at Woodward a small tributary from the Penn's valley narrows.

Pursuing a westwardly course from here it practically divides the limestone of the valley and slate of the Seven mountains as far as Reed's saw-mill, 3½ miles from Woodward, showing one prominent sink about midway between these two points.

At Reed's mill it enters the limestone area to the north, while keeping the same general course into Penn township, finally meeting the parent stream at Coburn.

Elk creek, its main branch, rises similarly in the Brush valley slate and sandstone narrows well up towards the east end of Miles township.

Flowing westward in the valley between Brush and Nittany mountains, with numerous accessions from these ridges and furnishing many excellent mill sites, this rapidly flowing stream enters the limestone of the dying Brush valley anticlinal near M. Rudy's mill approximately dividing Nos. II and III as far as a point midway between Rebersburg and Centre Mills.

At this point it bends south-west through the slate and then almost due south through the magnificent Millheim Gap in the No. IV sandstones of Brush mountain, striking south directly across the double anticlinal of Penn's valley to its junction with Pine creek, ¾ mile north of Coburn Station on the L. & T. R. R.

Its gorge through the Brush Mountain presents a magnificent sequence of the lower and middle members of No. IV and the succeeding slate and limestone of Penn's valley,

and its waters are frequently dammed for numerous saw and grist mills.

This about completes the drainage system of the county, the remaining streams being insignificant in character and confined to the mere headwaters of creeks which flow out from Centre, and become large streams in bordering counties.

Railroad levels.

The *Railway Lines* which traverse Centre county have furnished levels for various barometric observations taken in the region.

The following tables will show the elevations of railroad grade above tide at the respective stations.

Some additional elevations from experimental or preliminary lines are likewise appended.

(Table 16 of Report N.)

*1. Bald Eagle Valley Railroad.**

	Miles from Tyrone.		
Tyrone (See Tables 1, 15, 16),	0	900	907
Summit (Blair Co.),		1103	1110
Hannah,	10	1050	1057
Port Matilda, *Main Street*,	14	1000	1007
B. E. Creek bridge,		917	924
Martha,	17	905	912
Julian,	21	844	851
Dick's Run,		794	801
Unionville,	26	775	782
Snow Shoe R. R. (16),	29	715	722
Milesburg (17),	31	693	700
Bald Eagle Canal,		664	671
Holters',		644	651
Mount Eagle,	37	655	662
Bald Eagle Plank Road,		658	665
Howard,		672	679
Eagleville,	44	628	635
Beech Creek,	46	607	614
Mill Hall,	51	566	573
Lock Haven Junction, Junction with P. & E. R. R.	54	548	555

*The elevations on the B. E. V. R. R. were compiled from a profile in the Pennsylvania R. R. Company at Philadelphia. The datum is the same as that of the P. R. R. In the second column seven feet are added to reduce to mean Atlantic Ocean level.

(TABLE 17 OF REPORT N.)

2. *Bellefonte and Snow Shoe RR.*

	Miles from Bellefonte.	*A. T.*	*Ocean Level.*
Bellefonte, (see Table 18),	0	737	744
Bald Eagle RR. Junction,	4	715	722
Gum Stump,	8	1013	1020
Summit, *Allegheny mountain summit,*	14	1728	1735
Beech creek, *level of water,*	18	1542	1549
Beech creek, *level of rail over water,*		1592	1599
Snow Shoe,	21	1565	1572

(TABLE 18 OF REPORT N.)

3. *Bellefonte Branch.*

	Miles from Milesburg.		
Milesburg, (see Table 16,)	0	693	700
B. E. V. Plank Road,		692	699
Bellefonte,	3	737	744

(TABLE 15 OF REPORT N.)

4. *Tyrone and Clearfield Railroad.*

	Distance from Tyrone.	*A. T.*	*Ocean Level.*
Tyrone, (see Table 1,)	0	900	907
Gardner's,	8	1561	1568
Mt. Pleasant	10	1777	1784
Emig's Summit, *Allegheny mountain summit,*	13	2038	2045
Sandy Ridge,	15	1905	1912
Powelton,	16	1791	1798
Osceola branch RR.,	19	1481	1488
Dunbar,		1446	1453
Moshannon creek,		1435	1442
Steiner's Mills,	22¾	1421	1428
Philipsburg,	23	1418	1425
Clearfield,		1096	1103
Curwensville,		1103	1110

(TABLE 14 OF REPORT N.)

5. *Lewisburg and Tyrone Railroad.**

	Dist. from P & E. R. R. Junc.	*A. T.*	*O. L.*
P. & E. R. R. Junction, Junction with Phila. & Erie R. R. Elevation by Chas. W. Ames at this point 462.75; Lewisburg Sta. 465.26; west end R R. Bridge crossing Susquehanna River 463; east end do. 463.2. Datum, P. R. R., Harrisburg,	0	447	462
Lewisburg,	2	451	466
Tunnell, through Paddy's Mountain,	32½	944	959
Fowler's,	34	976	991
Beaver Dam Tunnel,	35	999	1014
Coburn, forks of Penn's creek,	36	1011	1026
Buchanan, mouth of Muddy run,	41	1044	1059
Duncan (Spring Mills),	43	1063	1078
Centre Hall,	49	1257	1272
Summit, summit of Penns valley, head of Penns creek and head of Spring creek,	50	1275	1290
Lemont, end of Nittany mountain,	58	987	1002
Kelley, State Agricultural College,	61	1096	1111
Pinegrove,	64	1221	1236
Shugart's,	67	1116	1131
Lyons (Penna. Furnace),	71	1059	1074
Tyrone,	88	892	907

6. *Bellefonte and Buffalo Run Railroad.†*

	Dist. from Bellefonte.	*Above Datum.*	*Ocean Level.*
Intersection with Bellefonte Branch P. R. R.,	0	0	720
Creek crossing Buffalo run,	1½	62	782
Road east of Fillmore,	5.0	192	912
Road leading north of Hunter's,	5.6	207	927
Patton-Benner township line road,	6.8	241	961
Buffalo run road at Sellers,	8.0	285	1005
Do. do. Waddell's	10.3	384	1104
Do. do. Stevenson,	11.1	426	1146
Summit,	12.3	526	1246
Pond Bank (on grade below mine),	13.9	480	1200
Lytle Bank on flat,	13.7	603	1323
Hiram Thompson's cross roads,	14.8	351	1070
Streuble ore bank,	18.0	452	1172
Johnson's bank, washer foundation,		480	1200
College road.	17.4	430	1150
Johnson's bank,	18.0	460	1180

*Constructed to Duncan? (Spring Mills), Jan. 1, 1884.

†Graded; ready for ties November, 1883. Levels and distances furnished by J. M. Bell, Resident Engineer.

7. *Bellefonte, Nittany Valley and Lemont Railroad.**

	Distance.	*A. T.*
Bellefonte station, Bellefonte Branch B. E. V. RR.,	0	744
Crossing Boalsburg pike,	2.6	863
Dale's Summit, (natural surface,)	7	1110
Lemont, (nat. surface opp. Presbyterian church,)	9	1040
Dale's Mills, (surface water in Spring creek,)	9.7	1000
Oak Hall, (Boalsburg pike,)	10.3	1029
Linden Hall, (public road,)	12.8	1109
Centre Hall, (public road,)	18.1	1274
Spring Mills, (rail at depot,)	23.9	1086.5

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8. *Beech Creek, Clearfield and South Western Railroad.*†

	Dist.	*A. T.*
Jersey Shore junction with P. & E. RR.,	0	597
Lock Haven, (Castanea ?,)	10.25	576
Beech creek,	19.27	616
Mouth of Hay's run, surface of water in Beech creek,		833
Surface of Beech creek, south side,		944
Grade, Hog-back	33.14	952
Surface of ground over tunnel, Tunnel,		1122
Surface of water Beech creek, north side,		975
Gray's splash dam,		1090
Cato bridge,		1174
Pancake mill,		1410
Snow Shoe summit, surface of ground,	48.21	1617
Rock run crossing,		1470
Briartown summit, surface of ground,		1603
Moshannon tunnel, surface of ground,		1643
Grade at Moshannon tunnel, E entrance,		1489
Moshannon creek, surface of water,		1262
" " crossing, grade,		1374
Six-Mile run surface,		1353
Black Bear run surface,		1365
Philipsburg grade,	73.35	1425

* Proposed railroad distances and elevations furnished by P. J. White, C. E., Feb. 20, 1884.

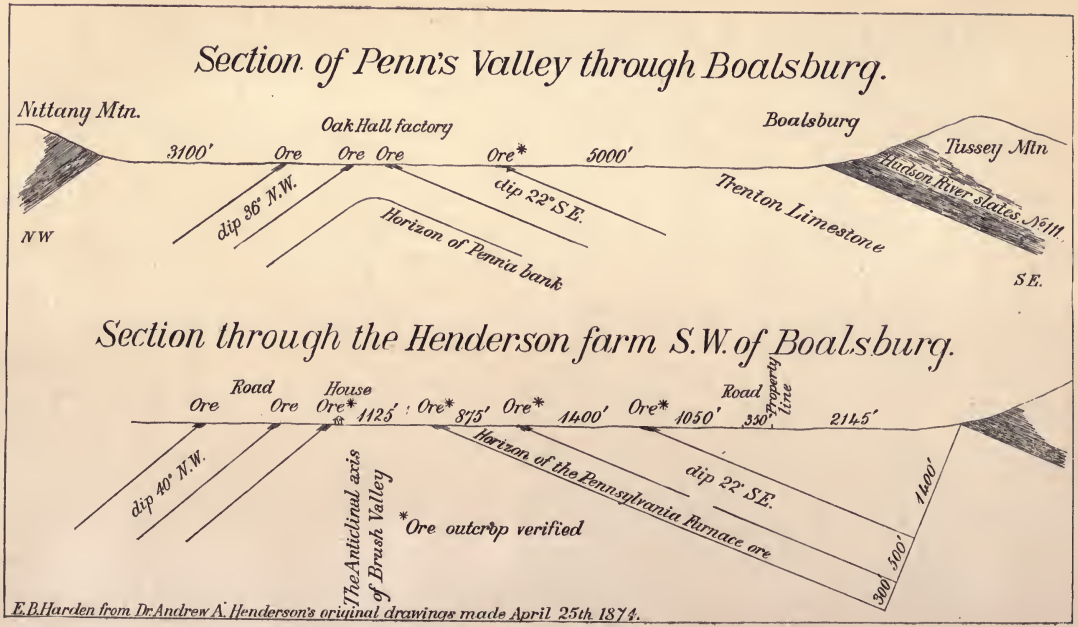
† Distances and elevations furnished by W. Wetherill, C. E., Feb., 1884.

(Tables 156 and 186 of Report N.)

*9. Other Levels in Centre County.**

Tyrone,	892	895
Emig's Gap Summit,	2025	2028
Pool, Osceola Dam,	1444	1447
Moshannon creek, mouth of Beaver run,	1444	1447
" " Bear run,	1467	1470
" " Mountain branch,	1485	1488
" " Whiteside run,	1488	1491
Crest of Allegheny mountain at Middle Summit, Three Spring Gap and source of Moshannon creek,	2233	2236
Do. at Northern summit Three Spring Gap,	2278	2281
Do. one mile east of Northern summit and highest ground,	2611	2614
Do. in gap between north fork of Sinking run and Mountain branch,	2406	2409
Do. in gap between Laurel run and tributary of Mountain branch,	2364	2367
Do. between Bear run and Mt. Pleasant run,	2221	2224
Crossing Nittany mountain at Hecla Furnace,	1867	1874
Head of Penn's creek, (water,)	1129	1136
Spring Mill's intersection with L. & T. RR.,	1072	1079
Bellefonte and Lewistown turnpike crossing, Nittany mt.,	1650	1657

*Statement of levels in the Clearfield region furnished by E. M. Leuffer, C. E. Add 3′ for ocean levels.


Section of Penn's Valley through Boalsburg.
Nittany Mtn.
Oak Hall factory
Boalsburg
Tussey Mtn
3100'
Ore
Ore
Ore
Ore*
5000'
dip 86° N.W.
dip 22° S.E.
Trenton Limestone
Hudson River slates. No III
NW
Horizon of Penn'a bank
SE.
Section through the Henderson farm S.W. of Boalsburg.
Ore
Road
Ore
House
Ore*
1125'
Ore*
875'
Ore*
1400'
Ore*
1050'
Road
330'
Property line
214.5'
dip 40° N.W.
The Anticlinal axis of Brush Valley
*Ore outcrop verified
Horizon of the Pennsylvania Furnace ore
dip 22° S.E.
1400'
300'
300'
E.B.Harden from Dr. Andrew A. Henderson's original drawings made April 25th 1874.

Chapter III.

Topography of the District.

The Escarpment of the Allegheny mountains presents an irregular but nearly straight front facing towards the south-east, and running parallel to the Bald Eagle mountain, entirely across the county.

It is gapped but once in the entire county, by the valley of Beech creek, which stream, for some distance, forms the divide between Centre and Clinton counties.

In spite, however, of the bold and rugged character of its southern slope, the coal industry of its three mountain townships has led to the building of two railroads directly over them, while a third is in a fair way toward early completion through the gap and valley of Beech creek.

The wagon roads over the mountains, however, are fast falling into disuse with one or two exceptions.

But little of the land on the Allegheny plateau can be economically worked, the sandy, porous character of the soil on its summits and the stony nature of the ground below, preventing profitable farming.

All these higher lands are formed by conglomeritic sand rocks (No. XII), creating summits varying from 1500 to 2300 feet above sea level, and generally wooded.

These rocks are all dipping at gentle angles to the northwest (see cross-section on colored map) but sufficiently rapid to allow of the occurrence of the coal measures 6 or 7 miles north of the crest line. The coal measure soils produce a fair farming land, but are apt to be harsh and cold.

The next lower sandstone formation of the county—the

Pocono or No. X—has likewise left its mark on the topography of the county. South of the Allegheny crest it occurs everywhere as an outer ridge or terrace, forming the rocky cliffs or ribs that overhang the headwaters of the numerous streams rising in the mountain. It is as equally unadapted for agricultural purposes as the conglomerate rock of No. XII. Indeed in many parts of the mountain plateau, its rocks bear so close an analogy to the conglomerate series as to make lithological identification difficult. This white sandstone also extends up the valley of Beech creek through the mountain gap to near Cato and up the valley of the Susquehanna and Big Moshannon nearly to Peale, reaching far up toward the headwaters of the mountain streams in the north end of the county, towards the line of the Hyner—Pine Glen—Laurel Hill axis.

The *Bald Eagle valley* lies north of Bald Eagle mountain, and stretches northward about two miles to the beautifully rounded foot-hills of the Allegheny mountains. *Topographically* it may be made to include the Lower Helderberg limestone (No. VI), the Oriskany sandstone (No. VII) and the Marcellus, Hamilton, and Chemung groups (No. VIII), meeting still further to the north and higher up the mountain slope the red layers of the Catskill or Old Red sandstone No. IX.

The valley proper is only about ¾ miles wide, except at its eastern end, in Liberty township, where its junction with the valley of Beech creek causes it to spread to twice that width.

As a whole, it is remarkably flat, rising gently from Clinton county at Beech Creek to the summit just west of the Blair county line, about 14 feet to the mile, but showing a cross-section everywhere of remarkable evenness of elevation. The excellence of its soil for cereals and grazing land is chiefly due to the presence of the upper Silurian limestones and the calcareous beds often found at the base of the Marcellus slates along the north edge of the valley.

Bald Eagle Mountain crosses the county from west to east as already mentioned, and occurring between two highly

cultivated plains on either side of it, is probably the most striking belt in the county.

It is a north dipping *monoclinal* as shown by the cross section of the county, formed by the usually steeply dipping sandrocks of No. IV. It is a double mountain made up of a lower Oneida gray sandstone forming the terrace overlooking the Nittany valley on the south, and an upper Medina white sandstone, fine grained but hard and compact, which forms the central ridge or keel of all the double synclinal mountains in the southern part of the county.

Between these two white sandrocks forming the ribs as it were of the mountain range, there is a softer intermediate shaly member, usually red in color but showing olive and green tints occasionally. This is the red Medina. It is this middle member that makes the fertile valleys which lie between the rugged, sterile sandstone mountains, and as its soil is susceptible of considerable cultivation where at all exposed, owners of mountain lands ought to give it special attention.

These same rocks just mentioned, together with the overlying formation, the Clinton sandstones and shales No. V occupying the north flank of the mountains, are here seen for the last time in Pennsylvania, as no anticlinal to the north has been strong enough to bring them to the surface within this State.

The sandrocks of No. IV form all the double synclinal mountains in the southern portion of the county, such as Nittany mountain, Brush mountain, Tussey mountain, and the various local ridges included in the Seven mountains.

Of the first of these, the *Nittany mountain*, it may be remarked that it forms a prominent feature in the contour of the county, rising from a plain of limestone at Lemont, and forking eastward so as to include within its bifurcated central keel a small patch of the Clinton No. V formation along the Clinton county line in Walker township.

Such also are *Brush mountain*, *Short mountain*, *Egg hill*, *Tussey mountain* and the various other ridges of the Seven mountains beyond—a series of synclinal canoe-shaped hills,

separated by anticlinal valleys of limestone and slate, but all presenting the same rocks in the same order.

Of the anticlinal limestone and slate valleys included between these synclinal mountains, that of Nittany valley is by far the largest and most important. Prof. Rogers in his Final Report p. 467, calls this grand axis 130 miles long, and from 15 to 16 miles wide from the Nittany mountain to the center of the first coal basin on the Allegheny mountains. "The actual vertical height of the wave, estimated by the difference of levels assumed by the base of the Auroral (Siluro-Cambrian) series on the axis in Nittany valley, and the same strata under the center of the first coal basin, is as much as 20,000 feet. If, in other words, the coal rocks which once spanned this mighty wave were now in the position from which they have been stripped, they would rest perpendicularly over the anticlinal axis of Nittany valley at the prodigious altitude of 4 miles."

Reaching its greatest altitude in Centre county, the axis dies so rapidly to the east, in Clinton county, as to allow of the arching over and connection of the Bald Eagle and Nittany mountains, which cuts off the topographical connection between Nittany and Nippenose valleys, otherwise mere parts of this same anticlinal arch.

Brush valley and Penn's valley—both lesser anticlinals of the same description, lying on either side of the Brush mountain in the eastern part of the county—likewise attain their greatest elevation in this county, and known as Penn's valley when joined together south-west of the end of Brush mountain, they continue south-westward through the county as the southern division of Nittany valley.

The short and minor anticlinals of Poe, Confer and other small valleys within the Seven mountains, are but repetitions of these folds in the earth's crust which have been only strong enough to bring to the surface the next higher or Hudson River slate formation No. III.

Thus between the Lewistown valley on the south and the Allegheny mountain on the north, in Mifflin and Centre counties, there are *ten* approximately parallel compressed rock waves; and at the head of each anticlinal cove, the

two bounding terraces unite and form a broad elevated mountain floor made up of three sandstones, a middle softer member between two harder and more resisting ones.

The limestone and slate lands of these valleys make the very finest farming lands and do excellently for cereals and grazing purposes. Composed of the same rocks that form the Great or Kittatinny valley and Chester valley in south-east Pennsylvania, they enjoy the same reputation in this county, until at the present time but few acres throughout this vast extent of territory remain untouched by the husbandman.

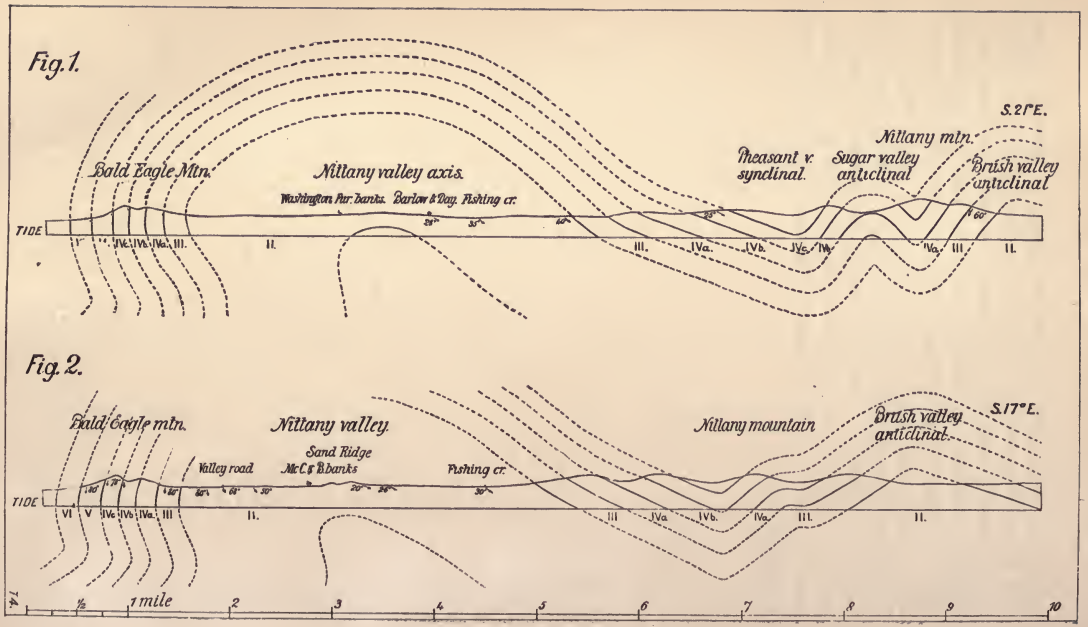


Fig. 1.
Bald Eagle Mtn.
Nittany valley axis.
Washington Fur. banks. Barlow & Day. Fishing cr.
Pheasant v. synclinal.
Sugar valley anticlinal
Nittany mtn.
Brush valley anticlinal
S. 2° E.
TIDE
I. Ia. Ib. Ic. II. III. IVa. IVb. IVc. IVd. Va. III. II.
Fig. 2.
Bald Eagle mtn.
Nittany valley.
Sand Ridge
Mc C's & Banks
Valley road
Fishing cr.
Nittany mountain
Brush valley anticlinal
S. 17° E.
TIDE
VI V IVc IVb IVa III II. III IVa IVb IVa III II.
1/4 1/2 1 mile 2 3 4 5 6 7 8 9 10

Chapter IV.

Geological Structure.

The various measures from the limestone of II to the coal measures of XIII in Centre county are folded in a regular succession of anticlinal ridges and synclinal basins, stretching from south-east to north-west.

Considerable variations, both as to the force and distance apart of these folds exist, and these differences play an important rôle in the economic interests of the county.

For instance, while the rocks of the anticlinal ridges all dip away from the axis normally to the north-west and south-east—as a glance at the map will show—the rising and sinking of these axes north-east and south-west *along* their lines of trend produce such differences of dip and sequence of measures as to alternately bury beneath the surface and elevate into the air the ore-bearing rocks of the valleys and the coal-bearing strata of the Allegheny basins.

A diagram will probably illustrate this important feature better than any description, so accordingly I reproduce from the First Survey report, in Fig. 1, Page plate 1, page 4, a section-line along the Nittany valley anticlinal, which clearly shows its effect.

South of the Allegheny mountains the two principal anticlinal axes of the county are those of Nittany and Penn's valleys. Both of them elevate the limestones of No. II and include between them the striking synclinal of Nittany mountain.

The *Nittany Valley axis* lies decidedly on the north side of the valley, close to the Bald Eagle mountain, its north dips being generally much steeper than its south ones. (See section on map.)

The crest of this flexure is not a straight line, but, like similar axes to the south, shows a crescent shape with the prongs of the curve bent southwards. The existence of Nippenose valley in Clinton and Musquito valley in Lycoming is due to this fact.

In Centre county however this axis keeps practically parallel to Bald Eagle mountain.

Nittany valley is about 31 miles long and from 2 to 5½ miles broad. Its central region, from about 3 miles east of Bellefonte into Clinton county, and in the western part of the county in Half Moon and Ferguson townships goes by the name of the "Barrens," owing to the sandy nature of the two low ridges known respectively as *Sand Ridge* and *Chestnut* or *Buck Ridge.*

This part of the valley is destitute of water, which has led to the sinking of artesian wells at various places to a depth of 400 to 500 feet to furnish water for washing the rich limonite or brown hematite ores which accompany these rocks.

Though chiefly marking the wooded and uncultivated valley tracts, the soil of the "Barrens" is by no means wanting in fertility, and to a great degree the name has become a figure of speech rather than descriptive of any actual condition of things.

These "Barren Ridges" attain in places considerable elevation, but are rather an elevated plateau shape than a definite ridge.

Between Bellefonte and the Clinton county line the main axis of the valley is everywhere from 1½ to 2 miles south of the Bald Eagle mountain, being well marked on the turnpike to Centre Hall about 1 mile south of Bellefonte where some of the sandy measures common to the Barrens are visible.

If I am correct in identifying Sand Ridge east of Bellefonte with Chestnut Ridge towards Huntingdon county, as parts of the same axis, the floor of the valley in the neighborhood of Bellefonte would seem to be a low part of this flexure, for the measures all indicate a type of limestone slightly higher in the great Siluro-Cambrian formation No.

II than that occupied by the sandy measures of these ridges. Yet the section through Bellefonte shows some sandy layers south of the town. The exact horizon of these sandy rocks is not yet well made out, but all ideas of their representing a portion of the next lowest formation (*Potsdam Sandstone No.* I,) seem to be dispelled by the fact that the Scotia Ore Mine wells on the south flank of Chestnut Ridge "Barrens" (400±′ deep) passed through a considerable amount of good limestone after piercing the sandy measures on top.

Professor Lesley writing under date of July 27, '83, gave as his opinion on the subject: "That the Barrens are low in II is evident from the fact that their 'ridge' (east of Bellefonte) only runs to within 5 miles of Mill Hall Gap, there sinking (with the central axis of Nittany Valley) and allowing the middle or upper limestones to circle around over the axis."

It is true that the increased dip of the measures south of Bellefonte (50°) over those of the Sand Ridge (20°–25°) would tend to expose the former to much more rapid erosion, allowing their disintegrated sand to be carried out of the great gap in the mountains by the waters of Spring creek, Logan's branch and Buffalo run; while the gently inclined rocks of the "Barrens," without present creek erosion, would naturally keep their place intact much longer.

Further evidence however of the lower horizon of the Sand Ridge rocks, or, in other words, the greater vertical elevation of the anticlinal axis there is shown in the effect on the Bald Eagle mountain to the north.

The map shows a marked bend *northwards* in the mountain east of the Curtin Gap, along the Spring–Marion township line.

It is just here that Sand Ridge rises, throwing the mountain forward and producing such a series of steep dips (often overturned) as to give rise to the belief that the arch had snapped or faulted somewhere south of Jacksonville, where a cross-section of the valley would show nothing but south-east dips from mountain to mountain.

I was unable to detect any signs of a *fault* on the

ground; and while the rocks are very greatly overturned, I am under the impression that the arch still remains whole.

Further east in Clinton county the vertical subsidence of this axis allows the mountain to right itself again, (indeed this erection begins in Centre county,) until south of the village of Salona, in Clinton county, the arch is perfectly regular and gentle, with north dips of 3°–8° and south dips of 10°–20°, gradually subsiding beneath the upper or Trenton limestones.

Similar effects are brought about by the elevation of Chestnut Ridge in the western part of the county.

For 8 miles west of Bellefonte the floor of the valley is made up of limestone (frequently siliceous and cherty, but devoid of the sandstone common to the "Barrens"); but west of this point in the neighborhood of the Pond and Lambourn Ore Banks in Patton township, the rising of the axis in Chestnut Ridge again throws the Bald Eagle mountain northward along the Half Moon–Patton line.

It only remains to trace this remarkable axis in its course through the county and speak of its effects as shown in several cross-sections of the valley.

It has already been stated that it is always to be found along the north side of the valley at from 1½ to 2 miles from the Bald Eagle mountain.

In the lower or eastern end of the county, its position is readily remarked by reason of the elevation of Sand Ridge, which practically divides Marion and Walker townships.

Passing into Spring township just north of the Taylor and Gatesburg Ore Banks, and creating quite a prominent *limestone* ridge, it is next well seen about 1 mile S. of Bellefonte near the toll gate on Pleasant Gap pike, where it throws off dips of 30°–50° N. W. and 20°–12° S. E. as shown in the section on colored map.

It next crosses Spring creek about 1¼ miles due south of Roopsburg with dips of 10°–12°, and continues southwestward, gradually rising in the high land of Benner township to the Patton line. Here, just south of Fillmore, it is again seen in the old Crust Bank workings.

Passing near the Pond Bank and between the Lambourn

and Newell openings, it gradually lifts up Chestnut or Buck Ridge, continues north of the Scotia Mines and leaves the county in the eastern corner of Ferguson.

Throughout its course in this county, this axis line is strikingly straight, keeping parallel with the Bald Eagle mountain all the way, everywhere exhibiting moderate dips to the S. E., but steep (and often overturned) N. W. dips into the mountain.

Two subordinate anticlinal axes range along the southern part of Nittany valley west of the dying spur of Nittany mountain.

They are confined entirely to *Ferguson township*, dying eastward before reaching College township, which exhibits nothing but gentle S. E. dips from the main axis to Tussey mountain.

Both these axes, however, bring up the lower sandy measures which are still further elevated in Chestnut ridge, so that the whole surface of Ferguson township north of the Whitehall road is an undulating plain of the "barrens," made up chiefly of loosely aggregated sand, devoid of exposures and generally uncultivated.

The *first* of these subordinate flexures, known locally as the *Gatesburg Ridge*, lies about 1½ miles to the *south* of Chestnut Ridge, and about the same distance *north* of the third, *Tadpole* or *Sandy Ridge* anticlinal passing close to Penna. Furnace and the Bryson ore banks.

The arch of the Gatesburg Ridge axis is will seen in the valley of Half Moon run just below the little village of Marengo on the L. & T. RR.

It is very flat here, showing dips of 12°–15° N. W. and 6° south-east, though increasing in a mile on each side of the axis to 60° and 35° respectively.

This axis makes no definite ridge, but rather an elevated plateau sinking to the N. E. and carrying down its sandy measures below the limestone area of College township.

Tadpole Ridge, a probable equivalent of the Cale Hollow
3 T⁴.

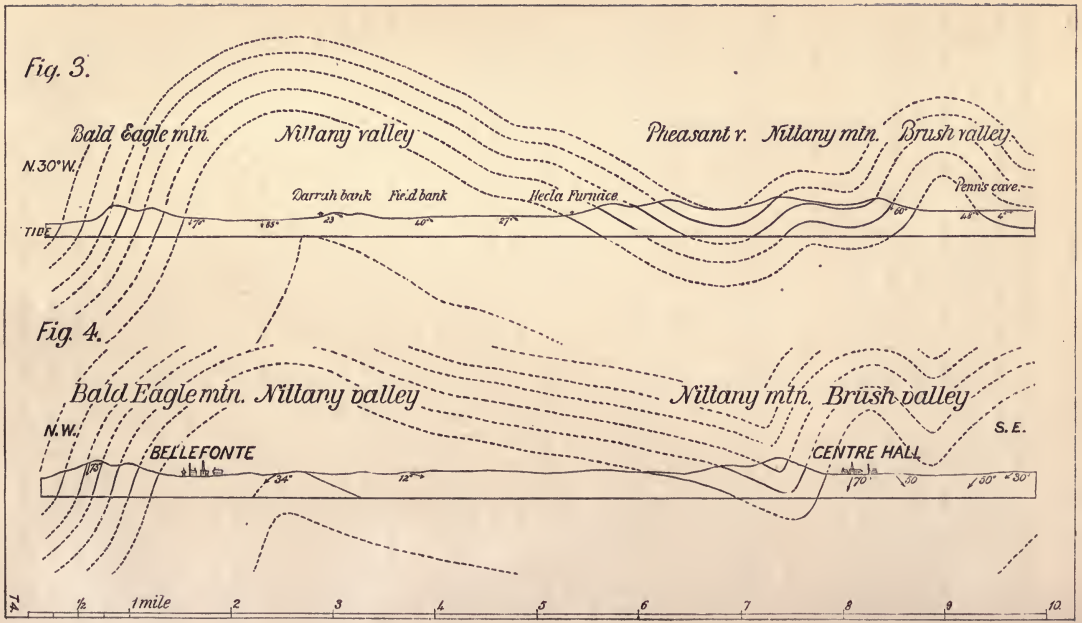


Fig. 3.
Bald Eagle mtn.
Nittany valley
Pheasant v.
Nittany mtn.
Brush valley
N.30°W.
Darrah bank
Field bank
Hecla Furnace
Penn's cave
TIDE
Fig. 4.
Bald Eagle mtn.
Nittany valley
Nittany mtn.
Brush valley
N.W.
S.E.
BELLEFONTE
CENTRE HALL
74
½
1 mile
2
3
4
5
6
7
8
9
10

axis of Huntingdon county, takes a parallel course from just north of Pennsylvania Furnace on the west to the neighborhood of the Johnston ore bank in College township, lapping past the dying Brush valley axis, between which two axes the Nittany mountain synclinal trough occurs, rising eastward and bringing up successively the slates of III and the sandstone of IV east of Lemont.

At Pennsylvania Furnace this axis throws off dips of 25°–60° to the N. W. and 25°–40° S. E. into Tussey mountain *monoclinal.*

But few exposures occur at its eastern extremity, all of which are to the south-east at angles of 15°–30°.

Several sections across Nittany Valley show the varying structure of the rocks.

(1.) *Madisonburg Gap Section.*—Beginning on the east the first to be described is at the Clinton county line.

The line of the Sand Ridge (Nittany valley) axis is here barely a mile distant from the Bald Eagle mountain.

The sand rocks of the mountain all dip steeply to the N. W.—are often vertical and even overturned, as is evidenced by S. E. dips 80° and 86° in the Hudson river slates of No. III along the south base of the mountain. Back of the slate the shaly, thin bedded Trenton limestone comes in, succeeded further south by magnesian sandy limestone of a white, hard crystalline character and finally by the loose sandy measures of the uncultivated "barrens." The axis is pretty regular here preparatory to righting itself in a perfect arch in Clinton Co., south of Millhall. Keeping to the north side of the anticlinal, the section line passes the ore banks of that region about 2½ miles N. W. of the old Washington furnace, where the measures, still show S. E. overturned dips.

These ores, Washington furnace and Beck banks, are about 3,000 feet below the top of No. II or junction with the black slates of No. III, and are again brought to the surface on the south side of the ridge and anticlinal in the Snavely, Barlow and Day, and Huston banks, where they occur between bands of cherty limestone dipping about S.

35° E. 30°. This dip continues to the base of Nittany mountain where dips of 40° S. E. in the slate and 50° in the Oneida sandstone or terrace mountain are exposed.

The mountain synclinal then flattens; the middle or Medina red sandstone member of IV shows dips of only 30°, and the inner Medina white S. S. 25°, before reaching the considerable body of Clinton red shale and sandstone No V preserved in the Pheasant valley trough.

(2.) *Section at Howard and Jacksonville.*

This section, 4 miles west of the last, was compiled near Jacksonville through which Lick run issues to the Bald Eagle creek at Howard.

The village is about ½ mile south of the Bald Eagle mountain. The siliceous limestone strata exhibit themselves here dipping 68°–80° to the S. E., overturned to that amount, some of it showing good pale blue limestone layers.

No evidences of a *fault* along here, as suggested in the First Survey Report, were seen.

The valley between Jacksonville and the mountain is narrow, owing to the steep dips of the rocks.

Good blue limestone, somewhat fossiliferous, is opened in several quarries north of the village, and within 100 yards of the mountain the No. III slates appear, black and shiny, polished by the excessive pressure exerted on the rocks here by the uplifting of the anticlinal to the south and leading to frequent expenditure of money under the idea of finding *coal*.

South of the village, magnesian limestone interstratified with the common sandstone strata outcrops with a dip of S. 40°, E. 50°–60°, just north of the Butler ore bank.

Sand ridge is very knobby and considerably broken up and shows a double crest line.

The north, or terrace ridge, is made up of a blue, flaggy sandstone, distinctly bedded and very hard, while the south ridge is flat and regular and shows nothing but loose white sand. All the irregularities of contour occur in the north ridge.

The blue rock is regularly interstratified in beds of mag-

nesian limestone and has only made a hill by reason of its superior resisting power to erosion.

The second ridge is the higher and shows S. E. dips of only 20°–25° along its southern flank.

The ore horizon 4 miles east, mentioned in the Madisonburg Gap section, is continuous here through the Hecla, Voneda and Schwartz mines—all referable to distinctly limestone strata which dip 30°–40° S. E. towards Nittany mountain.

To the south, along Little Fishing creek. the dark blue Trenton layers come in, weathering to a reddish soil, and succeeded in turn by the Hudson River Slates of No. III, which again have been extensively opened for coal in Henry Brown's tract and several hundred tons of worthless stuff thrown out.

A coal company was actually organized in Hublersburg to develop this field and a large acreage obtained for further development.

It is but another illustration of the failure attending all these "coal enterprises" in other parts of the county in the same rocks where coal has been searched for 15,000 feet below its proper horizon.

The slate dips 40° S. E. succeeded by the sand rock of Nittany mountain.

(3.) *Hecla Furnace Section.* Three miles further west another section may be obtained in the neighborhood of the Hecla Furnace Gap in Nittany mountain.

Back of the site of the old furnace in the gap of the Little Fishing creek, the outer sandstone is dipping 52° to the south-east, followed southwards by dips of 42° and 40° in the Medina red and white sandstones in Rag and Green valleys.

To the north of the old furnace blue limestone dips only 25°–30° along the Zion or South road.

The valley, between Nittany mountain and Sand Ridge, is very even, owing to the absence of the deeply grooved trough of Little Fishing creek and the gradual subsidence of the Nittany valley axis.

About ¾ miles from the furnace, blue siliceous rock was

Fig. 5.
S.32°E.
Bald Eagle mtn.
Fillmore
Hooversville
Boalsburg
B & B. & R.
Crust bank
Paddington bank
Slab cabin run.
Slower bank
110E
Fig. 6.
S.30°E.
Bald Eagle mtn.
Chestnut ridge
Galesburg ridge
Sand ridge
Spruce Creek
Lovetown bk.
Scaba bank
Tadpole run
Penna Fur. bk.
110E
½
1 mile
2
3
4
5
6
7
8
9
10
T4.

formerly quarried for paving *flagstones*, dipping 40° S. 30° E. near McKinney's Ore Bank—which marks the extension of the ore range south of the Barrens. The rocks, chiefly non-calcareous, dip 22° to the south.

In the Darrah bank, on the north side of the Ridge, the same blue siliceous magnesian limestones outcrop prominently in bold cliffs and ledges, dipping 20° to 25° *into* the ridge. This is something over a mile from the Bald Eagle mountains.

Along the North road, siliceous and semi-magnesian limestones stand nearly vertical, showing dips between Jacksonville and Bellefonte of 85°, 83°, 70°, 83°, 80°, and 88° to the south, and 85°, 88°, 60°, 65°, and 76° to the north.

It is uncertain which of these dips are overturned and which are regular, but the anticlinal evidently begins to right itself after passing into Spring township.

The north half of the valley, north of the ridge, is, in its general character, strikingly different from the southern portion. It is greatly grooved and broken, while the other is comparatively level, owing to the superior erosion along vertical strata as compared with that in rocks dipping only 20° to 30°.

(4.) *Bellefonte Section.* This is decidedly the best section of the Palæozoic rocks that can be obtained in the county, and the measured profile of the country presented in the general section from II to XIII *on the colored map* will show the relative position of the formations. Part of it is repeated on page plate 3.

The section line crosses comparatively uneven ground, but owing to the sinking of the Barrens 4 miles to the east, no regular ridge is encountered between the Bald Eagle and Nittany mountains.

The sand rocks of the Bald Eagle mountain dip regularly to the N. W., forming the double crested mountain north of Bellefonte with slopes to N. W. of 70°–80°.

South of these the slates dip about 50° in the same direction, their steep dip carrying them well up the mountain flank. The No. II blue fossiliferous Trenton limestone about 600 feet thick succeeds on the south with similar

dips, made up of massive and thin-bedded limestones, fine-grained and distinctly laminated and filled with characteristic fossils.

Blue compact limestone with some siliceous bands is largely quarried in Alexander's and Morris' quarries on both sides of Spring creek north of the town; succeeded below the Presbyterian church by magnesian limestones, banded and considerably broken by cleavage, and containing cherty masses. Its color is decidedly whiter than that of the higher limestones.

These same measures continue south of the town, all of a sandy nature and exhibiting numerous cross-fractures for nearly a mile south along the Centre Hall turnpike. The average dip is about 50° N. W., though local dips varying from 30°–60° are frequently met with.

The arch itself, one mile south of the town, is very gentle, with dips each way of only about 9°.

From there the same series of rocks already mentioned appear with south-east dips of 30°. 20°, 12°, and 10° into Nittany mountain.

There are but few exposures of the Hudson river slate and Oneida sandstone rocks in Pleasant Gap, though a vast amount of loose rock and boulders. The middle or red Medina member of No. IV however, shows dips of 20°–30° to S. E., with north dips of 60–70°, in the other side of the synclinal showing how the plane of the basin inclines northwards.

(5.) *Fillmore-Boalsburg Section across the whole valley.*

This section, 6 miles further west, and about ½ mile west of the end of Nittany mountain, is about 8 miles long from mountain to mountain, and crosses the three prominent structural features of the county, viz: 1. Nittany valley anticlinal; 2. Nittany mountain synclinal; 3. Penn's valley anticlinal.

About ¾ miles north of Fillmore on the Buffalo run road the edge of the Hudson river slates appears, the slate dipping 70° N. W. into Bald Eagle mountain.

The blue Trenton limestones follow to the south with equal dips. But the inclination diminishes so rapidly to

the southward that on the Buffalo run road at the village it is only 15°–20°.

Finally, half mile further south in the Crust farm, siliceous limestone forms the gentle anticlinal arch with dips of only about 6°, marking the gradual rise westward of the anticlinal in Chestnut Ridge.

This arch, it may be remarked, is very well seen on Spring creek, about a mile south of Roopsburg, where it shows dips of 10°–12° to the north and south.

Passing south from the elevated ground south of Fillmore, the section line passes into College township, where, in the Big Hollow N. W. of Houserville, it meets a fatter limestone dipping 10°, 15°, 18°, 16° and finally 30° (?) southeast in the Puddington ore banks.

Good limestone beds appear along Slab Cabin run and Spring creek, dipping S. 60° E. 15°–20°, marking the shoaling of the Nittany synclinal.

The Nittany synclinal crosses Spring creek south of Dale's Mills, swings northwards until again well exposed south of the Agricultural College, the slates swinging around the mountain's end.

On the south side of the synclinal the Trenton limestones dip steeply toward it 50°–60° N. 20° W.

Prolonging the section south, siliceous rocks are again brought up by the Penn's valley anticlinal about ½ mile south of the slates, dipping 48° N. W.

The dip soon changes to 8°–12° S. E., placing the Brush valley axis about a mile north of Boalsburg.

The south dip increases to 20° and 30° before the limestones finally pass beneath the slate and sandstone of Tussey mountain.

(6.) *The section across the western end of the county*, through Half Moon and Ferguson townships, has already been described. (See page 34 and page plate IV.)

The ore banks of this district are numerous and extensive and will be mentioned hereafter.

The limestones of upper Buffalo Run valley all dip steeply, and are either vertical or overturned with angles of 70°–80°

to S. E. The anticlinals produce a rolling country of Barrens to be succeeded finally on the south by good blue limestone along the Whitehall road, all dipping S. E. into the Tussey mountain at angles of 20°–40° and showing no evidence of the Brush Valley anticlinal which has expired to the east.

Anticlinal Axis of Brush Valley. This axis crosses the Susquehanna river near New Columbia and westward passes through the high spur of “Sand Mountain” in Union county, in the sand rocks of No. IV. Passing still westward and curving gently but steadily southward, it enters Centre county in Miles township, at the head of the long cove in which Brush valley commences.

Steadily rising as it passes westward it brings up the Trenton limestones of II about 4½ miles from the Union county line near M. Rudy’s mill.

Keeping to the north side of the narrow valley, closer to Nittany than Brush mountain, it passes to the north of Rebersburg and Madisonburg, crosses the valley road about 1½ miles west of the latter place with north dips of 65°–70° and south dips of 15°–20° and passes just north of Penn’s valley cave, where it throws off dips of 70° to the north and 45°–50° south, in good soft french gray limestones.

From here the Brush valley road practically marks the course of the axis to the Watson ore bank, attaining its greatest elevation in the neighborhood of Centre Hall where consequently the lowest limestones in the valley are exposed.

This axis however nowhere brings up the same thickness of No. II as is exposed in Nittany valley, not over 2500 feet being shown in the general section across the county, and this fact will account for the comparative poverty of this valley in iron ore deposits, much being buried beneath the present surface.

Moreover the steep dip of the measures along this valley as far as Centre Hall at least, has hastened erosion, the higher ore bearing strata having been carried off the arch.

Consequently as the valley widens and the axis sinks westward, owing to the subsidence of the Brush mountain

synclinal, the higher ore bearing rocks are preserved by reason of gentler dips, so that we find their ores intact in the Watson, Ross, Stover and other mines.

The axis crosses Spring creek about 1½ miles south of Lemont, showing dips of 48° N. W. and 12° S. E., the latter flattening to 8° opposite Boalsburg, west of which meridian the axis rapidly expires before reaching the base of Tussey mountain.

Anticlinal of Penn's Valley.—The main or north anticlinal of Penn's Valley crosses the Susquehanna above Lewisburg, and after passing through the Buffalo valley and mountain in Union county, enters the slates of Pine Creek Hollow between Brush and Stone mountains in Centre county, and 4 miles further south-west lifts up the Siluro-Cambrian limestone at Hosterman's saw-mill.

The axis in its course from the Union county line into the cove in Tussey's mountain, nowhere shows the same amount of northern curvature as was developed by the Brush valley axis. But while this is true as a whole, this axis develops several striking curves in that distance.

Keeping to the north side of the valley, the first part of its course as far as Aaronsburg, shows no special features.

One mile east of that village it crosses the Woodward road with dips in siliceous limestone of N. 25° W. 68° and S. 35° E. 40°. Passing thence through Aaronsburg and throwing off northerly dips of 60° and southerly ones of 35°–40°, it deflects sharply to the S. W., crossing the Millheim–Coburn pike about ¼ miles south of the first named village.

North of the axis, dips of 70°, 64°, and 80° N. W. bring us to the edge of No. III, while south inclinations of only 12°, 20° and 30° were observed.

From here the axis bends again northwards, keeping a nearly due west course to the German Reformed Church, 1 mile north-east of Penn Hall.

At this point the axis is not half a mile north of the edge of the Egg Hill slates.

It passes north of Spring Mills with N. W. dip of 60° and S. E. ones of 20°–22° and then takes about the center of the

valley at its Penn's Creek crossing, where it is exposed in a gentle arch of 10°–15°.

About two miles west it attains its greatest vertical elevation and crosses the Bellefonte and Lewistown pike about 1½ miles south of Centre Hall and the same distance north of the No. III slates along Egg Hill.

The country here is elevated, and shows a broad plateau. The arch subsides rapidly from here and deflects strongly S. W. into the indentation in Tussey mountain, 2 miles south of Linden Hall.

Anticinal Axis of Penn's Valley Narrows. This wave shows less curvature and less vertical rise between its extremities and center than any of those previously described; for dying away at both ends in the Clinton formation in Union and Huntingdon counties, it barely lifts to the surface the upper Siluro-Cambrian limestones of No. II in Penn's Valley narrows and George's valley.

Entering the county in the east in the narrow plain of III between Short mountain and the Seven mountains on the south, it first brings up the Trenton limestones about 1½ miles east of Woodward.

Bending slightly northwards, while keeping a course generally parallel to the Seven mountains, it ranges about 1½ miles south of Aaronsburg with sharp dips of 70° N. W. and 60° S. E.

It is next seen on the Millheim pike with inclinations each way of 40°–48° and attains its greatest elevation about 2 miles further west, throwing off dips of 70° N. W. and 50° S. E. From this point the arch begins to subside, the south-east dips only showing 10°–20°, and deflecting S. W., the axis keeps the north side of George's valley close to the south base of Egg hill. At Potter's Mills the arch is greatly contracted again, showing dips along branch of Sinking creek of 85° N. W. and 70°–80° S. E.

The limestones finally sink under the slate of III in "The Loop" 4 miles west of Potter's Mills, the axis ranging through the slate valley and passing through the terrace and knob of Tussey mountain at the "Bear Meadows," dying west in Huntingdon county.

The Confer or Decker Valley Anticlinal. This short axis while showing the same general northern inclination of curvature at its center as explained in the former ones, is of meagre relative importance, only having been of sufficient force to bring up the Hudson river slate of III in the Confer or Decker valley in Gregg and Potter townships and the same in the small oval "Lechathal" or Lick valley watered by Penn's creek and Swift run in the lower part of Haines.

Entering the county in southern Haines, south of the little Clinton red shale valley of V, it ranges successively through the upper, middle and lower members of IV in the first 2½ miles of its course, finally lifting up the slate in the small "Lechathal" valley. Passing north of Fowler's station on the L. & T. R. R. this sharp arch throws off 60° dips south of Beaver Dam tunnel and dies thence under a vast sand flat of Oneida sandstone between the western extremity of this valley and the eastern end of Confer's valley 4 miles apart. Here the anticlinal again brings up the slate of III with dips of 60°–70° at the M. E. Church, keeping the north side of that valley for 7½ miles, when it again carries down the slate under the Oneida sandstones of the resulting kettle, finally passing out of the county in southern Harris between the white Medina ridges of Thick Head and Bald mountain.

Poe Valley Anticlinal Axis. This, the last of the anticlinal axes of the county, has a length of only about 15 miles before passing into Union and Mifflin counties at its extremities.

It, like its predecessor to the north, only brings up the slates of III in Poe valley, a drawn-out, oval-shaped depression in the heart of the Seven mountains 8 miles long from east to west.

It is much straighter than the Confer valley axis and while it is 1¼ miles south of it in Gregg township its two extremities nearly lap with those of the northern axis.

It is insignificant in its results, lying everywhere along the north base of Paddy's mountain, which it divides on the west from Bald mountain spur seen rising west of the Lewistown pike where the Mifflin county line is offset.

The structure of the northern half of the county—north of the centrally dividing Bald Eagle mountains—is extremely simple, as a glance at the cross section of the county will show. From the Bald Eagle mountain northward the rocks all dip one way (northward); at first so steep as to be vertical; then less and less steep until they lie nearly quite flat, at the top of the Allegheny mountain, where the lower Productive Coal Measures of the Snow Shoe-Beech Creek basin come in.

This forms the First Coal Basin of Clearfield county and the synclinal axis or line of deepest measures passes approximately north of the Hogback in Curtin township—thence along Beech creek to Gray's Splash dam and thence a little south of west through Sugar Camp hill, Holt's and Askey's hills to the Moshannon, crossing which it extends north of Peale in an approximate line with the Morrisdale-Philipsburg-Osceola trough. (See Report H⁷.)

Like the flexures in the southern part of the county, this trough rises and falls in the line of its strike, alternately lifting into the air and burying its coal beds.

On the opposing dip the coal beds gradually rise northwards on to the First or Laurel Hill-Pine Glen-Hyner anticlinal axis in Burnside township, which creates the dividing line between the First or Snow Shoe basin and the Second or Karthaus basin.

This axis is partially indicated on the county map as far as traceable and is undoubtedly identical with the first axis of Clearfield county.

It will be referred to in detail in the chapter on—"The Coal Measures." It will suffice here to say, that entering Burnside township from Clinton county, where it attains its greatest elevation and brings up the lowest members of XII, it rapidly declines south-westward until at crossing the Karthaus pike about 1½ miles south of Boak's Pine Glen store, it apparently exposes on its flattened arch the buff-colored Clarion sandstone and allows the lowest coal A of the series to swing over the axis and join the deposit of the Second basin.

As far west as P. Etter's, this axis is marked by a bold

Conglomerate hill and forms a practically straight line. But beyond this point—except along the Karthaus road—its position and course are doubtful, and it is quite probable that it curves southward slightly to account for the jog noticed on the Trullinger lands near the headwaters of Cherry and Sandy runs.

West of the Karthaus pike the lower coal measures extend for some distance out towards the Moshannon until the erosion of that stream has cut down successively through the Conglomerate of XII, the Mauch Chunk Red Shale of XI and even to the Pocono Sandstone of X.

At the same time that this axis is pitching to the south-west and continually bringing in higher measures, the erosion of the West Branch Susquehanna is in the opposite direction, so that proceeding down stream *lower* rocks are continually being exposed along its course and confining the coal measures of the second basin in Centre county to a stretch of about 3½ miles between Karthaus Landing and Spruce Run.

The mountains of the county contained between the anticlinal valleys described above are, with the exception of the Allegheny and Bald Eagle, of synclinal structure.

The first synclinal is that of *Nittany Mountain*, south of the main Nittany valley which, for convenience sake, may be made to include all the mountain land between Nittany and Brush valleys, and embracing also the expiring anticlinal of Sugar valley.

The south-west termination of this system is in the Oneida terrace mountain of IV gray sandstone at Lemont. Traced east, it soon becomes a double mountain with the rocks of the two prongs dipping towards each other and including between them an elevated red shale and sandstone valley of lower Medina IV. This is just west of McBride's Gap.

At the Centre Hall turnpike the ridges are about one mile apart, and just about ½ mile to the east they receive between them the central keel or inner mountain of white Medina,

the upper member of IV, on which the outer mountains of Oneida form opposite terraces.

About 1½ miles east of the Hecla Gap road, the central Nittany mountain divides in turn to enclose "Little Sugar Valley" or Pheasant Valley. The south branch extends as far east as a point north of Rebersburg.

The north branch, called locally "Big Mountain," forms the N. W. barrier to Pheasant valley, and is deeply cut at the Madisonburg (Johnson) gap and the Washington Furnace or Big Fishing creek gap in Clinton county.

Pheasant Valley, containing the Clinton shales and sandstone of V, is about a mile wide from summit to summit in this county, succeeded south by the anticlinal of Sugar valley, which, expiring about 1 mile west of Madisonburg pike, only brings up the Oneida sandstone in this county.

To the east in Clinton county the slate of III and the upper limestones of II are both elevated to daylight as shown on map.

The north dips in these mountain members are always much steeper than the south ones, so that the plane of the synclinal axis inclines south-east to the horizon.

Brush Mountain Synclinal to the south, dividing Brush valley from Penn's valley, is a long and straight synclinal ridge of Medina white sandstone, extending from the Union county line to within a short distance of the road crossing from Rebersburg to Aaronsburg.

The terrace mountain of IV gray Oneida sandstone however, runs on much further west, beautifully gapped north of Millheim by Elk creek, extending as a double line of high and rugged hills to the high knob or kettle south of Penn's Cave in Gregg township, and between the two lies a high and wooded vale of the middle IV red Medina ending near the Penn and Gregg corner.

The south terrace ridge of Brush mountain unites with the north terrace ridge of the next synclinal of *Short mountain* in Union county, forming a high knob and closing up Penn's valley in Pine Creek hollow.

This mountain is a synclinal triple ridge, rising from the floor of Penn's Valley north-east of Woodward in Haines

township, and divides the Penn's creek narrows from the Pine Creek hollow.

Its central keel of white Medina just shows in this county, its two branches uniting in the high spur known as the "Hind Knob," dividing eastward and known as Stone mountain. The terrace ridge extends 2 miles further west and ends in the "Round Head," and is breached by several tributaries of Pine creek.

The Seven mountains and *Tussey's mountain*, as their continuation towards the south-west is known, form the main south barrier to the numerous limestone valleys of the county, of which the Bald Eagle mountain is the north barrier.

Several nearly parallel ridges of Oneida and Medina SS., forming together an elevated plateau 2000′+ A. T., separate the limestone valley of the Kishacoquillas on the S. E. from the Penn's valley region on the N. W. in this county.

On the Lewistown and Bellefonte turnpike these ridges number seven, four of which are contained in Centre county. An inspection of the colored county map and cross-section will better show the relationship they bear to each other and to the Poe and Confer Valley anticlinal flexures.

The depressions between these ridges are made up of the middle or red Medina member of IV, making Foust's and Triester's valleys, while the slates of III are brought up in Confer or Decker valley.

Numerous sections across this belt of mountains have been made from the barometrical contour map of Mr. Chas. E. Billin, and the detailed structure of the system can be readily learned from them. (See Report S.)

The cross-section of the county sufficiently illustrates their structure for all purposes in this report, as well as their connection with the rocks of Brush Nittany and Bald Eagle mountains.

The *Seventh* or most northern mountain of the group, lying south of George's valley, when traced west forms the inside of the Loop, sweeps around its north edge to form Tussey knob, and continues S. W. as the terrace of the main Tussey mountain of white Medina.

The Bare or "Bear" meadows lie in the hollow between this wall and the inner kettle of white Medina, and cover the middle or red Medina rocks at the head of Sinking creek.

George's Valley anticlinal cuts off the synclinal fragment of Oneida sandstone in Egg Hill from the main body of the formation in the Seven mountains; but its synclinal trough of No. III slates coalesces with those extending east from Tussey knob.

Chapter V.

The Coal Measures.

The Coal Measures are confined to the four northern townships of the county, which may be described together.

The Carboniferous Formation in Western Pennsylvania consists of

Upper Barren (Permian) Measures.
Upper Productive Coal Measures.
Barren Measures.
Lower Productive Coal Measures.

In Centre county only the Lower Productive Coal Measures, 280–300 feet thick, has escaped erosion.

This group comprises: —

Barren Measures (Mahoning sandstone, shale, etc.).
E. *Freeport Upper Coal.*
Freeport Upper Limestone
D. *Freeport Lower Coal.*
Freeport Lower Limestone
Freeport Sandstone.
C′. *Kittanning Upper Coal.*
Johnstown Cement Bed.
Gorman coal bed.
C. *Kittanning Middle Coal.*
B. *Kittanning Lower Coal.*
Ferriferous Limestone.
A′. *Clarion Coal.*
A. *Brookville Coal.*
No. XII. *Pottsville Conglomerate.*

Some few patches of the Barren measures still remain on the highest summits to mark the former outspread of this

division, but these cases are rare, and where preserved, are only so in part.

The Pottsville (Seral) Conglomerate No. XII, forms the crest of the Allegheny mountain south of Snow Shoe, and is made up at that point of about 255′ of massive gray sandstones, with some layers of rounded white quartz pebbles of various sizes from a pea to an egg.

On account of the gentle dip to the north-west no coal outcrop of any consequence is seen for 3 miles north-west of the summit.

One and a half miles south-east of Snow Shoe village the conglomerate shows on the surface in lumps and boulders.

Proceeding north of the village the successive coal beds come in on a north-west dip, the highest beds being confined to Lucas and Coal hills south of the Pennsylvania Railroad.

Crossing the north fork of Beech creek and the new line of the Beech Creek, Clearfield and South-Western Railroad, the basin line of this field passes through Askey, Holt and Sugar Camp hills, and thence a little north of east through the Beech creek region. North of this line the measures are all dipping in the opposite direction or south-east, and at about equal angles and rising towards the first anticlinal axis known locally as the Pine Glen axis in Burnside township.

This axis is identical with the Laurel hill axis of Clearfield and Cambria counties on the west and the Hyner axis of Clinton county, dividing the Philipsburg-Snow Shoe-Beech creek First basin from the Karthaus or Second basin.

The Snow Shoe basin is about 8 miles wide from the Allegheny summit to the First axis, though only about one half of that is occupied by the coal measures.

In addition to the inclination of the measures towards a central synclinal line, quite as important a feature, influencing strongly the economical wealth of the district, must not be lost sight of.

This is the fact that the basin *rises in nearly all directions* from its center between the Karthaus pike on the west and Sugar Camp hill on the east.

The rise eastward through the Beech creek region is

gradual so that the hills between the numerous branches of Beech creek descending from the high land in Burnside township, all carry small interrupted basins of the lower beds of the productive coal measures.

These small basins are considerably cut up and hard to mine as they are located high above the railroad. So likewise on the west patches, of the lower beds have been left on the tops of the hills between Snow Shoe and the Clearfield Bituminous Coal Co.'s Tunnel Mines in the north-east corner of Rush township. But these patches only serve to unite the coals of this district with those of the Philipsburg and Osceola basin in the western part of the same township. The darkest tint on the county map—indicating the horizon of the Freeport Lower Coal Bed D—will better illustrate this feature.

South of the southern outcrop line of this basin in Rush township the wide spread of the underlying Conglomerate measures will attract attention.

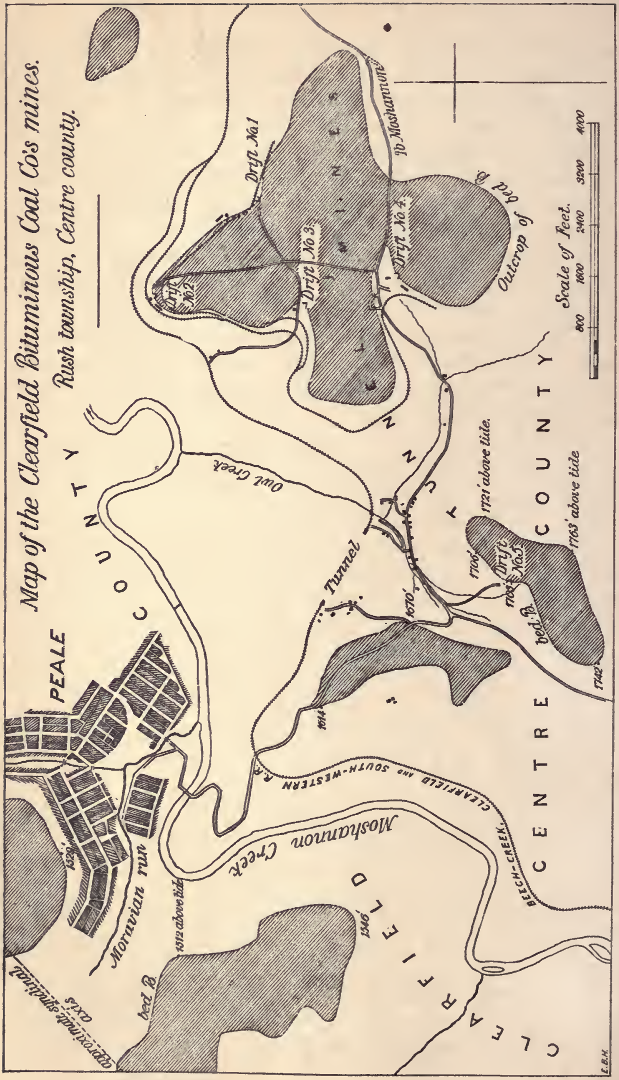
The limits of the little basin south of Peale on the line of the B. C., C. & S. W. R. R. have been instrumentally defined. (See page 54.) The dip is about 170′ to the mile, which is quite sufficient to carry the coal measures into the air before reaching the Little Moshannon creek to the south.

Moreover there is no ground high enough here to catch these coals, though it is possible that the low ridge north of Antes may indicate a local anticlinal roll, though no coal appears on its back so far as my examinations permit me to judge.

South of Antes, however, along public road to Beaver Mills, there are outcrops of slate apparently dipping south-east but succeeded by north-west dips in the same before reaching Underwood's Mill.

This may indicate a narrow trough and lend some coloring to the report of a coal field along the upper waters of Six Mile run.

The whole region, however, has been colored in as No. XII, and the basin, if existing at all, is of local interest only and of no commercial value whatever.


Map of the Clearfield Bituminous Coal Co's mines.
Rush township, Centre county.
PEALE
COUNTY
Owl Creek
Tunnel
Drift No 1
Drift No 2
Drift No 3.
Drift No 4.
Drift No 5
To Moshannon
Outcrop of bed B.
Scale of Feet.
800
1600
2400
3200
4000
1721' above tide.
1763' above tide
1706
1670
1703
1742
1614
bed B.
CLEARFIELD AND SOUTH-WESTERN R.R.
Moshannon Creek
BEECH-CREEK.
CENTRE COUNTY
CLEARFIELD
Moravian run
1529
1512 above tide
1546
bed B.
approximate synclinal axis

The whole region demonstrates the cessation of rise in the first basin, however, so that across the Moshannon in Clearfield county north of Peale we are prepared to find the country covered with the lower beds of the coal measures until the basin, again deepening at Morrisdale, takes in the Freeport lower or Moshannon bed and carries it thence through the trough of the First basin into Cambria county. (See Report H⁷.)

As may be readily supposed this trough line is by no means straight and varies in a horizontal as well as vertical plane.

So it may be traced from Morrisdale east in a nearly direct line north of Peale to the Moshannon creek in the vicinity of Weber run (Clearfield Co.) and thence through Moshannon village to Snow Shoe.

West from Morrisdale it swings through Philipsburg and north of Osceola and thence by way of Houtzdale and Utahville into Cambria county.

This short sketch of the course of this synclinal is rendered necessary to illustrate the cause for prevalent north-west dips to the Coal measures in the western part of this basin in Centre Co.

Philipsburg, like Snow Shoe, is the center of this depression or basin, the measures rising E. and W. as well as keeping their regular dip towards the synclinal axis.

Their rise there carries the Freeport lower or Moshannon bed into the air at Morrisdale* in about 4 miles and a similar result would have been recorded south-west were it not for a series of vertical faults through the Houtzdale region, the effect of which has been to retain these upper beds and the overlying barren measures through a vast extent of territory which otherwise would have been long since robbed of them by natural erosion.

While the absence of development on the Centre Co. side of this basin forbids any attempt to locate them or measure them with the same accuracy and skill as has been possible in the more largely developed Houtzdale basin, one such

* H⁷ Geology of Clearfield Co., by Dr. H. M. Chance.

apparently exists about two miles south-west of Stirling No. 3 colliery bringing down the Mahoning sandstone to the top of the hill on west side of small creek, while on the east side, the shales and sandstones between the Freeport coals cover the surface.

The southern limit to this coal basin can be seen by referring to the map. It will be noticed that from the Blair county line to Sandy Ridge station on the T. &. C. R. R. the outcrop is practically parallel to the Allegheny crest, which is here made up of a rather fine white sandstone devoid of large pebbles.

But from Sandy Ridge to its crossing the Moshannon creek 3 miles north-east of Philipsburg, this declination is changed to a much more northerly one, passing Cold Stream about 2 miles south of the town and after encircling the hill west of Black Bear run, passes into Clearfield county. This change is indicated by the course of the basin line and may be further explained by the continuation of the Antes roll south-west through the wilderness of Six Mile run as far as the old Philipsburg—Port Matilda pike.

The course of the *Pine Glen axis* dividing the first and second basins is shown on the map.

Its rise from the Moshannon north-east into Clinton county has produced precisely similar effects in the Karthaus Second basin to those already mentioned in the Snow Shoe-Philipsburg First basin.

Accordingly we find Karthaus Landing occupying the center of the basin from which the coal measures rise to the east *against the pitch* and are carried into the air before reaching Spruce creek.

The West Branch of the Susquehanna, between Karthaus and Buttermilk Falls, practically marks the synclinal trough of the Second basin. The axis shifts then a little northwards and confines the coal measures to the highest hill tops in Clearfield county.

The river deepening eastward at the same time that the rocks are pitching westward exposes the Mauch Chunk red shales No. XI just below Salt Lick and No. X Pocono measures further down the stream as shown on map.

Though the erosion of the river has made the hills on either side seem sufficiently high to catch all the Lower Productive Coal Measures, the wearing effect is now entirely in sub-carboniferous measures, and no coal need be looked for on the highlands marked by the Pine Glen-Hyner axis.

I cannot say that the *Furney axis* of Clinton county—occurring south of the Hyner axis* was identified anywhere through the Beech Creek region unless its presence has caused that outspread of the coal measures south through Curtin township which the map reveals.

In all probability this axis has died as an independent arch along the Centre-Clinton county line, and at best it is only a slight roll in Clinton county dividing the Wetham and Eagleton coals from those of Queen's Run and Tangascootac basin.

With this short generalization of the prominent features of the Centre County coal fields, I now proceed to record some of the details connected with the various coal beds and mine openings of the region.

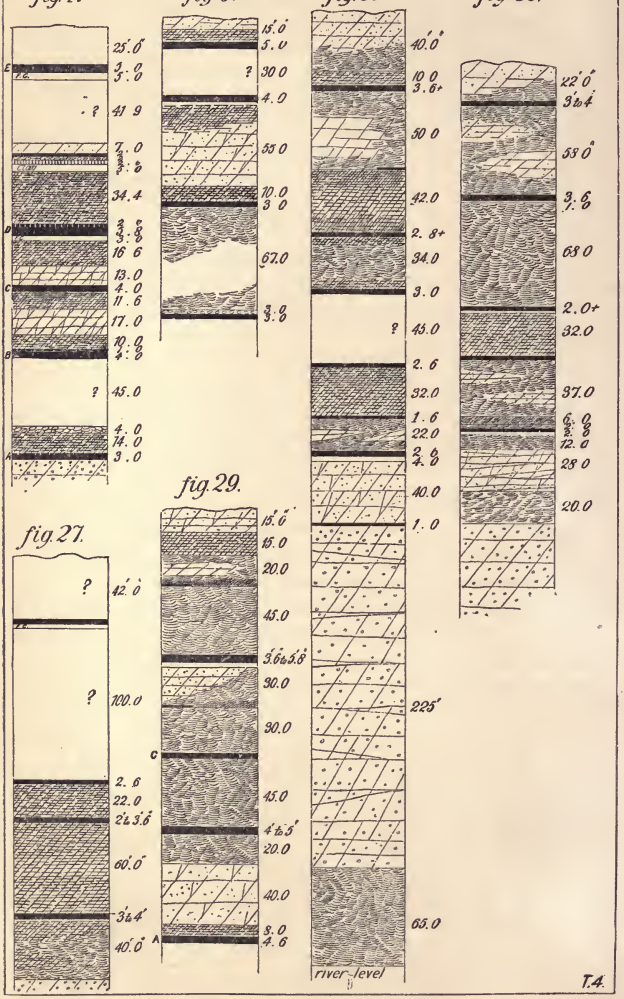
As has been already stated, the area of the Barren Measures No. XIV, is so insignificant as not to warrant any special mention. They have derived their name from the almost universal absence in them of *persistent productive coal beds*, though some exceptional instances are recorded in the various State reports where these strata have been found to enclose valuable coal seams.

The Barren measures.

In Centre county, this division is made up of argillaceous slates and shales and occasionally a gritty sandstone. So imperfectly intact are these Barren Measures in this county that I nowhere succeeded in finding an equivalent of the *Gallitzin bed*, usually occurring about 55–60 feet above the Freeport upper bed E, though it has been repeatedly identified in other portions of the Allegheny Coal Field.

*See Report G⁴.

Sections in Centre county.



The Lower Productive Coal Measures.

As recent surveys here and in Clearfield county have rendered certain changes in the nomenclature of the coal beds of this series necessary in order to make them agree with other districts of the State, I subtend, below, a section of this group copied from Report H, page 69, the data for which were furnished by Mr. James L. Sommerville's shafting. (See also Fig. 1, page 58.)

To the coal beds occurring in this section I have added in brackets the present approved names.

Section at Snow Shoe. Fig. 1.

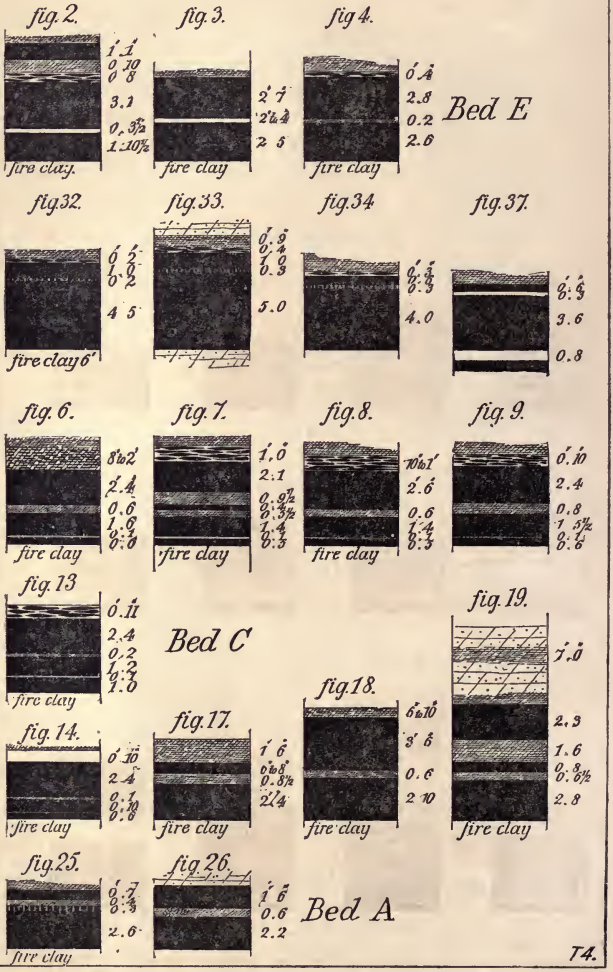
Surface and cover,	25′
Coal E, Freeport Upper,	5′
Fire clay,	5′
Concealed measures,	41′ 9″
Sand rock,	7′
Coal D′, Freeport Middle, [Freeport Lower D,]	2′
Brown ore and coal,	2′
Hard limestone,	2′ 6″
Light colored clay,	5′
Black slate,	34′ 4″
Slaty cannel,	2′
Coal D, Freeport Lower, [Kittanning Upper C′,]	5′ 8″
Fire clay,	3′
Slates, light colored,	16′ 6″
Light colored sandstone,	13′
Coal C, slate, "slaty coal." [Kittanning Middle C,]	4′
Black slate,	11′ 6″
Grey sandstone,	17′
Black slate,	10′
Coal, bony,	1′
Coal B, [Kittanning Lower B,]	4′
Concealed measures,	45′
Iron ore,	4′
Gray sandy slates,	14′
Coal A, [Brookville A,]	3′
Fire clay.	
Conglomerate No. XII.	

The section itself is comparatively correct, and sufficiently illustrates the position and character of the coal beds and intervals for the whole basin.*

In the interval of 63′ between A and B, as given in the

*Of course the intervals given in the section are by no means constant, but an easily-remembered approximation between coal beds in Centre county is as follows: A and B 60′; B and C 40′; C and C′ 40′; C′ and D 40′; D and E 50′.

Sections in Centre county.



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Sections in Centre county.

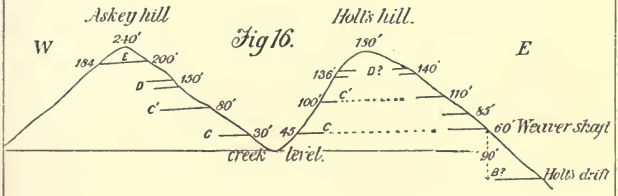

fig. 10

fig. 11.

fig. 12.

fig. 15.

fig. 20.

fig 21.

fig 22.

fig. 23.

fig 24.

fig 28.

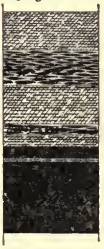

fig 30.

fig. 31

T.4.

section, there frequently occurs a small and worthless bed A′ 1′ 6″–2′ thick, usually from 15 to 25 feet above A, to which the name *Clarion* is given.

To the triple Kittanning group of coals have been assigned the letters B, C and C′—lower, middle and upper, with an intermediate bed between beds C and C′, usually showing 2′ of lustrous peacock coal with a hard slate roof and very persistent in this basin.*

The Freeport group retains its duplex character of lower and upper, and thus keeps its old letters D and E, which have been affixed to them throughout the State.

In the hurried preliminary survey of 1874 in Clearfield, Jefferson and a part of Centre county, the error of making the Freeport group triple and introducing a middle member arose from a variety of causes, among which may be mentioned: †

First. The frequent absence of distinct limestone benches in this field which characterize the horizons of these coal beds further west.

Second. From the mistaking of the Johnstown cement bed under the Kittanning upper for the limestone under the Freeport lower coal.

Third. The thinning of the great Moshannon-Morrisdale-Karthaus bed "D" from 4′–6′ in those regions to about 2′ at Snow Shoe, and the consequent false identification of the large bed along the upper Moshannon creek as the large ("middle") bed at Snow Shoe, whereas in reality they are two distinct beds.

Of the three well marked limestone benches which form so good a means of identifying these upper coal beds in the west and south-west counties, only one; the Freeport lower limestone 3′ thick, has been identified at Snow Shoe. The Freeport upper limestone 10′–20′ under bed E, and the Johnstown cement bed under C′, are either entirely wanting or disintegrated to such a degree as to leave only traces of their existence in the carbonate ore balls occasionally found under these beds.

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* Named "Goman Coal" by W. G. Platt. See Report H⁴.

†For correction see Report HHH, p. 316, Somerset county, also §151 Report T

To sum up the changes in a few words, the large coal bed called locally "Lower Freeport D," or "Middle Bed" at Snow Shoe is in reality the *Kittanning Upper C'*, the Freeport lower bed 2' thick occurring 40–45 feet higher in the series and about 60' beneath the Freeport upper bed E, and it will be necessary to bear these changes in mind when reading the following pages.

Snow Shoe coal basin.

The developments in the Snow Shoe basin proper have been almost entirely confined to the Kittanning lower, Kittanning upper and Freeport upper beds, B, C' and E to which custom here has affixed the names of "lower," "middle" or "big bed," and "upper bed."

Tradition assigns the first discovery of coal in this basin to Col. John Holt and a party of hunters, near a spring on Askey's land now owned by the heirs of William A. Thomas, not far from the Karthaus pike and just north of the summit cut of the Beech Creek R. R. At all events the first coal used in the county was taken from this place.

The commencement of mining on an extensive scale was on the Valentine's and Thomas' tract of the "Snoe Show Surveys." Mines were opened from time to time for local supply, notably by Samuel Gunsalus, Thomas Mayes, John Lucas, George Graham and Meese Gunsalus; but coal mining was not firmly established until the completion of the Bellefonte and Snow Shoe R. R. in 1859. The enterprise gradually developed until 1862 when an output of from six to seven thousand tons monthly was recorded. Various changes came about with the transfer of the railroad to the Pennsylvania system in 1881, and the 40,000 acres obtained of the Snow Shoe Land Association together with about 8,000 acres additional owned by the B. & S. R. R. and Moshannon Coal and Lumber Co. to the Snow Shoe Land and Improvement Co.

Berwind, White & Co. secured the coal lease on this large tract of territory and immediately began extensive developments. Coal shipments ran up to 300 tons a day and in

the fall of 1883 with the new openings in Sugar Camp hill, their output was probably 1000 tons daily.

The coal shipments over the B. & S. S. R. R. however for the year ending Dec. 31, 1833, show only about 300,000 tons, and this includes the shipments of Harned, Jacobs & Co. The control of this large body of coal and the limited facilities for shipping over the heavy grades on the B. & S. S. R. R. has naturally restricted mining to the land thus owned.

But the early completion of the new Beech Creek railroad will serve to stimulate production in the northern half of the basin, as yet untouched, and in the future encourage, no doubt, the opening of the Beech creek region to the east.

As has been already intimated, the display of limestone through the Centre county coal measures is very meagre, and the Snow Shoe basin is no exception to the statement.

The *Freeport upper limestone* was nowhere noticed in this district.

The *Freeport lower limestone*, recorded in the section under the Freeport lower coal D 2½ feet thick, is the key-rock in this basin, making a marked bench through Lucas and Coal Hills and Sugar Camp on the south side of the basin and in Askey Hill on the north.

It is everywhere thin—never over 3′ thick—and is quite impure, and usually carries about 2′ of carbonate ore between it and the Freeport lower coal.

The *Johnstown cement bed* under the Kittanning upper coal C′ was only occasionally identified in a few iron ore nodules scattered through a mass of slates.

The *Ferriferous limestone* beneath the Kittanning lower bed B, was only noticed in one place, on the north side of the basin on top of the low hill north of B. Viedorfer's place at Germania.

It is here, however, only in loose pieces of blue siliceous rock, and its perfect identification or vertical position in the measures doubtful.

The Snow Shoe section will also demonstrate the great *development of slate* in the measures at this point.

Thus the place of the Freeport sandstone between beds C′ and D is taken by 34½′ of black slate.

The enlargement of the black slates between the Kittanning middle and lower coals is again remarkable.

The *Clarion sandstone*, still lower down, between the Brookville coal A and the Clarion coal A′, seems absent unless it appears in the 45′ of concealed measures. It, however, nowhere offers a means of measurement through the basin and is consequently of little assistance in identifying the coal beds.

Coal bed E.

The *Freeport upper coal E*, or the "upper bed" as it is locally called, occupies but a limited area in this basin, confined to the hill tops in Lucas and Askey hills, a small patch on the Long estate and another on the Bird Coal and Iron Company tract on the north side of the basin in Burnside township. When opened, it shows an exceedingly handsome five-foot bed of bright clean coal, mainly of columnar structure, with a 2–3 inch slate parting dividing the bed in half.

It is above the average of marketable coals and is said to have made excellent coke, and was especially shipped for use in working iron.

The last work done in this bed was at drift No. 9 of the Snow Shoe mines, which is located on north face of Lucas hill about 50 feet below top of hill.

Bowlders of Mahoning sandstone cover the hill top mixed with some shales down to drift.

Though abandoned when visited in Oct., 1883, the gangways were in a good state of preservation.

All the openings on this bed in Snow Shoe have proved it to be seriously troubled with rolls and small faults and this is no exception in No. 9.

A horse-back roll was met when in a short distance from mouth of drift, and after proceeding further, a fault running about N. 8° E. and S. 8° W. with a small local fault crossing the Karthaus pike, at an angle of about 35°, throwing down the coal on the south about 13′.

A section of face at this *fault* supplemented from bone coal upwards by measurements taken nearer the drift mouth gave (See Fig. 2, page 60):

Sandy slate roof.	
Coal,	1′ 1″
Slate,	0 10′
Bone coal—cubical,	0 8″
Coal good—mined,	3 1″
Slate parting,	0 3½″
Coal good,	1 10½″
Fire clay floor.	

Another drift No. 5, further east around hill but on same outcrop, furnished a considerable amount of coal for coking at the ovens along railroad track, to which it was conveyed by an incline plane.

The troubled nature of this bed led to its abandonment here also, though a large percentage of the bed has been mined. The character of the coal at both these openings is very superior. It shows a great deal of mineral charcoal matter, is compact, columnar and with a bright, shiny luster. No. 5 opening was examined by Mr. F. Platt in 1874, who reports the following section (Fig. 3, Page 60, Report H, p. 71):

Roof slate.	
Coal	2′ 7″
Slate parting persistent,	2″ to 4″
Coal,	2′ 5″
Fire-clay floor, very soft.	

An average specimen of the coal yielded on analysis: (McCreath)

Water,	1.280
Volatile matter,	25.580
Fixed carbon,	68.937
Sulphur,	.613
Ash,	3.590
Total,	100.000

Coke per cent., 73.14. Color of ash, cream.

No. 5 opening is somewhat higher in elevation than No. 9, owing to the rise of the measures eastward.

This coal bench crosses to west side of Karthaus pike and has been found in a well recently sunk at roadside, but soon returns on south side of hill.

The rise of the measures prevents any of the bed from being caught on Coal Hill to the east, though a considerable mass of slate above the Freeport lower coal and limestone crowns its crest.

On the *north* side of the basin the Freeport upper bed E has been opened on top of Askey Hill, where a drift has been run in N. E. on a patch of about 40–50 acres.

This is on property of William Thomas estate, and just east of the Karthaus Pike crossing.

The bed here is in good condition, and has about 47′ of cover of the Barren Measures over it.

It has only been opened for local use and shows but a single gangway about 100 yards long.

A section of this bed at end of drift gave (Fig. 4, page 60):

Slate rock, firm,	
Bone coal,	0′ 4″
Coal, good, lustrous,	2′ 8″
Slate parting,	0′ 2″
Coal,	2 6″
Fire clay, soft.	

This shows 5′ 2″ of good mining coal. The bed is confined to the hill top, partly on Thomas' and partly on Holt lands. Neither of the other patches of this bed left on the hill tops in Burnside township have been opened, though "5′" of coal was reported from well on Bird Coal and Iron Co. tract just north of the township line. Both this area and that on the Holt and Smith & Rhodes portion of the David Lennox tract are small. The small amount of this bed left and the general excellence of its coal make these tracts important.

Coal bed D.

The next lower bed, the *Freeport Lower Bed D*, of this section is nowhere opened for working at present and its general character of a thin and worthless bed of coal 2′ 3′ thick in the basin warrants its neglect.

Together with the underlying limestone, it may be traced as a distinct bench around Lucas and Coal hills, though cut off between these hills by the cove running up from the railroad. Its outcrop is shown by the darkest tint on the

colored geological map accompanying this report. Two small patches of it occupy the tops of the double curved Sugar Camp hill, where it passes into the air eastward and is not caught again through the Beech Creek region.

On the north side of the basin it shows in Askey hill on both sides of the pike, from 45′–60′ beneath bed E and makes a distinct bench near barn on the Thomas estate north-west of Orvis, Williams & Co's drift. Passing around that hill it shows in smut on pike, the second south from Stiefel's B. S. S.

East, across hollow, this bed again crops on Holt's hill, where it has been shafted upon thirty-six feet above C′ and is reported to have shown 4′ of good coal. This shaft is fallen shut now so that no personal measurements could be made. The point is an interesting one to settle, however, and is by no means improbable, when considering the other changes in the basin.

This bed is the famous Moshannon bed of Clearfield opened all through the first basin and at Karthaus in the second basin as an excellent 4′–6′ bed, and its local enlargement in the Snow Shoe basin, where usually worthless, would be quite possible.

The outcrop in this hill is narrow, though extending a considerable distance south-east toward nose. It is partly on lands of Messrs Hoy and Holt.

Mr. F. Platt in Report H, p. 73, gives the following section (See Fig. 5, Page 58):

Hill top,		
Drab slates and thin sandstones,		15′
Coal not seen,	reported	5′
Concealed measures,		30′
Coal not seen,	reported	4′
Thin slaty sandstones and gray slates,		55′
Black slates and shales with lean hematite,		10′
Coal not seen,	reported	3′
Brown and green shales and *concealed measures*,		66
Iron ore beds,	reported	3′
Coal,		3′
Water level of creek.		

The top coal of this section is evidently bed D just referred

to. The small openings in these beds for local use have long since fallen shut.

A considerable acreage of this bed crowns the hill north of William Holt's house on property of Wm. Holt and John Hoy, where it is reported 3'+ thick and is again caught in the high ground in the Blanchard & Waddle and Bird Coal and Iron Company's tracts, though all through this part of the basin it seems to be devoid of a distinct underlying limestone bed.

There is another old drift on this bed on the Humes & Holt 142-acre tract in Burnside township, where considerable coal was taken out in past times for country use from a bed reported 3' 6" of clean coal.

Similar areas of this bed occur on the Stewart lands between branches of the Seven Mile run and east of the pike. But these places are all undeveloped, and nothing can be said concerning the size of the bed or its character. The coals are rising here to the north-west on to the Pine Glen axis and very little of this bed occurs north of the road from Germania to Dr. Stewart's, except on the high ground just at the Germania school-house.

The flats and meadows at Hipple and Fisher's places can only carry the lowest coal beds.

Coal bed C'.

The Kittanning Upper Bed C'—the "middle" or "big bed" of Snow Shoe is by far the most important seam through this basin.

The limited extent of the Freeport upper, the general worthlessness of the Freeport lower, and the large area of the A and B beds that are beneath water-level all combine to make this Kittanning upper bed one of prime importance to the district under consideration.

Lying everywhere above water-level and yet readily reached by railroad; retained over considerable areas where it is always a merchantable coal, its great thickness in the Snow Shoe trough readily accounts for its being mistaken for the Freeport lower bed of the Moshannon region.

On the south side of the basin it has been extensively

worked at drifts Nos. 1, 2, 3, 6, 7, 8, where it shows an excellent seam of coal; in Harned, Jacobs & Co.'s drift on Coal hill, Gunsalus drift and various local openings *with* the dip from the *south* side of the hill.

Its general character is that of a rich, bright, heavy coal, useful for all purposes of bituminous coal, and capable of making an excellent coke with proper care in preparation.

The *Snow Shoe railroad*, after leaving the village and heading around Pine run ascends the south flank of Coal hill, reaching the outcrop of this bed towards its eastern end, and then following it around that point, past the various drifts to No. 8, the present opening in Lucas hill.

The grade of the railroad is about the *pitch* of the coal westward.

Mr. Platt's measurement in mine No. 6, Report H, p. 70, gave (See Fig. 6, page 60):

Black slate roof.	
Slaty cannel coal, worthless,	8" to 2'
Coal,	2' 4"
Slate, persistent,	6"
Coal,	1' 6'
Slate, persistent,	1'
Coal,	6"
Fireclay floor.	

"The upper bench of the coal is harder, and breaks out somewhat in blocks; the lower benches are friable, columnar in structure, and seem rather purer."

An average specimen of the whole sent Mr. McCreath gave on analysis:

Water,	0.650
Volatile matter,	24.560
Fixed carbon,	70.416
Sulphur,	.964
Ash,	3.410
Total,	100.000

Coke per cent., 74.79. Color of ash, cream.

This coal was then (1874) roughly coked in the open air near mine mouth, and yielded a fine, compact coke. It was carelessly done, and much slate got into the coal slack, so that I have no doubt a much better analysis could be ob-

tained from the improved methods of oven coking now pursued to the following made in 1874 by McCreath, from open air coke:

Water,	.990
Volatile matter,	2.950
Fixed carbon,	82.626
Sulphur,	1.104
Ash,	12.330
Total,	100.000

Much of the slate which holds iron pyrites, could be eliminated by washing. This mine was abandoned in 1883.

An examination of No. 8 drift in Lucas Hill in same bed developed the following facts:

The first *fault* met with in the region was found to exist between No. 7 and 8 drifts. The second *fault* found here further south has a general N. 8° E. and S. 8° W. direction, passing through the workings of No. 9 on the south and possibly through Hoys and Trullinger lands on the north side of the basin.

All the country to the east in Coal Hill was found undisturbed. A short distance in from mouth of drift at No. 8 a serious *horse back* (?) was encountered.

The floor rock of sandstone came up, cutting out without at all displacing the coal on either side, while at the same time crushing the coal and slate near the rock.

Passing directly through this wedge, the coal was found with its usual thickness until the fault between No. 8 and 7 was met—an *upthrow* towards 7 or eastward of about 13′.

Developing beyond this the present fault—a *downthrow* of 7′ on the south was being (Oct. 18th, '83) cut out.

The combined effect of these two faults has been to elevate the bed 6′ above its normal position, and where measured by barometer in the workings immediately beneath No. 9 drift above it, the interval was 95′ between C′ and E. At the *fault* the bed was nearly 70′ above the drift mouth, the bed rising rapidly south-east.

A section of face at fault gave (See Fig. 7, Page 60):

Slate roof.	
Bone and block coal not mined,	1′
Coal good,	2′ 1′

Slate,	0′ 9½″
Coal,	0′ 4″
Slate,	0′ 5½″
Coal,	1′ 4″
Slate,	0′ 1″
Coal,	0′ 5″

Fire clay floor.

It is a noteworthy feature that in the neighborhood of *faults* there is a considerable increase of slaty matter. Another section in side track of No. 8, about 300 yards in, gave (See Fig. 8, Page 60):

Slate roof.	
Bone and black coal not mined,	10″–12″
Coal lustrous and good,	2′ 6″
Slate,	0′ 6″
Coal,	1′ 4′
Slate,	0′ 1″
Coal,	0′ 5′

Fire clay floor.

This mine has a daily production of over 300 tons. Westward the bed rises rapidly toward the Karthaus pike, where its outcrop—3′–4′ thick—is seen passing south of the Vanderbilt Hotel and about 45′ above level of bridge, covered with a characteristic black slate weathering red.

The rise in the measures westward carries it into the air before reaching the grade of the Beech Creek R. R.

Going south towards Snow Shoe, the bed passes through Lucas hill and is brought out at Gunsalus' place 55′ higher where it has been tested in field east of road.

Two openings in this bed in Coal hill were being operated in the fall of '83.

The first of these is on the Bird Coal and Iron tract and is worked by James L. Sommerville for Harned, Jacobs & Co.

The drift is run in from north side of hill against the dip and on the east side of draft separating Coal and Lucas hills and about 150′ above Snow Shoe.

A section of this bed on east side of main gangway gave: (See Fig. 9, Page 60.)

Black slate roof.	
Bone coal not mined,	0′ 10′
Coal, columnar and good,	2′ 4′
Slate parting, soft and sometimes sulphury,	0′ 8″

Coal,	1′ 5½″
Mining slate,	0′ 1″
Coal,	0′ 6″
Fire clay floor.	

The bed is in excellent condition here, and does not show any of the "troubles" met with further west in Lucas hill,

A section further east in same mine gave (See Fig. 10, page 61):

Roof black slate.	
Bone coal,	0′ 10″
Coal,	2′ 7″
Slate parting, persistent,	0′ 8″
Coal,	1′ 6″
Slate,	0′ 1″
Coal,	1′ 0′
Fire clay floor.	

Passing through Coal hill, this bed crops out on south side about 40′ higher. The hill covering is 50′ in which the bench of Freeport lower coal and limestone is seen near summit.

Further south-west up cove the old Gunsalus mine is still worked for local use, and a most excellent character of coal is displayed at face, made up of brilliant columnar glance coal.

At present face (Oct., '83) the bed dips slightly to the *south* probably only a local roll, which however creates bad drainage. The *pitch* westward towards the Moshannon is marked. A section of this bed gave (See Fig. 11, Page 61):

Hard slate roof.	
Bone coal,	0′ 10″
Coal,	2′ 6″
Slate,	0′ 8″
Coal,	1′ 5″
Slate, sulphur,	0′ 2″
Coal,	1′ 0″
Fire clay floor.	

This *Kittanning upper bed C′* is again opened in Sugar Camp hill about 2 miles to the N. E., outcropping in both wings of that V shaped hill through which the synclinal axis of the basin passes.

The railroad branch passes up into cove between this double hill, near the head of which this bed is opened at

No. 1 drift about 25′ above the track and probably 50′ below Snow Shoe by barometer.

About 300 yards in from the mouth the following section shows (Fig. 12, page 61):

Roof slate, soft,	
Coal,	2′ 7″
Boney coal and slate, not used,	0′ 5″
Coal,	2′ 0″
Fire clay.	

This is about the cleanest coal in the mine. Usually there is about 6″ of bone beneath the roof.

At this point the bed has risen about 30′ from opening. The bed shows slightly different from No. 8 on Lucas hill, there being no mining slate of any account, and the upper bench showing about 2 inches thicker.

There is not sufficient cover for the *Freeport upper bed E* on top of this hill though the summit is about 115 feet higher than the opening.

The rise of the bed south-east however, would bring this measurement under 100′, when measured in a vertical plane. The slates of the Freeport upper bed show in patches on crest.

The *Freeport lower limestone* bench is about 35′ above C′. It shows about 18″ of Freeport lower coal on top of it.

No. 2 Sugar Camp drift is located further west down track about 300 yards. It goes in nearly east, or at right angles to No. 1 workings, and at mouth of drift is 20′ above track and only about 35′ lower than the opening on C′.

It is ordinarily called B—*Kittanning lower*, though that bed usually occurs 80′+ below C′, and its vertical interval makes it possible that it is the *Kittanning middle bed C* enlarged to give the following sections reported by George Ramsey, Supt. No. 1, section at face in drift. No. 2, trial shaft. No. 3, section at trial shaft sunk on south-east part of bed. (See Fig. 13, Page 60.)

	1.	2.
		ditto.
Roof slate sandy,	0′ 10″	0′ 10′
Bone coal,	2′ 0″	2′ 0″
Slate,	0′ 1″	0′ 1″

Coal,	1′ 4″	1′ 5″
Fire clay.		Fire clay.

3.
ditto.

Bone coal,	0′ 11″
Coal,	2′ 4″
Slate,	0′ 2″
Coal,	1′ 2″
Slate,	0′ 1″
Coal,	1′
Fire clay floor.	

The mine was not opened for shipments at time of visit and no personal inspection could be made.

It certainly underlies bed C′ in No. 1, for in the test drift 500′ long the gangway is under the rooms in No. 1, which have been carried towards the south-west.

Massive sand rocks show in railroad under this lower coal.

Such is the variation of these Snow Shoe coal beds over small areas that any identification of beds here (as indeed elsewhere) by means of partings or benches is not at all practical, and with the *Freeport lower limestone* in place on the top of the hill as a key-rock, the interval to this bed makes it probable that it is the *Kittanning middle C* locally showing a bed section something like the *Kittanning lower* B or Snow Shoe No. 10.

Kittanning Lower bed B.

This latter bed is opened and worked in the east end of Coal Hill. The top of the hill shows a knob of Freeport lower limestone, over which the slates of the Freeport upper bed E are in place.

About 80′ below crest an old drift was run in *on the dip* on the Kittanning upper bed C′ from south side of hill.

An old shaft from here down to bed B developed bed C only as a mass of slate and slaty coal and B 72′ below C′.

A section in mine No. 10,500′ in main heading, gave (Fig. 14, page 60):

Slate roof.	
Bone coal,	0′ 10′
Coal,	2′ 4″
Slate,	0′ 1″
Coal,	0′ 10″
Coal, sulphur and worthless,	0′ 6″
Fire clay floor.	

In other parts of the mine the bottom slate is thicker, but the underlying coal improves in quality. This bed sinks below water level west along railroad grade and Beech creek, but is exposed directly east in *Crider's hill.*

Below it from 60′–70′ the Brookville bed A shows in cut along railroad, but it is nowhere opened* in this basin, as it goes under water level near the forks of Beech creek west of charcoal kilns.

The Kittanning upper bed C′—after passing through Sugar Camp hill—is probably caught again south across ravine in Crider's hill, where several old drifts have been run in *with dip* from south side of hill.

One recent opening has been made on east end of hill, overlooking the Pancake mill, but though twice visited, the drift was locked up so that no examination could be made.

This is to be regretted, as common report makes this bed B or *Kittanning lower* the same as worked in No. 10 of Coal hill.

Though the rise of the Kittanning upper bed through *Sugar Camp* hill southward is rapid, this *Crider hill* is further west, and consequently gets the advantage of the *pitch* of the measures. Moreover, it is considerably higher than Sugar Camp. Other reasons for naming it C′ in the absence of any key-rocks are mainly these.

The road south from the charcoal kilns to Snow Shoe is apparently on a coal bench which corresponds in position and trend to the large smut outcrop 50′–60′ below No. 10 drift (B) which is exposed in the Beech creek railroad cut along Coal hill.

This A (Brookville coal) bench heads up the cove through which Crider's road runs, and returns around Coal hill and passes under water level about one mile west of kilns at forks of creek.

Starting up *Crider's hill* from this bench, another bench was passed 65′ higher—or bed B.

*Unless this be the large bed opened on the Hoy property.

One hundred and seven feet higher and a little to the east the top bench occurs, where smut is seen in open field, which is evidently the Kittanning upper C′. The coals are rising eastward against pitch, which accounts for the increased interval. East from this smut there is a drift on same bed 10′ higher, the bed rising 20′ higher still to where it is opened on east side of hill.

No appearance of the Kittanning middle C was noticed here, nor of the overlying Freeport lower limestone, though the summit is about forty feet above last named drift.

By barometer this hill is fully 80′ higher than Sugar Camp, while at the same time it is further *west*, and nearer the center of the basin.

Going south-east down hill towards school-house at the cross roads, the lower bench (B) was passed in open field 80′ below C′ accompanied with a profusion of hematite balls.

This bed catches for the last time on south side of basin in the knob just south of cross roads.

North side of the basin.

On the north side of the basin the Kittanning upper bed C′ has been but slightly developed, though it makes a marked bench throughout the region and has been tested in several trial shafts. Messrs. Orvis, Williams & Co. have opened the first regular mine on it on the north side of the synclinal on the Thomas estate lands on *Askey Hill.*

A drift has been run in N. W. on this bed by Mr. James Pope. The level of opening is about 60′ (by barometer) above the No. 8 drift on south side of basin, but the measures have risen fully that much going westward, though this rate of rise diminishes if not ceases altogether along the Karthaus pike.

In 140′ from mouth, coal smut first shows in this mine. At 400′ the coal had risen 21′ on the dip (see Fig. 15, page 61,) and showed

Roof—hard black slate.	
Coal,	0′ 6″
Slate parting persistent,	0′ 4″
Coal, bright and columnar,	3′ 1″
Fire clay floor—hard.	

The coal is lustrous and heavy and remarkably free from impurity. As far as developed, this bed seems to have lost most of its upper bench, though when last visited (Nov., ’83,) the top coal showed 9″ thick.

A roll of slight extent was met with in the early workings of *Pope’s drift*, pitching the coal to N. W. All the drainage of this mine passes through the floor south of this roll and issues in a spring at next lower bench in meadow.

When first met it had comparatively little cover. Askey Hill sloping gradually to meadow below drift, where a small bed of coal was struck, evidently the small (Gorman) bed occurring between beds C and C′ and though thin in this region as elsewhere, shows usually good, bright coal.

A section north up *Askey Hill* shows both the Freeport beds in place as already mentioned; and the cross section in Fig. 16, page 61, along an east and west line will show the relations between measures in Askey and Holt’s Hills.

The Kittanning upper bed crops on the Karthaus pike just south of Stiefel’s B. S. S. and the underlying intermediate bed above mentioned shows 47′ lower in pike north of shop. Possibly a little of the Kittanning upper bed C′ remains in *Seven Mile Run Hill*, though this is mostly occupied by the lower measures.

This *local coal* also shows in the deep summit cut on the Beech Creek R. R. just beneath the Karthaus road bridge, where the measures, mostly shales, are considerably distorted.

North-east around hill from the Pope drift, a new opening on the Kittanning upper bed C′ was being started in the fall of ’83 by Mr. Sommerville at a barometric elevation 10′ higher, where only about 1 foot of soft outcrop coal had been exposed.

Another trial drift still further north in same hill, on Holt’s land, shows this bed with a firm slate roof under

which there is 1′ 6″ of coal, a slate parting of 6 inches and then coal again; bottom not seen. The opening is on east side of hill and 26′ by barometer higher than Somerville's, showing the rise north-west towards the anticlinal.

The enlargement of the upper bench here without apparently affecting the lower is important, and if persistent, will considerably increase the value of this bed.

North-east on opposite side of ravine, this same bed is opened in *Holt's Hill* 26′ higher than last drift and about 36′ below D on top of hill. The shaft is now fallen shut, but the bed was reported 3′ 7″ thick here.

The *Kittanning middle bed* C benches in hollow below at Quick's house, the Kittanning upper C′ heading around cove and cropping on north side of narrow ridge dividing this creek from the branch of Seven Mile run at J. H. Holt's house. A lower bed, probably C, crops just at his house and shows in road to William Holt's about 100 yards north-east of J. H. Holt's.

The Kittanning upper crops south of this road and returns along north and east side of *Holt's Hill*, where it was opened in an old drift above Weaver's house, 3′+ thick. Just at Weaver's house the intermediate bed between C and C′ was struck in well. One hundred yards to the north in woods a shaft was put down about 50′ below the Kittanning upper drift, which struck the Kittanning middle bed C under 4′ of cover 3′+ thick and slaty.

This shaft was carried down 20′ through a blue siliceous sand rock and 30′ ± of shales and slates without striking coal.

However 90′ by barometer below this shaft at base of hill an old drift was opened about 15 years ago.

This is the bottom bed of Mr. Platt's section on page 58, Fig. 5, and his measurements, Report H, p. 74, are as follows: (See Fig. 17, page 60.)

Black slate roof,	1′ 6″
Coal,	6″ to 8″
Slate,	8½′
Coal,	2′ 4″
Fire clay,	2′ 6″

"The coal averages from 28 to 30 inches in thickness in one bench, the upper 16 inches being of columnar friable coal 12 to 14 inches, very hard."

An analysis of the upper bench yielded (McCreath) 1874:

Water,	1.680
Volatile matter,	21.870
Fixed carbon,	71.108
Sulphur,	.612
Ash,	4.730
Total,	100.000

Coke per cent., 76.45. Color of ash, red.

The coal has a shining luster generally, some pieces dull metallic luster, irridescent.

The lower bench yielded (McCreath):

Water,	0.880
Volatile matter,	23.620
Fixed carbon,	70.089
Sulphur,	.661
Ash,	4.750
Total,	100.000

Coke per cent., 75.50. Color of ash, red.

"The coal has a very dull luster, and shows considerable irridescence."

The above analysis shows an excellent character of coal.

Mr. Platt's section makes the next coal 70′ higher, an interval which will correspond with my own, when allowance is made for the position of Holt's drift, farther south than line of cross section.

Kittanning lower? bed B in Holt's drift.

Quite a deposit of bog ore of a red, slimy nature accompanied this lower bed, being dissolved from the shales beneath it.

Considerable controversy exists as to the horizon of this bed, but with all the data I collected by repeatedly visiting the locality, I have named it, though with some hesitation, Kittanning lower B.

It does not seem possible that the full thickness of this bed has been exposed in the drift, for its bench is a very

large one.* However, on the south side of the run (which enters Lick run before the latter reaches Beech creek at the Splash dam) and 150 yards south of the drift, on low hill a shaft 40′± deep struck this bed with the same thickness and the same excellent character of coal. From this place the hill points to forks of stream in Hoys' land where a splendid bed of coal 6′+ thick in two benches has been opened in a monkey drift 47′ (barometer) below Holt's drift but considerably to the south. This bed gave the following section though the sides were very dirty, obscuring contact lines, (see Fig. 18, page 60):—

Slate roof,	0′ 6″—0′ 10″
Coal,	3′ 6″
Slate,	0′ 6″
Coal,	2′ 10″
Fire clay.	

Proceeding north-west towards Holt's drift this bed was shafted upon in Holt's McClelland tract where it showed about the same thickness and elevation, and again in Hoy's land 3′ lower a good 6½′–7′ bed with slate partings.

Finally 200′ N. W. a shaft was put down on Hoy's land where I measured the following section, (see Fig. 19, page 60):—

Sandstone and slate cover,	7′
Coal,	2′ 3″
Slate,	1′ 6″
Coal,	0′ 8″
Slate,	0′ 6½″
Coal,	2′ 8″
Fire clay.	

The hill above is made up of buff and white sandstone bowlders similar to the rock overlying bed B at the Tunnel Mines in Rush township. See page 87.

Between the last shaft and Holt's shaft on south side of run, a shaft is located which is reported to have shown the bed curved *downwards* and feathered.

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*The Kittanning lower bed B is frequently characterized by a fire-clay slate or shale parting. It is typically a *double bed* divided by this fire-clay parting and frequently its upper bench is again split by a slate bed.

Possible Fault.

If this be true and used as an argument for a *fault*, it would tend to prove this region raised above its normal height and consequently we would expect to find this bed *over* the bed opened in Holt's drift.

If, on the contrary, the bed was feathered *upwards* it is —on the basis of a *fault*—to be looked for *under* the coal in drift. No effect of a fault would tend to diminish the size of the bed in identifying them as the same, and unless the coal in Holt's drift has not been fully opened, the two beds can not be identical, and it would become necessary to call this large bed the Brookville coal A if Holt's coal be the Kittanning lower B.

In comparing the lower benches of the two beds they are quite similar and in the face of the great and sudden changes in the Kittanning upper bed C′, at No. 8 Snow Shoe and Messrs. Orvis, Williams & Co.'s mine, it may be possible that similar changes may have occurred here in a lower bed. The difference in elevation between this last shaft and Holt's opening is about 36 feet.

The *fault* line in No. 8 (N.8° E. and S. 8° W.) if continued northward would certainly pass somewhere between Hoy's and Holt's drifts, and apparently the coal beds on the *west* side of this line are generally reduced in size as compared with those to the *east* of it.

Future developments will alone make these points clear and an explanation of them here will evidently apply to similar circumstances to be afterwards mentioned, occurring in the Trullinger lands along Little Sandy creek and in almost a direct continuation of this line north-eastward.

The large coal bed wherever tested lies apparently very flat, and its rise north-westward from the drift to the shaft where it was squeezed, is practically nothing.

Kittanning upper bed C′ on north side of basin.

North of the road leading from Holt's around to the Germania settlement theKittanning upper bed makes a distinct bench, and is mainly confined to the high land south of the road from Dr. Stewart's to Germania. It passes into the

air on its north outcrop south-east of the Germania schoolhouse.

The road running south from here to J. H. Holt's is in a hollow made by a branch of Seven Mile run which cuts out this bed. West of the road, however, this bed is preserved over a considerable area extending west nearly to the Karthaus pike south of Dr. Stewart's and benching near Oscar Holt's house before swinging north on the Smith and Rhoades lands.

Coal on Stewart lands.

On a branch of Seven Mile run about 150 yards east of pike on property of Wm. Stewart, coal was opened in hill 30–40′ above creek level. This is probably the Kittanning lower bed B. Several other openings were made in hillside, all of which have been closed up for some reason.

Dr. Stewart reports 3′ of coal in the lower drift, slaty and with a soft roof. 62′ higher by barometer, smut and black shales were seen at an old shaft where coal 4′ thick is claimed. Hematite balls have been thrown out here also. This is probably C′, as 33′ above this an opening has been made in the Freeport sandstone, here very well exposed and making quite a terrace. It is about 45′ from here to top of hill and though the Freeport lower bed D was not located, both it and the Freeport upper come in on the unbroken ground extending from here east towards Germania.

The Kittanning middle bed C, with its accompanying black band ore, shows well on the pike just south from cross roads at Dr. Stewart's. This bed has also been struck in Dr. Stewart's cellar, but soon passes out to daylight north of his place.

Coal on Martin Long tract.

On the Martin Long place near the extreme edge of the basin at the head of the most northern branch of Seven Mile run, a "3" foot coal bed has been opened. The drift is about 25′ long and runs mostly in the slate roof. By barometer it is about 60′ above Stewart's, though a mile and a half nearer the anticlinal, and is probably bed B. It

is very similar in appearance to the bed opened in the William Holt drift and is accompanied by the same bog ore.

The coals are rising rapidly here as they approach the Pine Glen axis, though the hill above this drift is said to show a good bed of coal near crest—possibly a patch of the Kittanning upper C'.

A section of bed in drift 400 yards west of Fred. Carson's gave (See Fig. 20, page 61.):—

Top sandstone,	0′ 15″
Black slate,	0′ 3″
Bone coal and slate,	0′ 3″
Black shale and slate,	1′ 4″
Gray shale and SS. banded,	3′ 6″
Coal soft bottom not seen,	1′ 4″

The rest of the country south of this drift is flat and swampy, and contains but little coal.

The Clarion? Sandstone crops in pike near Pine Glen school house dipping S. E., so that the underlying Brookville bed A probably passes over the flattened arch of the anticlinal into the Second basin. The map has been colored with this view in mind.

West of Karthaus Pike.

Generally speaking, the country west of the Karthaus pike along the Seven Mile run in Snow Shoe and Burnside townships contains only the lowest coals,—that is, under C'.

On township road from S. H. to Stewart's saw mill the ground is flat and covered with the lowest coal measure shales. Coal bench (A') crosses road just below mill and passes thence north over axis into Newcomers land.

At mouth of Seven Mile run on the river, Pocono SS. No. X shows along Moshannon creek dipping S. E.

It is probably 100′+ thick, and going up the run No. XI red shales, carrying red bog ore decomposed from carbonates, shows along ravine for 30 or 40 yards.

After this all is No. XII conglomerate to top of hill, where Clarion coal bed A′ was sunk through 2′ thick.

Near barn to the north and 45′ higher there is another bench,—probably Kittanning lower bed B.

These, with bed C already mentioned, south of Stewart's, pass through Seven Mile Run hill on the south.

Going south towards Snow Shoe, bed B outcrops at both sides of North Branch to Seven Mile run at water trough, about 75′ below Stewart's, and ascending the hill south to J. Craft's, bed C shows about 50′ higher. This bed was struck in a shaft at Craft's about 25′ below surface.

The hill east from here takes in higher measures, as already mentioned in speaking of Wm. Stewart's lands.

North of Stiefile's B. S. S., smut shows on pike, being the small bed between the middle and upper Kittanning beds, and further down pike the Kittanning middle C has been struck in a shaft at roadside 23′ deep, through a mass of firm black slate on to 2′+ of excellent, bright, irridescent coal.

Moshannon Village coals.

On road from B. S. S. to Moshannon P. O. the upper Kittanning and Freeport coals bench everywhere to the east.

The conglomerate of XII is seen on this road shortly after passing the saw mill, and is well exposed on south side of the Little Moshannon, where it extends nearly to hill tops.

All the hills through here as far as the Rush township line carry only the lowest coals, possibly insignificant patches of Kittanning lower B, marking the shoaling of the basin towards Moshannon creek.

East of the mill the upper members of XII, Homewood SS. and shales are dipping south-east, until bed A, Brookville coal, is met. The Clarion buff colored sandstone is next met with further N. E. towards village, succeeded by bed B. This is the same bed as opened many years ago on Beightol's run close to road in a drift now fallen shut.

The bed here is reported "3" feet and again opened "4" feet thick at P. Walker's on north side of run.

Both these mines were opened *with* the dip, and are drowned out. No. XI red shale and No. X Pocono sandstone come in along this run before it empties into Moshannon creek.

The Clearfield Bituminous Coal Co's Mines.

The only other field of promise in the western part of the basin is the small 300 acre patch of the Kittanning lower bed,

with neighboring smaller remnants, that have been caught on the high ground between the waters of Big and Little Moshannon creeks at the Moshannon tunnel of the B. C., C. and S. W. R. R.

This patch forms part of the *Clearfield Bituminous Coal Company's* tract of land, and extensive preparations were being made to secure a large output of coal from this hill upon the completion of the railroad line.

The position and character of the deposit will be shown on map, plate 6, page 54, reduced from map of the above company, which shows the outcrop of the Kittanning lower bed B at the Tunnel mines.

Along the railroad.

After crossing the Little Moshannon at Rock run, the railroad passes through the sandstone of XII to the Briartown summit, where an intra-conglomerate coal bed eight inches thick is exposed in the cut at about 1600′ A. T., underlaid with blue sandstone and covered with blue shales and black slate. It lies about 60′ below bed A.

This is the same bed seen over the east entrance to Moshannon tunnel at about 1520′ A. T., the difference (80 feet) of elevation showing the amount of *pitch* westward in the two outcrops two miles apart on a nearly east and west line.

The *dip* of the measures N. W. is shown on map of 300 acre tract where a difference of 182′ in 5600 or about 170′ to the mile occurs between the south outcrop of bed B and No. 2 drift.

Clarion sandstone shows in railroad cut west of summit, the Brookville or A bed cropping to the north below grade. In November 1883 the company had located 5 drifts on these lands as shown on map, 4 in the main body of 300 acres. and 1 in the 50 acre patch on the hill south of tunnel. The Clarion coal bed A′ has only been opened in one place, on hill back of boarding-house where it showed 2′ 6″ thick of excellent coal.

The crop of the *Kittanning lower bed* B needs no description as it will be readily seen in Plate 6. The drifts

are all double gangways, and were built in the most substantial manner under the superintendence of Col. G. H. Platt, Chief Engineer, and Mark Hopkins, Assistant, to whom I am indebted for courtesies.

No. 1 drift was in about 60′ at time of my visit.

The bed had not developed itself here yet, showing mere soft outcrop coal and considerably troubled.

Description of Kittanning lower bed B.

The hill cover at mouth of drift is slight but elsewhere it averages 40′–60′ and yet none of the air shafts sunk from surface show any signs of the overlying Kittanning middle bed C. The measures immediately over bed B seem to be everywhere a dense gray sand rock strongly resembling the Clarion sandstone thus differing materially from the Snow Shoe region where black slates largely predominate. The air shaft back of No. 1 should give nearly 80′ of cover but as it had been only carried down 15′ in loose rock at time of inspection, no results of the section down to bed B could be obtained.

No. 2 drift further N. W. along grade is 70′ lower *on dip* or 1605′ A. T.

It had been driven 75′ S. E. against dip and showed at face, (Fig. 21, page 61):—

Slate roof.	
Coal, with strings of sulphur, though generally good, . . .	3′ 1″
Slate parting, persistent, ...	0′ 8″
Coal, ...	0′ 11″
Fire clay floor.	

The coal here seemed rather dirty, but the drift was hardly far enough in to judge of the true character of the bed.

No. 3 drift is at head of Buck hollow, a small stream flowing N. W. into the Moshannon and meeting coarse conglomerate a short distance north of railroad grade.

This drift is about 75′ above railroad which shows in cut massive blue sandstone carrying intercalated shales impregnated with ore balls, and showing a wavy bedding.

Coal measure shales show in west end of this cut. This same sandstone, no doubt the upper (Homewood S. S.)

member of XII, is well exposed 25′ thick in the next cut just east of tunnel entrance.

The cut to the east towards Briartown summit shows 6′ of fire clay and a slight coal seam (A′,) overlaid with 10′ of bluish shales and ore balls.

A section of bed B at *No. 3 drift* at first west heading shows, (Fig. 22, page 61):—

Sandstone top.	
Slate roof,	0′ 11″
Coal,	0′ 11″
Bone and slate,	0′ ½″
Coal, good,	2′ 10″
Sulphur seam,	0′ ½″
Coal,	0′ 6″
Slate,	0′ 10″
Coal,	0 10″
Floor sandy fire clay,	0′ 8″+

This section shows the varying character of the slate partings.

The main bench of coal 2′ 10″ thick is columnar and lustrous.

The sandstone is irregularly bedded and friable. Hill cover about 60′.

No. 4 drift is opened about 500 yards S. E. at an elevation of 1723′ just south of Moshannon road.

The bed here showed as follows:

Slate roof.	
Coal,	3′ 2″–3′ 4″
Slate parting,	0′ 8″–0′ 10″
Coal, dirty,	0′ 10″
Floor not seen.	

The bed soon passes out into the air on south side of the hill and no coal has thus far been found south of the Little Moshannon.

About a mile S. W. of No. 4, and south of public road to Philipsburg *No. 5 drift*, is opened in same bed at 1715′ A. T.

The bed here has but little cover and reaches over an area of about 50 acres. The drift was driven about 25′ and was boarded up at face somewhat concealing the following section, (Fig. 23, page 61):

Sandy shales and slate roof.	
Coal, dull,	2′ 6″
Sulphur in bony slate,	0′ 1″
Coal, slaty,	0′ 7″
Slate parting, persistent,	0′ 8″
Coal, soft,	0′ 9″
Fire clay floor,	3′ 0″+

It is doubtful whether any of the hills to the south-west between Little and Big Moshannon creeks are high enough to catch any of the coal measures.

At the Moshannon tunnel.

On west side of divide and west of road over summit to Peale, the contractors of tunnel opened a drift in bed A for local use on railroad, 100′ (?) according to Mr. Hopkins below bed B on hill top. It was not examined, but is said to have furnished a very fair quality of coal.

The east tunnel entrance is 1489′ A. T. on grade. The Moshannon creek below at bridge crossing is about 1200′, showing No. XI just east sinking under creek level.

The surface of ground above tunnel is 1643′, showing the intra-conglomerate bed before mentioned at 1520′ in a compact bedded blue sandstone overlaid with soft sandy shales, and two benches higher up at about 1560′ and 1620′.

Identifying the first of these as A, and allowing for a thickness of 75′ for XI and a rise of 75′ in the half mile from creek to tunnel we get a thickness here of about 300′ for the conglomerate series No. XII.

These coals continue to dip N. W. in Clearfield county, catching bed B in the hill tops around Peale at about 1550′ A. T. and sinking to the synclinal north of Peale to about 1500′ before rising on to the First or Laurel hill axis.

West of tunnel an iron ore seam shows in Wild Cat Hollow at an elevation of about 1465′ in XII.

The rather soft and shaly nature of the upper member of XII through the tunnel hill—mostly a fine-grained gray sandstone with coal specks and bearing many good fossil imprints—accounts for the very rapid work of driving this tunnel 1300′ long in about five months. The grade is .8 of a foot in 100′.

Coal measures between Snow Shoe and the tunnel.

These lower coals cross at various places along grade of Beech Creek Railroad between Snow Shoe summit and Rock run. Good fern and leaf impressions are found in the big slate cut at *Askey's Summit*, above and below the small (Gorman?) coal bed before mentioned as probably intermediate between the Kittanning middle and upper beds.

This bed, however, makes a marked bench in hill side south of grade in the Samuel Wetherill tract of the SS. Land Co., where some old drifts have been run on it.

It displays local enlargements here.

It again shows in first cut south of bridge, largely interbedded with slate and underlaid with fire clay and a blue siliceous sand rock. A decided pitch towards the Moshannon creek is seen in this cut.

In second cut from summit west the measures are waved, where coal first shows on top of cut at each end, pitches down S. W. to grade in centre, where it thickens temporarily before taking another roll.

The same smut, nowhere over 10″ thick, appears in next (3rd) cut, where it is fully 40′ lower than at Summit cut. A section here shows:

Surface.	
Loose sand top,	2′–4′
Gray shales,	10′
Coal,	0′ 10″
Fire clay,	6′+
Shales,	4′
Blue sand rock,	4′–6′

The coal rises going west out of cut and at south-west end a much larger smut 1 to 3 feet thick (C?) comes in *under* the sand rock and overlaid with gray slate. A coal bed 3′ thick shows in the fourth cut, beyond bridge over small stream, overlaid with 20′ of black slate, with a soapy texture. This is probably the Kittanning lower bed B, as the next bed shows *Clarion sandstone* with a small coal bed (A′) very much broken and shaly.

The sandstone is buff-colored when weathered but shows a fine-grained gray sandstone 15′–25′ thick where freshly broken.

The basin edges up in this direction at about Rock run, the cuts to the west being in XII.

The hills to north show some coal slates and possibly patches of the lower beds, but are of little importance.

Beech Creek basin.

This basin is but an eastern extension of the Snow Shoe trough just described. As yet no developments have been made, the wild and rugged nature of the district and the inaccessibility of its coal beds, hitherto without railroad communication having combined to keep this field in the background in the face of the more advantageously located beds at Snow Shoe.

The highest coal bed in this region is the *Kittanning upper bed C'* which occurs in small patches on the highest hills as far east as Wolf run ; but beyond that point the rise of the basin carries even this bed into the air and in the succeeding hills eastward to the Clinton county line, leaves only patches of the underlying measures.

The continuity of the measures is everywhere interrupted by the numerous streams entering Beech creek from the north and south, confining the coal deposits to the hills between them and showing in their channels exposures of the subcarboniferous rocks.

Thus the red line of No. XI Mauch Chunk red shale indicates the *rise of the basin eastward* bringing that formation to daylight on Beech creek near Gray's splash dam, and rising gradually from that point eastward until it passes into Clinton county high in the hills and exposing probably 200'+ of Pocono sandstone No. X along the creek bottom. The outcrop line as marked on the map is only approximate, as this formation is almost everywhere covered with boulders and drift from the overlying conglomerate rocks which flank Beech creek in precipitious bluffs as far west as the Pancake mill.

The hills through the region rise several hundred feet above the creek in places and are almost everywhere wild and uncultivated.

In *Curtin Twp.* the synclinal axis is apparently to the *north* of Beech creek and it is possible that there may be some representation of the *Furney axis* of Clinton county to the south as is evidenced by the *south dips* north of Beech creek along Two runs, Eddy Lick and Panther creek, though the roll is a gentle one and can not be noticed further west than last named creek.

Thus the coal *south* of Beech creek along Hay's run may belong more properly to the Tangascootac basin of Clinton county while those to the *north* forming more properly the Beech Creek-Snow Shoe trough lie in the flat synclinal between the Furney and Hyner axes.

The distinction is one of little practical importance, however, for the amount of coal there is insignificant.

Coal beds South of Beech Creek.

The high hill south of Beech creek and east of Hay's run has probably a small patch of the Kittanning lower bed (B) on its western end; but rising eastward it soon passes into the air and leaves only the Brookville and Clarion coals on the summit near the Liberty township line.

Coal hill between Hay's run and Beech creek also contains a small amount of these lower coals, though very little, if any ground is high enough in Snow Shoe Twp. south of Counsel run to retain any of the coal measures, which edge up rapidly here towards the Allegheny plateau.

At *Morrison's camp* at mouth of Three Rock run there is a considerable thickness of No. X exposed in the precipitous hill sides. Coal A ? is opened about 430′ (barometric) above creek, to the south on lands of *Midland Mining Company.*

This company owns large bodies of land through this region, about 3000 acres south of Beech creek, 5700 acres in the Trullinger lands along Sandy run, 1300 acres in the West tracts, and 6000 or 7000 acres north of creek along Big run, Two and Three Rock runs, and Eddy Lick.

South 50° west from splash dam the hills are high enough to get small areas of the Kittanning upper C′, though this bed was not identified east of Wolf run as already stated.

There are from 140′–155′ of coal measures here, to hill top 750′ above creek.

Coal Hill measures.

Four coal beds have been opened in trial shafts on north-east end of Coal hill.

The *Kittanning lower* bed B has been opened about ½ mile west along north face of hill overlooking creek. The drift shows a slight *south-east* dip, which is not unusual in outcrop coal owing to the effects of frost and erosion at the surface. At the same time it may be the result of the Furney anticlinal to the north. The bed crops at the south side of hill at a higher elevation and shows a pitch to south-west of about 30′ per mile, comparing its elevation here with that obtained at east end of hill.

The following section of bed was taken in drift about 30′ in from mouth (Fig. 24, page 61):—

Black slate roof.	
Block or cannel coal, worthless,	0′ 4½″
Coal, hard and dull,	0′ 6½″
Slate parting, sulphury,	0′ 7″
Coal, good,	3′ 1″
Fire clay.	

This shows an enlargement of the lower bench as compared with the Tunnel Mines.

The coal is friable and columnar, and is well spoken of by the smiths along railroad who used it during the construction of the B. C., C. & S. W. RR.

An analysis of the coal from sample sent Mr. McCreath by the Midland Coal Company, June 15, 1883, gave:

Water,	.716
Volatile matter,	23.554
Fixed carbon,	65.778
Sulphur,	.787
Ash,	9.165
Total,	100.000

Coke per cent. 75.730. Color of ash, cream.

The hill has flattened away so much coming west as to show a covering here of only about 45′. Below it there are two benches partially opened.

About 2 miles south-west on the Fishburn-Wharton tract, adjoining the Midland Mining Co.'s land, the "Job Packer drift" was run some years ago. The drift is 40′ higher and further south than the last-mentioned opening and is probably on the *Brookville coal A*. The opening was very much closed up and the old timbers squeezed out. The bed is said to have measured 4′ 4″ from roof to floor, with 4″–6″ slate parting.

I saw nearly 4′ of coal here with a blue slate roof, and 300 yards east, on the William Yardley tract of the Midland Co., a daylight drift showed at face of same bed the following section (Fig. 25, page 60.):—

Bluish black slate roof.	
Coal fair, glossy,	0′ 7″
Slate,	0′ 4″
Coal cannel—dull,	0′ 3″
Coal columnar,	2′ 6″
Fire clay floor.	

An analysis of a mixed sample of both benches of this bed made by McCreath under the same circumstances as the sample of the Kittanning lower already given, showed:

Water,	.544
Volatile matter,	22.411
Fixed carbon,	60.901
Sulphur,	.834
Ash,	15.310

Coke per cent., 77.045. Color of ash, gray.

North of Beech Creek.

North of Beech Creek in this township the lower coal beds run up for about 3 miles, though often interrupted by cross streams. No personal examination of this wilderness was possible with the limited time at my disposal, nor would it have been productive of much benefit, owing to the distortions of the maps of this region and the filling in of the trial shafts located there.

Mr. Isaac Harvey spent considerable time in this locality for the Midland Mining Co. and reports the south outcrop of the coal measure at about 450′ above Beech creek. He made several openings on A and B beds and gives the

Brookville bed A a thickness of 3′+, the *Clarion A′2′* and *Kittanning lower bed B* from 4′–6″ to 4′–10″ thick, with a slate parting of 3″ to 5″ inches under the upper bench of coal 10″ thick. He also reports that patches of the Kittanning middle coal bed, coal C, exist 3′ thick and slaty, and even the small local bed of the Snow Shoe region 20′–25′ above C, with the same excellent peacock coal 1′ 2″ thick.

East of Big run proper the hills seem to be everywhere capped with XII. But west the above measures come in, the highest (C) bed being confined to the northern part of the tinted area on map, the coals shoaling rapidly as they rise on to the Pine Glen–Hyner axis.

Between Two and Three Rock runs the country is generally low and barren; but west of the former towards the Hogback tunnel and north of Beech creek some acres of bed B crown the hill top.

This tunnel is 300′ long in No. X, the hill rising 75′± above grade. A thin seam of coal is reported to exist in the Pocono SS. here.

Eddy Lick shows no coal for some distance above its mouth and then catches only the lowest beds.

Its junction with Beech creek is by barometer 130′ above Morrison's camp or 1025′ A. T.—the latter being 895′.

Going up hill to south of Beech creek to the Fisher tracts and "Red Dave" McCloskey's, red shale (No. XI) shows 180′ above creek. There is about 125′ of coal measures here, the highest knob catching the little 2′ (Gorman) bed over the Kittanning middle, everywhere distinguished by its hard black slate roof in contrast with the sulphury blue smut slate of the underlying C bed. The hill breaks between here and J. Walker's, but carries the Kittanning lower bed B throughout, with the two upper Kittanning beds C and C′ in knob east of his house.

Westward towards Snow Shoe the hill tops all seem to be XII, exposing a coarse conglomerate on road to Cato bridge.

Walker's porch is about 1445 A. T. The bench mark in grade at mouth of small run leading down from his meadow

is 1152 A. T. and Cato bridge about 1174′ No. XI passes under water level midway between this point and the mouth of Wolf run at about 1130′ A. T. The mouth of Big Sandy is about 300 yards below (east) of Walker's run and about 10′ lower in elevation or 1142′. South of the south branch of Counsel run, back of Walkers, all the hills seem to be XII to their summits.

Between its two branches on the James McManus tract there are the lowest coals, with probably bed B on top. The conglomerate, passing under ground south of Counsel run comes out again south of Beech creek, making a bold and rugged terrace about 300′± above creek.

Cato Coal Field.

A coal bed was exposed in an old drift close to public road about ½ mile south of Walker's run 46′ above his house at 1450′ A. T. If I am right in identifying this as bed A (and Conglomerate bowlders show a short distance below it) No. XII has a thickness of about 280′ measured from the presumed outcrop of XI in creek and allowing for the rise of the measures south-east.

About 300 yards south-east of the old Cooke shanty, now occupied by D. McCloskey, coal was opened many years ago at the head of Logway run (a branch of Beech creek mouthing at the Hogback.) It has been worked at short intervals each year for local use, and quite actively in 1883 for the smith shops along the Beech Creek R. R.

Most of the work has been "grubbing" along the line of crop, as the bed has been opened *with* the dip on its south outcrop and consequently liable to be drowned out.

The opening by barometer is 62′ below McCloskey's, and is probably on bed A, as conglomerate appears in the hill on the south side of the run.

The bed is claimed 4′ thick, but the following section only showed in the fall of 1883 (Fig. 26, page 60):—

Sandstone, brown and gray,	2′+
Black slate and bone coal,	1′ 6″
Slate,	0′ 6″
Coal, bottom not seen,	2′ 2″+

The coal is columnar and lustrous, and shows comparatively little sulphur or impurity in the lower bench.

This bed covers considerable territory here, and if regularly opened against dip from the north side of hill, might prove profitable. The opening is on the Samuel Fisher tract.

About one mile W. N. W. what appears to be the same bed has been opened on the north side of the hill on the James Hale tract owned by Henry Croskey, but known as part of the Saylor lands. The opening is in sight of Gray's splash dam, about $\frac{3}{4}$ miles N. 42° W. in the hollow of Beech creek.

By barometer it is only about 10′ below the opening on Logway run, and if identical with it, shows the pitch of the measures to be very slight here.

It is but little further north than the McCloskey drift, and, consequently, no difference of elevation due to dip was to be expected. Conglomerate is in place about 40′ below drift, the interval between being concealed. The sides of drift were boarded up, and no examination of the bed here was possible.

It makes quite a distinct bench along the north face of the hill west 400 yards on to the James McManus tract, where three beds have been partially opened above it.

A section here shows somewhat as follows (Fig. 27, page 58) :—

	Hill top.	
	Interval concealed,	42′
4.	Coal, drifted upon and reported,	3′ 6′
	Fire clay,	2′
	Concealed measures, mostly slates,	100′
3.	Coal, impure and bony,	2′ 6″
	Interval slates,	22′
2.	Coal, opened and reported,	2′ to 3′ 6″
	Slates and heavy sandstone,	60′
1.	Coal, reported,	3′ to 4′ 0″
	Fire clay, shale and slates,	40′
	Conglomerate,	—

A great mass of black slate has been taken out of No. 2, and these slates seem to replace, to great degree, the sandstones of the measures. No. 2 drift is 50′+ long, and is reported to have shown 2 to $3\frac{1}{2}$ feet of good coal.

No. 3 shows considerable bone and slate, and No. 4 is a

good, free, lustrous coal, of excellent character. The large interval between 3 and 4 is noticeable.

The ridge holding these coals is very narrow, so that but little tonnage could be won from the upper beds.

West, however, on the other side of the cove, the hill is broader and slightly higher near Ed. Walker's, and carries a considerable acreage of these coals. They all dip north-west. None of the openings were examined.

Coals north of Beech Creek.

Big Sandy creek receives the waters of Beauty run about 2½ miles above its mouth.

The hills between the latter and branches of Wolf run contain the lowest coal beds, which is likewise true of the Panther creek country, though the hills are bare there and the amount of outcrop coal small.

On the West tract of the Midland Mining Company a shaft was sunk 300 or 400 yards north of Big Sandy, close to the south line of this tract.

It was 14′ deep to coal. No measurements could be made here, as it was partially filled up, but the dump showed an excellent quality of coal, free from sulphur.

Conglomerate occurs not far below it towards creek bed, and its position indicates it being the Brookville bed A. If so, it is greatly enlarged and improved.

The men who dug the shaft give its thickness as 6½ feet from roof to floor, showing on top slate and cannel coal, and a slate parting, but bearing 5′ 6″ of mining coal in two benches. I cannot vouch for these measurements. The roof slate is firm, and the bed gets sufficient cover to insure good coal.

Another shaft nearer outcrop showed a less thickness. The hill to north rises 100′ above this bed.

The *pitch* is to the south-west, carrying this bed to creek level in the Snow Shoe lands.

Northwards, after being cut off by a cove, it catches in again on the next west tract, with sufficient cover for two more coal beds. Up the hill eastward 63′ above the lowest

bed a shaft had been started on a bench (B?) showing a gray, soapy slate cover, but had not then struck coal.

Higher up hill 50′ smut and muddy slates indicate C or the Kittanning middle, over which, toward the Hugh Dallas tract, the hard, black slates of the intermediate bed frequently mentioned, are exposed. At all events, the lower bed is under good cover and occupies considerable area.

On the west side of Spring Run branch to Sandy, north of the old cabin, the bench and 3′ of smut of the lowest (A?) bed is exposed.

Above this and around hill to N. W. on Wm. West's tract, Mr. Harvey reports coal (B) 4′ thick at outcrop. The opening is 75′ above the lowest bed though the interval is somewhat increased by lying further to the N. W.

These coal dips to south-east, lying on *north* side of basin.

Northwards the hill rises probably 75′ to 100′ and catches the Kittanning middle and overlying small bed, though the latter only in patches and 12–15 inches thick.

In the country south-west of the Big Sandy the hill rises fully high enough to catch C, rising from the Sugar Camp region further west, though the Freeport lower bed D does not extend further east than the main Sugar Camp hill.

The synclinal axis through this hill must pass somewhere near the forks of Big Sandy and Beauty runs as the coals north of the junction all dip south-east. The country to the south over which the Snow Shoe-Cato road passes is evidently not high enough to retain any but the lowest coal measure slates, if that. It has been colored XII on map, as no bench could be distinguished.

The Trullinger lands.

The Trullinger lands lying 1½ miles directly N. W. of Sugar Camp evidently retain nearly the same measures though none of the Freeport lower limestone was found there. These comprise four tracts lying between Big and Little Sandy creeks: Wm. Bingham, Andrew Bayard, Person Hunt, and Polly McClanahan. The two latter being the most northerly catch only the lowest beds in their

southern extremities being mostly covered with the conglomerate measures.

Quite an acreage of the Kittanning upper bed C′ occurs in the Bingham tract, extending east probably into the the Bayard, but cut off on the south-east by a cove before the hill rises again on the Snow Shoe lands in Sugar Camp nearer the centre of the basin.

This property has been quite extensively tested ; but the shafts were all filled in so that I can only give reported thicknesses, well corroborated, however, by several parties who have examined the beds.

Thus the Kittanning lower bed B is reported 4′; C has been struck in half a dozen shafts, slaty but 4′–4½′ thick ; while the C′ bed has quite as good an appearance as at Sugar Camp. It has a cover of 20′–30′ of hard shale with but little signs of the Freeport sandstone unless in loose pieces on the top of the hill.

The small bed between the middle and upper Kittanning is also opened here, showing beautiful lustrous coal 2′ to 26 inches thick with a hard slate roof. Its frequent presence throughout the basin indicates it being everywhere a persistent but commercially worthless bed. All these coals dip S. E., especially well seen in the big drift on the west side of little Sandy creek.

Kittanning lower bed B has been opened in several places on the Person Hunt tract, with good thickness, rising rapidly towards the anticlinal. This axis shows evidence of a jog here southwards, for in the country west from here the coal measures extend much further north, an effect aided by the flattening of the arch in that direction.

Little Sandy Creek Coals.

On grade at Pancake mill the elevation above tide is 1410′.

Going north-west along road on the narrow hill between Cherry run and Little Sandy the successive benches of A, B, C, and C′ are seen with the latter opened on hill top. The ridge is narrow though and rises rapidly to catch the Kittanning upper bed C′ and then falls off again. This road leads into M. Hartline's and the Trullinger lands.

On the hill summit north from the C' bench and about 2½ miles in from the mill a small shaft was put down just east of the road on what is apparently the little Gorman bed, which showed here its usual character of 2' of coal overlaid with hard blue slate. This is about 415' (barometer) above grade at mill, or 1825' A. T. The Kittanning upper coal has passed into the air to the south.

The road keeps along the crest until the south line of the *Trullinger tracts* is reached where the hill top is 13' higher at 1838' A. T., and may still retain this small bed.

But descending east side of hill towards Solt's camp on Little Sandy a large bed has been opened on the George Harrison tract* at 1795' A. T. or 42' below crest. Between these two points no coal bench is visible, but the following section of face of the bed in a monkey drift will at once strike the eye as abnormal, (Fig. 28, page 61):—

Sandy, broken slate cover,	2' 6"
Smut and soft coal,	2' 4"
Slate,	2' 6"
Bone coal and slate,	0' 8"
Slate,	0' 10"
Coal,	0' 9'
Slate, thin—not persistent,	0 to 0' 3'
Coal (bottom not seen), lustrous,	4' 9"

This bottom coal could not be measured owing to falling in of drift, but is said to have shown 5' clear.

Little Sandy creek below is 62' lower and shows coarse-grained sandstone bowlders (XII ?)

This bed is possibly the Kittanning lower B locally enlarged.

The *line of fault* N. 8° E., already described in No. 8 Snow Shoe mine, if continued through Hoy's land would pass close to this opening, and may have had some effect in producing this remarkable section.

Three *analyses* of coals from these tracts were furnished me by the Midland Mining Co. made from samples sent Mr. McCreath in June. 1883:

No. 1, labeled "Coal from bed B, Trullinger lands, obtained from shaft 12' deep."

*These figures are barometric.

No. 2, coal from bed C, Trullinger lands, obtained from shaft 10′ deep.

No. 3, coal from bed D, (C′ ?,) Trullinger lands, obtained from shaft 20′ deep. Height of cover 35 to 40′.

	(1.)	(2.)	(3.)
Water,	.680	1.826	.944
Volatile matter,	24.225	26.094	23.096
Fixed carbon,	67.061	64.065	67.947
Sulphur,	1.129	.990	.738
Ash,	4.895	7.025	7.275
Total,	100.000	100.000	100.000
Coke per cent.,	75.095	72.080	75.960
Color of ash,	Cream,	Brown,	Gray.

In general, the coals of this Beech creek extension are too little developed to warrant an opinion of their value. At best but few shafts have been spread over a very great area, and the large percentage of ash and sulphur in the coals analysed are in a great measure, due to the fact that mainly outcropping coal was sampled.

The completion of the Beech creek railroad through this section may lead to renewed efforts to develop, but the operation will be costly and hardly warranted now by the position or extent of the beds.

To be sure the coals of this region have some little advantage of proximity to market over the Snow Shoe basin, but this advantage is much more than counterbalanced by the advantageous position of the Snow Shoe beds with relation to railroad lines.

Iron ores.

A few words about the Snow Shoe iron ores will conclude this region, and as no changes have been made since Mr. Platt's inspection in 1874 I quote from his report H the following facts:

"The vertical section of the Snow Shoe measures (Fig. 1, page 58,) shows the Freeport iron ore resting on top of the Freeport limestone; the black band ore in the shale overlying coal bed C, Kittanning middle, and the iron ore overlying coal bed A—Brookville.

The *Freeport iron ore* as found in the shaft and seen upon

the outcrops averages about 2 feet (in all) of "ore and some coal," the Middle (Lower?) Freeport coal two feet thick, resting directly on top of it. A specimen of the ore from Yeagher's place, west of Snow Shoe city, on analysis at the laboratory of the survey, yielded (McCreath):—

Iron,	30.250
Sulphur,	.112
Phosphorus,	.211
Insoluble residue,	19.630

A specimen forwarded by Mr. Sommerville was probably taken from the underlying limestone, as it yielded (Mr. McCreath):

Iron,	5.000
Sulphur,	.599
Phosphorus,	.050
Carbonate of lime,	42.941
" " magnesia,	22.764
Insoluble residue,	18.730

A specimen of iron ore from McMaster's place, near Snow Shoe city yielded (McCreath):

Iron,	35.800
Sulphur,	trace.
Phosphorus,	.204
Insoluble residue,	16.050

A fair specimen of the Freeport limestone of the Snow Shoe basin was forwarded to Mr. McCreath for an analysis and yielded:—

Carbonate of lime,	51.153
" " magnesia,	13.265
Sulphur,	trace.
Phosphorus,	.287

The *iron ore overlying bed C* is a black band iron ore of good quality. It is called a "20-inch to 36-inch" ore bed as found in the shaft. Mr. McCreath did not determine the percentage of carbon carried by the ore, but reports the other constituents thus:

Iron,	29.300
Sulphur,	.010
Phosphorus,	.201
Insoluble residue,	17.600

When roasted, this ore yielded in the laboratory of the Survey 43 per cent of metallic iron.

Mr. Sommerville also forwarded to the laboratory a specimen of this ore (labeled clay band ore), and it yielded on analysis (McCreath):

Iron,	28.700
Sulphur,	.011
Phosphorus,	.173
Carbonate of lime,	——
Carbonate of magnesia,	——
Insoluble residue,	23.600

The iron ore overlying coal bed A is not now worked. From the old opening it was possible to procure specimens, but not to verify the reported thickness of the ore bed "4 feet in all." Two specimens yielded on analysis (McCreath):

	(1)	(2).
Iron,	30.100	32.600
Sulphur	.086	.013
Phosphorus,	.364	.993
Insoluble residue,	23.250	20.530

Just west of the summit of the Alleghany mountain, and in the bottom of the (Seral) Conglomerate of XII, pieces of hematite ore cover the surface, and are found a little below it, over a limited area. The line of the ore is not found extending along the strike of the measures, and there is no indication that a regular and persistent workable deposit is to be looked for.

A specimen of the ore yielded on analysis (McCreath):

Iron,	41.000
Sulphur,	trace
Phosphorus,	.692
Insoluble residue,	25.250

Philipsburg-Osceola district in the First Basin.

This western extension of the Snow Shoe trough is only coal-bearing between Black Bear run and the western end of the county along the Blair-Cambria county line.

The lowest coal beds of the Lower Productive Measures have their south-east outcrops just west of Sandy Ridge, on the Tyrone and Clearfield R. R., but are not opened there.

They are seen outcropping on the railroad between Sandy Ridge and Osceola, and the Kittanning lower bed B is extensively mined at Powelton.

Though the coal beds seem to dip 3° to 4° north-west at their exposures along railroad, yet the entire amount of sinking from Powelton (1798″ A. T.) to the outcrop of bed B above the railroad level at Osceola (1500′ A. T.) is not quite 300 feet.

The synclinal or basin line passing through Osceola and Philipsburg has already been described. It lies wholly in Clearfield county. To the north of it the coal beds rise on to the *First* or *Laurel Hill axis.*

The basin is also *sinking to the north-east* as far as Philipsburg, east of which it again *rises* in the same direction towards Morrisdale, as already described, carrying the Freeport lower (Moshannon) bed D into the air at that point.

The rising to the south-west from Osceola is more gradual, and several faults through this part of the basin have served to keep the Moshannon bed D (and, indeed, the Barren Measures overlying it), within the hills of western Clearfield and Centre counties.

There is a section in Report H, on page 23, compiled by Mr. Platt, at Osceola and vicinity,* which may be compared with the Snow Shoe Section, (Fig. 1, page 58,) of this report. It is reproduced in Fig. 29, page 58.

Two miles north of the summit, and resting on top of the Conglomerate, are the Snady Ridge fire clays; and over them mostly sandstone 35′ to 40′ thick. Over this latter lies coal bed A Brookville, 4′ to 4½′ thick, though in this part of the basin usually so slaty and sulphurous as not to be mined.

It outcrops at the Powelton mill, and a shaft put down back of railroad station is reported to have struck the same bed 45 feet below the Kittanning lower bed B.

Kittanning lower bed B at Powelton.

Over coal A there occurs a few inches of slate, and then 20–25 feet of brown sandstone described by Mr. Platt, Report H, p. 24, as "a rusty mass of thin sandstones, with an occasional massive layer, sometimes running into rusty shales and slate, in places with ore nodules, hematitic."

* A full description of the underlying conglomerate series XII will be found by reference to the same page of that report.

Over this, and extending up to the floor of bed B, is "a hard, massive sandstone, in some places conglomerate, but always fine grained and much current bedded."*

The usual interval (60 feet) between A and B is here shown by shaft to be reduced to 45 feet.

The Kittanning lower bed B, as already stated, outcrops at Powelton. There are three openings on this bed here in the Black Diamond Mines of the Powelton estate.

The bed is pretty well worked out in the two southern drifts, but coal from them is being used in small quantities for the engines at the brick works.

No. 1 Black Diamond mine is opened below railroad track west of Powelton (1798′ A. T.) 34′ below station at 1764′ A. T. It is one of the earliest workings in this region.

The drift below the track goes in beneath the bed for some distance, gradually rising on it N. E. until in 500 or 600 yards, with 21′ of rise the following section shows (Fig. 30, page 61):—

Slate roof, firm,	2′+
Bony coal, not mined,	0′ 8″
Black slate,	0′ 8″
Coal,	3′ 4″
Black slate,	0′ 10″
Coal,	1′ 6″
Slate,	0′ 8″
Coal,	0′ 8″
Fire clay, blue,	6′+

The coal of the main bench is lustrous, with columnar structure, somewhat sulphurous, the sulphur occurring in bunches rather than seams through the bed.

At face where the last mining was being done, the coal showed an excellent slate roof and floor, with a bed 44″ thick, without any parting. The gangways have been carried clear through the hill 1½ miles to the south-east crop of the coal north of Cold Stream. The coal is largely used on the engines of the T. and C. R. R., and a sample taken in 1874 from upper bench gave on analysis (McCreath):

*Can this be the same sandstone rock found covering the low hill between Holt's drift and shaft on the McClelland tract and Hoy's monkey drift? If so, the two beds are probably different, and the large bed the Brookville bed A

Water,	0.540
Volatile matter,	22.560
Fixed carbon,	71.551
Sulphur,	1.079
Ash,	4.270
Total,	100.000

Coke per cent, 76.90. Color of ash, light gray.

The lower bench yielded as follows:

Water,	0.600
Volatile matter,	22.600
Fixed carbon,	68.709
Sulphur,	2.691
Ash,	5.400
Total,	100.000

Coke per cent, 76.80. Color of ash, gray, with pink tinge.

The long haulage rendered necessary here to bring this coal out to the railroad entailed considerable expense, so that the cost *for mining alone* here on Sept. 28, 1883, was 44 cents per ton.

No. 2 *Black Diamond mine* was just being opened N. W. 400 yards of No. 1 and about 80′ below it at 1684′ A. T.

The drift had been carried in under the track 100 yards and showed 42 inches of coal with the same characteristics as in No. 1 drift.

The following section, compiled from facts already stated and exposures on hillside at Powelton, is taken from Report H, p. 41:

Powelton section.

Hill top.		
Shales, with thin sandstone,	40′	
Coal, not seen, reported,	2′	
Shales, rusty, with some ore balls,	30′	
Coal reported,	3′	(block coal.)
Shales,	35′	
Coal B,	5′	
Concealed measures,	45′	
Coal A,	4′	
Concealed measures,	10′	
Iron ore balls.		

All these measures crop out on east side of hill north-west of the Powelton clay bank. Coal A was drifted upon just near the crossing of the tramway and pike 35′ above its N. W. crop on the railroad.

There is a fallen-in drift on this bed on the hill just north of Clover run, and crossing N. W. over Dale's hill to the north of Twigg's Hollow the same beds appear, though with somewhat greater intervals, and with probably the Kittanning upper C′ bed crowning the crest and crossing the lane about 200 yds. south-east of Dale's house.

The Phœnix Mine, Bed B.

No. XII conglomerate is just under creek level at Osceola, at or about 1444′ A. T. Down creek from here the Kittanning lower bed B is opened in the *Phœnix mine* by J. Burns under a contract with Orvis, Williams & Co., owners of the land.

This is an old mine. The level of drift is about the same as Osceola junction, or 1486′ A. T. The normal dip of the bed is N. W. with a slight N. E. pitch.

The bed was seriously troubled between mouth of drift and first gangway, being rolled and requiring blasting through roof, though no diminution of size in the bed was noticed.

In the first of the bed chambers being re-opened I measured :

Slate roof.	
Coal, impure and bony,	1′ 1″
Slate parting with bone coal,	0′ 7″
Coal, columnar and clean,	3′ 0″

The top bench is rather slaty and sulphurous, the latter occurring in balls and masses as at Powelton. With care in cleaning, it will make a good, strong steam coal, and is at present used to some extent on the railroad engines.

The headings were in about ½ mile, (Oct. 16, 1883,) where the same thickness of bed is reported. The floor* has a thickness of 18″ to 2′, mixed sand and clay with coal reported under it. Production of mine 100–120 tons daily.

*This is doubtless the "fire clay slate" parting before referred to as dividing the bed into two main benches. Beneath it is the lower bench.

South up hill there is a small coal bench at spring-house 38′ above the drift, the hill rising 200′ higher while receding and showing some coal thrown out 120′ above spring-house.

It is probable that a small area of the Freeport lower bed D shows on this summit north of Dale's house. But the measures are rising rapidly and the area of this bed cannot be large. Massive sandstone (Freeport ?) shows on the terrace at the house, barometrically 240′ above Osceola junction.

Further down creek there are two more operations on this bed, both abandoned, located in Spring Run Hollow.

The *Ætna colliery*, on west side, is 27′ higher than the Phœnix, being located further south-east. The quality of the coal was poor and the bed thinned greatly.

A considerable amount of money was spent here in outside improvements.

The *Boynton Coal Co.* have two drifts on the other side of the run and nearer to the railroad.

The lower on B is 4′ lower than the Phœnix. The other bed (C ?) is 35′ higher and the dump is filled with sulphur balls. Reported sections of these two beds gave as follows:

Lower Bed.		*Upper Bed.*	
Slate roof.		Roof slate.	
Coal, ...	0′ 6″	Coal with sulphur balls, .	2′ 10″
Bone, coal and slate, . . .	1′ 10″	Fire clay, ...	5′ 0″
Coal, ...	1′ 8″		

The measures pass through this hill and on to Cold Stream—though the hill is low and probably only takes in a patch of the Kittanning upper C′.

The thin Freeport lower bed D of Snow Shoe becomes through this region the famous Moshannon bed 4′–6′ thick and furnishes nearly the entire output of this basin.

Around Philipsburg.

The country around Philipsburg is generally broad and flat and as far as the Freeport lower bed D is concerned, none of the hills on the Centre county side of the Moshannon are high enough to catch it, so that between Cold Stream and the Moshannon creek only outcrops of the low-

est beds—probably as high as the Kittanning middle in places—are to be found.

The basin rising from Philipsburg to the N. E. has likewise contributed to the effects of erosion in the higher measures.

Bed A has been opened in various places in this region showing it to exist as a 4 to 6 foot bed but of too impure a character to warrant its mining in the face of superior coals in other parts of the basin, so that all these old drifts have been abandoned.

These old openings are seen on the pike below (north of) Cemetery hill; on east side of Cold stream just at head of dam, where some little coal is still mined for country use, and in numerous drifts on both sides of Williamson's run.

A New York company opened this bed in the latter place on a branch of the main stream, and in report H the bed is described as showing

Sandstone roof.	
Coal,	4′ 4″
Fire clay floor.	

and very sulphurous.

An upper bed (B) was opened by the same company 60 feet higher in the hill which showed, (Fig. 31, page 61):—

Black slate roof.	
Coal,	0′ 6″
Small slate plating.	
Coal,	2′ 9″
Soft fire clay,	1′ 6″
Coal,	4′ 4″ to 4′ 6″
Fire clay floor.	

At Williamson's mine, on same creek, 1 mile east of Philipsburg the following section is given in report H:—

Slate roof,	1′ 0″
Bony coal,	0′ 2″
Coal,	1′ 1″
Slate,	0′ 2½″—3½″
Floor fire clay.	

An average specimen in 1874 yielded on analysis (McCreath):—

Water,	0.62
Volatile matter,	22.73
Fixed carbon,	68.794
Sulphur,	1.576
Ash,	6.28
Total,	100.000

Coke per cent 76.65. Color of ash, gray.

"The coal is shining, columnar, contains veins of charcoal and pyrites, very heavy."

Reservoir Hill at Philipsburg is high enough to take in bed C. Its crest is covered with bowlders of a friable sandstone with a coal bench 50 feet below top.

Between Cold stream and Williamson's run two small outcrops show in pike—the lowest one (A) being well seen in cleared field to north-west. The hill rises high enough east to catch C. Before reaching Williamson's run massive buff-colored (Clarion ?) sandstone shows in road, from under which coal (A ?) has been drifted about 15′ higher than the opening in Cemetery hill, marking the rise of the coals north-east.

The lower coals crop out in a low broad hill between the Moshannon creek and Black Bear run, and *west* of the hill road to Munson's mill. The road everywhere shows bowlders of XII all the way to the creek with bed A in a marked bench (and I believe opened) on Clearfield side 20′–30′ above level of water.

The country to the south seems everywhere XII and so to the crest of the Alleghany mountains, unless allowance be made for the occurrence of the compressed trough far up Six Mile run, which at best can take in only the very lowest beds of the coal measures.

It is just as probable that the rise of the measures through here has led to the erosion of the entire coal series, exposing the underlying Conglomerate of XII throughout a large portion of Rush township.

Around Osceola

South-west of Osceola the basin is one of much more importance to Centre county, owing to the preservation of the "Moshannon bed" over a considerable area.

As yet, however, the region south of the Moshannon is but little developed, owing to its general inaccessibility as compared with the Clearfield coals, and its structure through a thickly wooded district, but imperfectly made out.

Coal bed A, at creek level at Osceola, was opened many years ago ½ mile up Trout run, according to report.

Cropping as it does with bed B on the south-east between Sandy Ridge and Powelton, it passes through all the hills to the north-west, showing in the different valleys, and extending south-west into Cambria county.

Bed B was formerly opened at the old *Philadelphia colliery* on the south side of the Moshannon and about 20 feet above level of water in Osceola dam. The old drift has long since fallen shut. Going south-west up hill road to point of the ridge flanking the creek, well-defined coal benches, slate and smut were seen at 36′, 116′ and 170′ (barometric) above Philadelphia mine, the last bench being probably the Freeport upper bed E, which is comparatively thin through this region and largely known as the "rider" to the underlying bed D.

Buck ridge.

The rise of the basin *south-west* soon carries this little patch of the Freeport beds into the air; but after being cut out to the south by a ravine heading from Leskey's branch they are again caught in the flat of Buck ridge.

Two little patches of the Freeport upper bed caps this ridge between its north-east extremity and the Leskey branch; but the Freeport lower bed D extends solidly through the hill to Bear run for 2 miles N. E. and S. W., and though the hill is not very broad a considerable amount of coal can be mined here.

Three openings had been made in this hill in the fall of 1883. The Leskey branch of the Moshannon and Clearfield R. R. serves to carry their products to market.

The Osceola mine of Mears & Co. was about ready for shipment when last visited (Nov. 1, 1883). The main

gangway was in 400′ and the following section of bed was reported by superintendent (Fig. 32, page 60):—

Slate roof.	
Bone coal,	0′ 2″
Coal,	1′ 0″
Cannel coal,	0′ 2″
Coal,	4′ 5′
Fire clay,	6+

The old *Leskey drift*, now *Stirling No. 3*, (R. H. Powell & Co.,) is on the west side of railroad, 20′ above the track and 5′ higher than the 'Osceola Mine' drift.

The drift enters the hill S. 23° E., and at the first or A heading I measured the following section of bed (Fig. 33, page 60):—

Sandstone top.	
Slate,	0′ 9″
Bone coal,	0′ 4″
Coal, soft,	1′ 0″
Cannel coal, not mined,	0′ 3″
Coal,	5′ 0″, with a streak of cannel coal about 2′ 6″ from top.
Sandstone floor.	

About 70 yards in this heading N. E. the coal has the same general character and with the cannel seam, is about 6′ 3″ thick. But the slate roof has swelled to 8′ in a great measure replacing the sandstone.

No fire clay occurred in this mine until further south, where the coal rises rapidly. A roll was met in the main drift, and the sandstone roof was driven through.

Further south-west 600 yards along north face of the hill the same company has driven a second drift in this bed, with a rise in that distance of about 32′.

The bed has only about 30′ of cover here, though a small patch of bed E occurs on top of hill *between* the two openings.

The second heading was driven about S. 5° E., and a section gave me (Fig. 34, page 60):—

Slate roof, firm.	
Bone coal,	0′ 3″
Coal,	0′ 6″
Cannel coal.	0′ 3″
Coal, good,	4′ 0″

Both these drifts show an excellent, bright, and clean columnar coal, with an occasional ½ inch slate binder hold-

ing sulphur, but otherwise very free from impurity, and capable of making a handsome steam coal.

To Mr. Campbell, the superintendent, I am indebted for much information and assistance.

Buck ridge continued.

Keeping the same course along hill south-west, and crossing a flat made by the small Bear run, these coals are continued in the next knob of Buck ridge, though there are evidences of a *fault*, running transverse to the mountain, passing through here.

It may be connected with some one of the *Clearfield faults*, though in the absence of any developments its direction and extent could not be determined.

A shaft was put down at eastern extremity of this hill, 48′ higher in elevation than No. 2 drift of the Stirling mine No. 3. It went through 5′–6′ of loose sandstone and 8′ of slate.

Slightly to the north-west on the same hill another shaft was put down 22′ below the first, and struck coal 3′ 6″ thick under 8′ of cover, or as compared with Stirling drift only 18′ higher than the Freeport lower bed D.

Allowing for same rate of rise south-west this bed should correspond to that in the Stirling and Mears mine; but the appearance of the coal itself, as well as its covering which is everywhere a massive conglomeritic sandstone with ore nodules and resembling Mahoning SS., makes it probable that this 3½-foot bed is the Freeport upper bed E brought down by a *fault* of 40′–45′, and that the Freeport lower coal will be found beneath it.

Mountain branch.

Another patch of Freeport lower bed D is caught on the hills between Mountain branch and Moshannon creek, dipping N. W. into Clearfield county where it is mined above and below creek level on Whiteside's run. The Brookville and Kittanning lower coals both probably go under water level before the Mountain branch is reached. The latter is well exposed on the Leskey branch, with two if not three intermediate benches between it and the Freeport lower bed at the end of the railroad.

The Freeport sandstone shows in the railroad cut north of Leskey mine. A single word of comparison is all that is necessary in reviewing this end of the basin in relation to Snow Shoe.

Here the large bed so largely mined is the *Freeport lower* D; in Snow Shoe it is the *Kittanning upper* C', occurring 40'–50' lower in the measures.

The *Kittanning lower bed* B in this basin is everywhere too sulphurous to work in the presence of the larger and purer seams above it; in the Snow Shoe district it is an excellent merchantable bed though under water level through a great part of the region.

The *Kittaniny middle bed* C is worked at neither place,* nor does its character generally warrant any development of it.

The absence of limestone from this part of the basin is even more marked than at Snow Shoe.

Fire clay beds.

The Sandy Ridge fire clay works and mines are located about 2 miles N. W. of the Allegheny mountain summit and about 1912 feet above tide. The clay is worked here on its south-east outcrop, overlying the Pottsville Conglomerate No. XII, and in addition to a N. W. *dip* towards the synclinal of about 8' in 100', shows a decided N. E. *pitch* towards the centre of the basin at Philipsburg in obedience to the general fall of the measures in that direction.

Where measured at outcrop at face of old stripping at mouth of new drift (1917' A. T.) it showed:

1. Sandstone covering, opened into,	4' 0"
2. Black slate,	10' 0"
3. Soft clay (blue),	2' 0"
4. Hard clay (French gray),	2' 6"
5. Soft clay "under strata,"	3' 0"
6. Sandstone floor opened,	4' 0"

In the early application of this clay to making fire bricks the soft blue clay No. 3 was most sought after, until the superiority of the underlying hard clay was noticed. In

* Unless in Sugar Camp hill.

consequence of this fact, all the old workings and drifts in this clay bank show a portion of this hard clay No. 4 in the bottom. A persistent coal seam, measured 1′ 4″, occurs about 9′ from top of clay in the overlying black slate roof. It is bony and sulphurous, though formerly mined here for local use at the works. It is beneath the bottom or A bed of the Lower Productive Coal Measure series.

In 400 yards in the new drift the following section showed at face:

Sandstone roof, with slate.	
Soft (blue) clay,	3′ 6″
Hard clay,	2′ 6″
Soft clay "under-strata" in floor.	

In face at most eastern workings (Oct. 16) the clay showed as follows:

Sandy roof.	
Soft clay,	3′ 4″
Dirt band,	8′ 0″
Hard clay,	2′ 6″

The clay shows a slight *rise* N. E. here, marking a local roll.

In a cross-cut south of this the hard clay showed 45 inches thick, and in the old workings, where mostly soft clay has been mined, I measured:

Slate roof.	
Soft clay, blue,	5′ 10″
Hard clay,	3′ 4″
Soft clay "under-strata,"	1′ 8″
Sandstone floor, mixed with clay.	

These sections will be sufficient to show the varying character of the clay in different parts of the mine.

The mine is drained under the floor of the main gangway, and does not seem to be seriously troubled with water.

Lagoon-fault in fire-clay bed.—Clay banks are not more free from "troubles," "horse-backs" and "rolls" than the overlying coal measures, results brought about by the same causes, so that a serious roll was recorded here in about 600 yards in the old workings, which cut out both strata of clay entirely, and brought the slate roof down to the under strata.*

*A similar feature was recently noticed by Mr. Frank Wilcox, superintendent at the Powell clay banks, though his clay seems to be gradually thinning rather than cut off by a roll.

The line of this squeeze runs about N. 10° W.

There was no displacement or fault, the clay strata coming in with regularity on the other side of the roll.

The mines were producing (Oct. 16) about 60 tons a day, from which about 25,000 bricks of different grades are made.

The hard clay is crushed in its natural state with sand obtained from the sandstone floor; molded, pressed and burned.

The top (blue) clay is well adapted for furnace bottoms; the hard clay for No. 1 fire brick, and the under strata is used for tiles and in-walls of furnaces not requiring as high a grade of brick.

The essential difference between the clays is in the percentage of iron,* which occurs as a protoxide decomposing when exposed to air and heat, becoming fusible when burned, and producing black specks in the burned brick.

The blue clay contains most iron; the under strata less, though more than the hard clay.

The alkalies are also detrimental.

Average specimens of these four layers yielded on analysis (McCreath H, p. 119):

No. 1, top layer, blue soft clay; 2, hard clay; 3, under strata; 4, sandy clay floor.

	1.	2.	3.	4.
Silica,	45.650	44.950	45.820	74.950
Alumina,	34.730	37.750	35.950	15,940
Oxide of iron,	3.546	2.700	3.330	1.899
Lime,	.112	.302	.112	.106
Magnesia,	.619	.216	.573	.407
Alkalies,	5.750	.985	4.130	1.756
Water,	9.650	13 050	10.130	4.885
	100.057	99.953	100.045	99.943

A glance at the above table of analyses shows why the bottom layer is not worked.

An analysis of Sandy Ridge fire clay made in 1870 by Mr. McCreath for the Pennsylvania Steel Company, and published by permission of the President of that company, yielded:

* Mr. A. S. McCreath thinks that in these clays most of the iron occurs as a silicate of the protoxide.

Silica,	45.880
Alumnia,	33.920
Oxide of iron,	4.680
Lime,	.160
Magnesia,	.750
Alkalies,	4.643
Water,	10.370
	100.403

The above analysis agrees very closely with the average of the three analyses of the top, second and third clay layers.

"Clay No. 1 (top layer) is massive, of pearl color, has a soapy feel, and the outside of the lumps slightly fibrous.

Clay No. 2 (second layer) is compact, massive, has grayish color, with bluish tint on fresh surface.

Clay No. 3 (third layer) is compact, of pearl gray color, and breaks in plates and contains small scales of mica.

Clay No. 4 (bottom layer) is compact, of pearl gray color, uneven fracture, and containing small scales of mica."

No determination of titanic acid is shown separately here, though its presence in the Powelton clays renders it more than probable that it occurs in the Sandy Ridge clay as well.*

Powelton fire-clay bank.

About ⅝ mile north-east of Miller's '*Sandy Ridge*' mine, the same bed is worked on its outcrop 72′ lower along south flank of hill and north of the flat caused by a branch to Cold Stream, on east side of Philipsburg and Tyrone pike. This is the *Powelton clay bank.*

The outcrop crosses the pike in a N. E. and S. W. direction near the tram-road to the mines, and after turning south, faces again west to Miller's. No clay occurs in the flat south-east of the Powelton drift, and as it has not as yet been sufficiently shafted upon to allow of working *against* the dip, a drift has been run in N. 25° W. *on dip* about 200′ long (Oct. 16, 1883), at bottom of which the water is allowed to collect.

*A full discussion of these clays, tables of comparison, &c., will be found in Report H, p. 119 *et seq.*

Chambers are run off right and left every 10 or 12 feet, in which the clay is worked southward towards outcrop.

At outcrop face of drift, the following section shows :

Soft and sandy cover,	4′ 0″
Broken black slate,	6′ 0″
Coal, bony,	0′ 4″–6′
Soft clay (blue),	2′ 3″
Hard clay,	0′ 11″
Sand rock floor.	

This shows a slightly different roof than Sandy Ridge, and the coal is a mere string lying immediately on top of the soft clay without slate parting, and forming a guide to the workmen. The dip N. W. is about the same, 8′ in 100′.

Up to the time of my visit the chambers had all been run off to the right (east) from main gangway, the longest then measuring 56 feet.

Lagoon-fault.—In all of these, as well as in the main drift, a *squeeze* similar to Sandy Ridge, but bearing about east and west, was noticeable.

The *squeezes* apparently have some relation to the outcrop here, but are liable to occur in any part of the mine. This one was met with about 160′ in on main heading, and its effect had been to crush out the upper (blue) clay 2′ thick, and replace it with about one foot of siliceous sandstone, over which occurs the coal, here considerably split and mixed with slate. The hard clay did not seem to have been at all affected then, though I have since (Feb., 1884), learned that in further development it also shows signs of thinning out. In main heading near squeeze I measured :

Slate roof with 2″ coal.	
Sand rock, blue,	1′ 4″
Hard clay,	3′ 0″

And in chamber to east :

Slate roof.	
Coal,	0′ 4″
Blue clay,	2′ 0″
Hard clay,	3′ 4″
Under strata,	1′ 0″
Sandstone floor.	

The clay costs about 15 cents per ton to mine and place at the mill, having to be hauled ¾ miles by tramway to works at

Powelton. Messrs. James Pierpoint and Frank Wilcox are the lessees from R. H. Powell & Co., owners.

The company had proposed sinking a shaft in the near future somewhere near their works, from which they could mine against dip and do away with the long haul and maintenance of tramway, but I have heard nothing of this plan being carried into effect.

They were then producing about 1000 tons of clay per month, and making 12,000 bricks daily. A slightly different method in manufacture of brick is used here.

They charge their pan with 10 shovels of calcined clay and 40 of hard fresh clay. At Sandy Ridge the crushed sandstone floor is used instead of the calcined clay. The former is claimed to insure less shrinkage.

A pan holds by weight about 1000 pounds.

An analysis of the clay, which has only been worked about 2 years, was kindly furnished by Mr. Wilcox.

No. 1, Hunt & Clapp, Pittsburgh Testing Laboratory; Nos. 2, 3, 4, J. Blodgett Britton, Philadelphia.

	(1) *Hard clay.*	(2) *Under-strata.*	(3) *Soft blue clay.*	(4) *Sand.*
Silica,	42.32	45.72	48.87	60.80
Alumina,	37.01	39.14	34.43	28.18
Lime,	0.47	trace.	—	trace.
Magnesia,	0.16	trace.	—	—
Protoxide of iron,	0.95	1.34	2.93	1.34
Alkalies,	1.29	2.05	1.96	1.48
Titannic acid,	3.83	—	—	—
Undetermined matter and loss,	0.23	0.36	0.29	0.20
Water and organic matter,	13.74	11.39	11.52	8.02
Total,	100.00	100.00	100.00	100.00

TiO_2 is generally considered equivalent to so many per cent of silica and added to that account.

It is not known how much or in what manner the presence of that ingredient would affect the heat resisting power of the brick.

The small percentage of iron in the above analyses speaks well for the character of this clay.

Coal Measures of the Second Basin.

These are all confined in this county to an area of 10–15 square miles in the N. W. corner of Burnside township, between the West Branch Susquehanna at Karthaus on the west and Spruce run on the east.

To the south, the coal measures, with the possible exception of the Brookville bed A, are cut off by the *Pine Glen* (first) *anticlinal* axis, which divides the first and second basins.

It has been already stated that this axis rises steadily from the Moshannon near its junction with the river, N. E. into Clinton county, and while the Conglomerate Measures and even formations No. XI and X are exposed in the high bluffs bordering the stream by reason of its erosion, the flat arch itself does not bring No. XII to the surface for 1½ mile east of the Karthaus pike, if I am correct in judging the buff-colored friable sandstone along that road between the school-house and Boak's, to be a higher coal measure rock and not XII.

North of Cherry run however, the axis begins to make a distinct ridge, and shows plainly the coarse conglomeritic bowlders of XII on its surface all the way from Etter's place into Clinton county and consequently this entire hill region is devoid of coal.

Sub-carboniferous rocks.

The effect of this rise of the measures north-east is shown by a glance at the colored map of the county, where the red shales of XI carrying carbonate ore oxidized superficially into hematite, rise from beneath the bed of the river below Salt Lick and in all the branch streams eastward appear higher and higher in the hills, whose crests are capped with bold terraces of XII.

Of course the outcrop line of this formation is only approximately drawn on the map, as its position is almost everywhere concealed by drift and bowlders from the overlying Conglomerate rocks. The river deepening eastward from Karthaus assists in exposing greater thicknesses

of the next underlying formation, Pocono No. X, whose rocks are frequently exposed in the numerous ravines *dipping* to the N. W. and *pitching* towards the centre of the basin at *Karthaus*.

This subsidence at Karthaus is only temporary, however, for just north of the mouth of the Moshannon creek, No. XI again rises to the surface and skirts the latter stream as far up as the new town of Peale.

In the north corner of Burnside township, *Burns* and *Jews* run show only XI. Yost run, further west, heads well up on to the plateau of XII, which is here 250′± thick.

This ravine shows mostly X, for the most part a fine-grained white and gray sandstone, sometimes holding dull, rounded pebbles and frequently showing bands of red and greenish argillaceous shales at various horizons throughout the formation.

On the river at the mouth of Yost run, these thin-bedded sandstones and shales extend almost continuously to the summit, meeting there beautiful terraces of XII.

The north side of the river, along the cuts of the Susquehanna and Clearfield R. R. likewise shows excellent sections of these sub-carboniferous rocks.

Field's run shows a similar section, with frequent outcrops of gray, slaty sandstone beds dipping about N. 30° W.–3° to 5°, over which the stream falls in a series of cascades. All these streams are exceedingly wild and rugged, and owing to thick brush, logs and débris from old timber operations, are nearly impassable.

Almost all this land as far west as Pine run, is owned by the city of Philadelphia—in all about 13,000 acres—containing little or no coal except perhaps in the most western tracts, and is being fast stripped of its timber. The geology *south* of this anticlinal ridge is quite similar, though the greater width of the Snow Shoe–Beech creek basin, and the less erosion of Beech creek stream, has not allowed of these sub-carboniferous measures being largely exposed. Burnside township, however, east of Germania, contains little coal—only the very lowest beds crossing the Snow

Shoe line before the First basin edges up quickly on to the first axis.

Coal measures in the Second Basin.

The lowest coals of the second basin crop on their southeast outcrop west of Spruce run, for east of that point all the hill tops seemed to be capped with XII.

The hill between Spruce and Pine runs probably takes in some area of the Kittanning lower bed B, and the country between Pine and Miles run, the Kittanning middle C, with possibly a small patch of the Kittanning upper C′ close to the Pine Glen–Buttermilk Falls road.

Much of the land is yet heavily timbered, and when visited in the fall of the year the ground was so densely covered with dead leaves and brush as to greatly conceal the character of its rocks and coal benches.

Buttermilk lands.

Between Miles and Stirling runs, however, on lands of Capt. White, Brockerhoff heirs, J. H. Holt, and others, known as the *Buttermilk property*, some considerable testing has been done.

With the reputation of Karthaus coals 2 miles west in the same trough, and with a well constructed railroad with low grades along the river at its base, if its test drifts develop anything like those on the north side of the basin in Karthaus, Heckendorn, and McGarvey hills, the future of this territory is promising.

The center of the basin or synclinal axis is practically the Susquehanna river at this point from which the coal beds rise both ways.

About 100 yards west of the old Buttermilk hotel along river bank the following section shows at low tide:

Bog ore, slimy, about	3′
Red and brown shale, with hematite nodules,	14
Clay, holding carbonate ore, drifted upon,	11′
Fire clay, good, bottom not seen,	3′
Interval to river,	20′

The measures exposed here are evidently No. XI, dipping about 4° N. W. towards river. Westward the rise of the

river covers up everything here exposed east of Salt Lick. The top ore band—decomposed at its outcrop into a slimy red mass—can be well traced that far.

North of Capt. White's house, on north flank of hill, several of these coal beds have been opened, and a barometrical section, partly compiled, shows somewhat as follows (Fig 35, page 58):

Buttermilk hill section.

	Hill top, (Mahoning sandstone ?).	
	Sandstone and shale,	40′ 0″
	Hard gray slate,	10′ 0″
1.	Coal, (E) drifted upon,	3′ 6″+
	Concealed measures, SS. and shales,	50′
2.	Coal bench, (D) not opened,	——
	Concealed measures, mostly slates,	42′ 0″
3.	Coal, (C′) opened on crop,	2′ 8″+
	Interval, slates and shales with a little SS.,	34′ 0″
4.	Coal, (C)	3′ 0″ ?
	Concealed measures,	45′ 0″
5.	Coal, (B) opened,	2′ 6″
	Interval, mostly slates,	32′ 0″
6.	Coal, (A′) good, hard slate roof,	1′ 6″
	Sandstone and shale,	22′ 0″
7.	Coal, (A) opened,	2′ 6″
	Fire clay,	4′ 0″ ?
	Sandstone, blue,	40′ 0″
8.	Slate and coal smut,	1′ 0″
	Conglomerate,	225′ 0″
	Shales, etc., to river,	65′

This gives the bottom coal A (No. 7) about 340′ above river, and top coal E (No. 1) about 234′ higher, or 575′ above river.

The openings on these various beds in detail show:

No. 1, *Freeport upper E* drifted upon 25 feet from outcrop, where it showed 1′ of smut under 5′ of broken shale.

The bed gradually increased with development until at end of drift 8 yards in from crop I measured 3′ 6″ of coal with 4 inches slate at bottom and 10 inches hard slate roof.

This same bed has been struck in a shaft about ¾ miles N. E. towards east end of hill at a somewhat higher elevation. This is just north-west of the old Dixon house.

The shaft passed through 10′ of broken sandstone, red and gray; 2′ of shaly rock and 16′ 4″ of hard black and gray slate to coal reported 4′ thick.

A small shaft 20′ below the crop of this bed here shows 4′ of carbonate ore, marking the horizon of the Freeport upper limestone. Thirty feet below this there is a marked bench, which would correspond to the position of the Freeport lower bed D of Karthaus and Moshannon region. This bench has strangely enough never been opened owing no doubt to the prejudice against it in the Snow Shoe region, where its attenuated condition always led to developing the next bed below it, Kittanning upper C′ 40′-50′ lower.

Mr. J. H Holt however states that he opened the intermediate bed further west toward Stirling run and found it 3′–3½′ thick. This is about its thickness where opened by the old Karthaus company on Boak's (Walker) property, to be mentioned afterwards.

Kittanning upper C′ No. 3 bed of section, 92′ below E, has been drifted upon 22′ and showed a face of clean coal 2′ 8″ thick with 2′ of firm slate cover.

There is no parting in this bed, and a considerable amount of clean bright lump coal has been removed in drifting which shows no sulphur and no slaty impurities.

The *Kittanning middle bed C, No 4*, is not opened, but the next lower bed 85′ under No. 3 is shafted upon and corresponds in position to bed B, *Kittanning lower*. The shaft was partially filled with water so that no measurements could be made, but the bed shows 2′ 6″ of soft outcrop coal and will no doubt show better under more cover.

The *Clarion bed A′, No. 6* of the section, is here as elsewhere worthless as a mining bed, being only 1′ 6″ thick and separated from the Kittanning lower bed B by slate.

The *Brookville Coal A No. 7* shows 2½ feet of good coal, slightly sulphurous, but not nearly so much so as in the first basin.

The two upper beds are confined to the area between the public roads down Sterling and Miles run, but the underlying seams crop out in hills to south-east and are present over a considerable territory.

It will be urged against these Centre county coals that they are too high above the river; but this same fact presents all the beds here above water level, whereas at Snow

Shoe but a limited amount of the lower beds are thus exposed. An inclined plane here, similar to that recently put up at Karthaus landing to mine the Freeport lower bed could be advantageously located. The measures are pitching slightly towards Karthaus as already stated, and thus the Freeport lower D bench here 525′ above the river is about 479′ at Karthaus. The fall of the river in the same distance is probably 20′ but the Karthaus bed occurson the *north* side of the synclinal, so that a comparison can hardly be made.

These same coals show in public road up from *Stirling landing*, the lowest coal A being opened on west side of road in a monkey drift 320′ (barometer) above the river, underlaid with 40′ of shale and fine-grained blue (Homewood) sandstone, 20′ of shaley sandstone and then conglomerate to river.

The dip to N. W. is quite severe and the total thickness of XII will be probably about 250′–280′.

Coal A here shows 2′+ in a drift 15′ long, very good lustrous coal, free from impurity, overlaid with 2′ of shales carrying ore balls.

A section up side hill here across the edge of the measures shows somewhat differently from the Buttermilk section, (Fig. 36, page 58):

Stirling section.

Hill top 558′ above river.	
Sandstone and shales,	22′ 0″
Coal smut,	3 to 4
Concealed measures, white SS. and shales,	58′ 0″
Coal, drifted upon—good columnar,	3′ 6″
Fire clay,	1′+
Shales and concealed measures,	68
Coal, opened back of Walker's in creek,	2′+
Interval mostly black slate,	32′
Coal, not opened, large bench,	—
Buff sandstone and shale,	37′
Red and gray shales,	6′
Shales with ore balls,	2′
Coal, drifted on Stirling road,	2′
Fire clay and shale,	12′
Bluish gray sandstone with mica scales	28′
Shaly sandstone,	20′
Conglomerate.	

The bottom coal A has already been spoken of.

The next coal is not opened, and while probably B, its interval (45 feet) is rather short. It shows a marked bench west of the Stirling road in field toward's Walker's house, where an uprooted tree had torn up some black (roof) slate.

The small coal bed 32′ feet higher in the section may be the Kittanning middle bed C. It has been opened at head of little stream—a branch of Stirling run, and I believe has been struck also on north face of hill.

Where scratched south of Walker's house it showed:

Soft clay roof,	6′ 0″
Coal,	0′ 2″
Clay slate,	0′ 6″
Coal,	2′ 0″
Clay,	?—

Much of this clay in section of bed may be only the decomposed portion of outcropping slate which is here continually exposed to disintegration by drainage.

From here to Walker's cellar is about 68′—where coal smut shows at about the same elevation as the old Karthaus company's drift.

This bed has been opened in several drifts by the old Karthaus company, who took a considerable amount of coal from here. These drifts have been partially cleaned out by the Messrs. Boak, and in the most westerly one, first opened, I measured:

Roof black slate firm,	6′+
Coal, free, columnar and lustrous,	3′ to 3′ 6″
Fire clay,	0′ 6″+

The second opening, further N. E. gave, (Fig. 37, page 60):

Slate roof.	
Coal good,	0′ 6″
Bone,	0′ 3″
Coal,	3′ 6″
Clay slate "horse" local,	0′ 8″
Coal, bottom not seen,	0′ 10″

This is probably the Freeport lower D, and the equivalent of the large "6" foot bed at Karthaus, and if correctly identified here, its presence as a good bed of workable thickness on east side of Stirling run in White's hill is more than probable.

A sample of coal scraped from both benches, and sent Mr. McCreath, analysed as follows:

Water,	1.994
Volatile matter,	23.921
Fixed carbon,	67.059
Sulphur,	.806
Ash,	6.220
Total,	100 000

Coke per cent, 74.085. Color of ash, cream.

As compared with the Karthaus bed, as analyzed in 1874 for F. Platt's report H, p. 81, as follows:

Water,	.630
Volatile matter,	24.630
Fixed carbon,	70.396
Sulphur,	.654
Ash,	3.690
Total,	100.000

Coke per cent, 74.74. Color of ash, red.

The two compare favorably except in point of ash, and the larger percentage of that ingredient in the former was, no doubt, in part due to the great weathering and breaking down of the bed and haste in sampling.

With care, this coal will make an excellent coke.

The coal bed above this 60′, Freeport upper, shows quite a heavy smut outcrop, but is confined to a very small area on top of hill, and commercially is but of little value to this property.

The Freeport lower D is possibly caught on hill between the two branches of Stirling run, and, though time did not permit an examination here, it has been so colored on map.

Along the Karthaus pike

The Karthaus pike shows most of these beds between the river and Pine Glen P. O.

White sandstone crops on road for a couple of hundred yards, dipping along river front N. 20° W. 2°–3°. Just north of second bend of road to Pine Glen, a reddish, fine-grained sandstone outcrops with the same dip, coloring the

soil red, and succeeded in the next 100′ along road by gray, marly shales, blending in with conglomeritic sandstone.

Black slates and coal smut show at barn, 340′ by barometer above the river, and if this be coal bed A, and the interval correct, it marks the cessation of pitch towards Karthaus, for it is 20′ higher than the same bed on the Stirling road.

Another weak coal smut shows 20′ higher, with an interval of shale and sandstone, with black slate 74′ (without allowance for dip) above the latter, possibly representing the horizon of bed B.

Above this, with an interval of 120′, there is a strong coal smut on roadside north of Laurel Run House.

This same bed benches strongly on road to White's from Pine Glen, beyond Advent church.

Sandstone crops on pike south of Laurel Run House, showing a very pretty roll with dip to N. W. and S. E.

West of Karthaus pike from school-house there is a pretty broad hill showing four benches.

South of this hill is a cove leading up to Boaks' farm buildings, where some recent tests have proved the presence of the lowest coal beds.

Smut was found 6 inches thick at a spring in his meadow, the outcropping of a good bench south-east on the Stewart tract.

Where shafted 10 yards to S. E. 26 inches of fine coal was passed through, probably the same bed as struck in the well at his farm.

The farm lane to the pike passes over a hill of shales, 100′ higher than smut in spring, and which contains a small area of a higher coal bed,—probably Kittanning middle C. No higher coals occur in this hill.

South-west from the spring the ground rises over a summit 60′ higher, and from there down to the river two benches were passed before conglomerate was met,—the upper of which corresponds probably to the bed tested. The conglomerate XII dips about N. 20° W. 3°.

Ore of XI.—The "red ore" bed, which everywhere in previous sections occurred at the bottom of XII, if not in

the shales of XI, is seen here also, as well as on Red Lick run and Seven Mile run, in this township.

The river is 575′ below summit south-west of the spring, and shows a fall from here to Karthaus (barometer) of 20′ in 1½ miles. There is evidently a considerable thickness of X along here.

On Red Lick run the top of XII is met with about 545 feet (barometer) above its intersection with the river, and at about 300′ below this the "red ore band" shows in the run. From here to river is fully 200′—most of which must be Pocono sandstone No. X.

The exposures on Red Lick all dip to the north-west.

The mouth of Moshannon creek is 850′ A. T. and the flow of the river is considerably enhanced by that stream, showing a fall in ½ mile to Red Lick run of about 25′.

Along township road from mouth of Moshannon creek several exposures of gray and reddish sandstone are seen, made up of shaly and sandstone strata 30′ thick, before distinctly conglomerate rock is met with.

South of Boaks' lane, a narrow hill on land of J. H. Beates catches on its summit a patch of same bed mentioned on that lane (C?). Mr. Beates reports 2′ of fine coal with 3′ slate cover in one trial shaft sunk on this bed, and 4′ of coal and slate with 10′ slate cover in another.

There is only about 12′ of cover altogether here, though the point is topographically high, and commands a fine view of the surrounding country.

Mr. Beates reports having passed through 7 feet (?) of limestone rock without coal in sinking on a bench 41′ below hill top in his meadow. If so, this must be the *ferriferous limestone* below the Kittanning lower bed B.

The two upper coal beds pass out into the air south-east before reaching the anticlinal, which passes somewhere near the old Bower house now occupied by J. B. Newcomer and just south of the old Pine Glen tavern, carrying on its arch here the lowest coal bed of the series.

The topography of the country is very flat and the soil is made up mostly of buff-colored (Clarion?) sandstone.

The country immediately west of Hipple's, in the Newcomer and Zimmerman farms, is very flat, though elevated, and carries only the lowest coal measure rocks.

The features of this basin, then, in Centre county show the same absence of limestone as already remarked in the first basin, though at Karthaus, in Clearfield county, several horizons can be identified.

The coal beds as far as opened show no very great thickness, but are very regular, and, as a whole, show very little impurity and good coal.

In the face of the limited development (the longest drift being only 25 feet in from crop) it is too early to speculate on the future of this field.

The limited amount of the Freeport group still left here and opposite in Clearfield county will be remarked by referring to the colored maps; but its proximity to a ready market should lead to some thorough testing.

Some steps have been taken towards developing the Centre county side by means of a railroad from Sugar Camp by way of Little Sandy or Cherry run and Miles or Pine run to connect with the S. & C. R. R.

Chapter VI.

Brown Hematite Ores of No. II (Siluro-Cambrian Limestone) in Nittany Valley and Penn's Valley.

The iron ores of formation No. II are of the greatest importance in this county.

The various mines and outcrops will be described in the following chapter with analyses and characteristics.

There are in many places very flattering showings of loose ore, tested by trial pits to some extent, which call for no special mention here. But wherever possible, the numerous outcrops have been traced and openings on them located on the colored geological map, so that descriptions here given all refer to that map.

Though some of the mines in the county have been worked for many years, the industry of iron ore mining may be said to be still in its childhood.

With but few exceptions, the mines of the county are operated by very primitive methods.

No great reason for a large output, requiring more modern machinery, as yet exists. There is not a single coke or anthracite furnace within the county limits at present writing; nor are there sufficient railroad facilities as yet to meet any outside demand, and but four small charcoal furnaces, all in practically the same portion of the field, in active blast.

Even the little charcoal furnaces whose romantic ruins dot the Bald Eagle and other valleys have long since passed into history, and their demand, feeble as it was, has ceased altogether. On Jan. 18, 1884, only three of the charcoal furnaces were in blast, whose combined necessities could be satisfied by one good mine.

When it is remembered that a means of supplying copious wash water to many of these ore banks was only discovered about 15 years ago by the sinking of artesian wells in these dry valleys, it is not surprising that the county does not occupy the position as an ore producer that both the character and quantity of its raw material justifies.

Varieties of ore.

The two chief varieties of ore occurring in the county are:
1st. The wash and lump hematite ore of the "barrens."
2d. The pipe ores.

Of the first class it may be stated that the appearance and character of the ore in all the banks as well as the accompanying waste material showed evidence of their being wash deposits, caught in vast caverns, of irregular shape, showing mixed sand, tough clay, and rolled ore, and though intimately associated with sandy measures *in* the limestone measures of II have really a still lower limestone bottom.

In the chief mines of the district—notably at Scotia and Tow hill—after a superficial covering of 15 to 30 feet of mixed clay, sand, and fine ore has been removed, the under surface reveals solid rock ore in large lumps mixed with clay in a confused arrangement, of great richness and variety.

An integral difference in the clays of these ores and the limestone pipe ores (one to be expected probably from their different horizons) is the much greater stiffness and toughness of the former.

The clay of these lower ores frequently occurs in non-ferruginous bands or dykes, running through the length of the banks, barren and hard to pass through the washers, but by no means cutting off the ore.

This non-ferruginous clay has usually a white to pink color, while the yellow clay of the pipe ore deposits is intimately mixed with the ores and offers no material resistence to their thorough cleansing in the washing-machines.

Moreover, it may be noted that in every case the ore of the barrens needs jigging in addition to washing to free it from the mixed sand and flint that accompany it.

All the analyses of these ores show an absence of bisul phide of iron and the occurrence of all the iron as sesqui-oxide, at once suggesting a different chain of effects in the production of these as compared with the pipe ores to be immediately described where this salt of iron is frequently present.

The sand rocks which originally held these ores occupy a position low down in the limestone series of II. By having their lime leached out, these loosely aggregated sandstones have fallen into sand, and it is probable that this same leaching action has cencentrated their iron salts, which would be deposited as insoluble peroxide. What changes may have followed this process of deposition to bring about the irregular and confused appearance of the banks to-day and the grading of the ore body from fine to coarse lumps is a matter of speculation still.

The deposits do not look like formations *in sitû*, nor would such a theory explain the rounded character of ore and flint balls and the occurrence of barren spots beside nests of great richness.

While no distinctively pipe ores have been reported from the ore banks in the "barrens," some persons detect in the compact needle ore occasionally met with a form of pipe, and illustrate their opinions of the common origin of pipe and hematite ores by this fact. Physically and chemically they appear to be quite different; but the general resemblance of all ores from different banks, divided only as to two classes, is not as remarkable as the local variations which give rise to the occurrence of bessemer, neutral and cold short ores lying quite close to each other, and apparently along the same range.

More detailed information as to the characteristics of these ores in special deposits will be found in the descriptions of the individual mines.

2. The *pipe ores* have varying horizons in the limestone, and though generally *above* the essentially "barrens" hematites, it is by no means certain that some of them do not occur also in the 1000± feet of limestone beneath them down to the top of Potsdam sandstone No. I.

In comparison with the ores of the Lehigh region and those of the Great valley, it may be worth while to note the fact that neither of the two principal horizons which have furnished the bulk of material to the Lehigh and Schuylkill furnaces are represented in Centre county.

In that region the contact lines, or, more properly, the transition layers between No. I (Potsdam SS.) and No. II (Siluro-Cambrian) limestone and between Nos. II and III (Hudson river slates) are the chief ore ranges. Of these, the first or lower horizon is nowhere brought to daylight in Centre county, being buried beneath 1000′± of rock along the floor of Nittany and Penn's valleys.

The second or upper horizon has not been found to be ore-bearing as yet, a fact which may be explained by reason of the presence of 400′± Trenton fossiliferous limestone in Centre county, whereas, its almost total absence in the Great valley allows of the contact of the slates of III with the ferriferous magnesian limestone.*

Again: The frequent connection of damourite slate beds with the chief ore bodies in the south-eastern district of the State is not observed in Centre county.

It is true that most of the pipe ores are accompanied with a white and buff-colored clay, which may be the result of the decomposition of such slate bands; but it may also represent the disintegration of the magnesian limestones themselves.

While the chemical explanation of these facts is still a matter of speculation, repeated examinations of the ore banks in various parts of Nittany and Penn's valleys leads me to believe that the pipe ores are deposits probably due either, first: To the decomposition of iron pyrites, originally contained in the limestone or slate bands, and after oxidation as sulphate, filled into interstices in the limestone and changed into peroxide by contact with vegetable matter or other organic substances; or, second: To the prior production of ferrous carbonate, by reaction between the ferrous sulphate and the calcium carbonate of the limestone,

*But in Blair county the Leathercracker ore occupies the position between the top of the Trenton and the slates of No. III.

afterwards converted into limonite by oxidation and hydration.

The manner of occurrence between walls of regularly-bedded limestone, sometimes as thin shells of ore and again as large pipes in masses 8 to 10 feet thick, would confirm one or the other of these views, while the presence of iron pyrites in perfectly undecomposed pipes, surrounded with thoroughly oxidized ore in the Sinking Creek mine in Penn's valley, lends probability to the theory.

The presence of pyrite in hematite is not new, and the many analyses showing bi-sulphide of iron in the succeeding pages will illustrate its frequency in this district.

Crystalized brown hematite, a pseudomorph after pyrite, has been gathered in the Cumberland valley, as well as specimens of bomb-shell ore, holding a clay inside filled with loose crystals of pyrites.

In other banks showing a low percentage of sulphur many of these ores may have occurred as carbonates in the slates, which upon the dissolution of their lime matter have deposited these iron salts as now found.

In those banks where a considerable surface deposit has escaped from the general erosion, this oxidation has been so complete as to show but a low percentage of sulphur; whereas, in the case of the Sinking Creek mine before mentioned, the ore occurs in place between limestone beds, and has not yet had a chance to become thoroughly changed.

The outcropping of these pipe ores is spread out to a much greater extent than they occupy lower down between limestone layers. The width of these outcrops is affected by the topography of the country. This surface ore is greatly disintegrated, and occasionally is indeed so fine as to be hardly distinguished from so much reddish brown loam or earth; but a close inspection of it will reveal the presence of small stems or pipes, making usually a cubic yard of ore for each 4 or 5 cubic yards of material, and often better.

The work of the season did not confirm the popular belief in continuous belts of ore-producing territory along

miles of surface outcrop. At best, while assigning approximate horizons to these pipe ore deposits, they have their rich and poor places—feather out entirely in the line of strike and widen again into masses several yards thick, while keeping a general parallelism of bedding with the parent rock and liable to show its change of dip. It is useless to speculate on the possibilities of these deposits, but the ore has been found at great depths, and much original outcrop soil is as yet untouched.

Many individual characteristic features of the ore deposits will be noted in describing the separate mines. For convenience sake it has been thought best to describe them in groups, *geographical* rather than *geological*, with such accompanying notes as will serve to connect the different ore banks in ranges according to their different horizons. The outcrops and mines will be described as follows:—

Ore mine groups.

A. Bellefonte-Nittany Valley Group, embracing the following banks: Curtin Bros., Fishing Creek bank, Jackson mine, Red bank, Hoy bank, etc., Gatesburg, Taylor, Nigh, and Logan banks.

B. *Jacksonville Valley Group*, containing Zimmerman, Darrah, McCalmont, Butler, Beck and Washington Furnace bank, etc.

C. *Hublersburg Valley Group*, with the Field, McKinney, Quinn, Hecla, Howard, Voneda, Schwartz, Huston 1 and 2, Snavely and Barlow & Day mines.

D. *Buffalo Run Group;* Hunter, Crust, Markle, Lambourn, Pond, Newell, Desert and Celtic banks.

E. *Barrens Group*, Lovetown, Tow Hill, Scotia, Ackley, Lytle, Red bank, Bull bank, etc.

F. *Pennsylvania Furnace and College Group*, holding Bryson bank, Johnson, Streuble, Stover, Puddington, and Big Hollow banks.

G. *Penn's Valley Group*, Watson, Ross, Sinking Creek, J. P. Runkle, Emerick, etc.

A. *Bellefonte-Nittany Valley group.*

1. *Curtin Bros. Fishing Creek Bank.* This mine is about 1¼ miles east of Bellefonte on road to Zion. Its name is one applied to at least half a dozen openings in this region and retained for each new mine in this line of deposit. It is however, practically one long narrow trench of ore extending east into Valentine's property and lying close to and parellel with the public road.

The position of the various openings will be noted on the county map in Spring township.

Beginning at Valentine's line, a short distance west of the school-house cross roads, the line of this deposit may be traced north-westward for 400 rods, swinging down draft as a wash deposit towards Jacksonville valley road. The original work by Messrs. Curtin and Trezuylny (from whom a large tract of Curtin's land is named), was done in a rather narrow pit just south of the lime kiln where No. II is exposed in the side hill (probably marking the anticlinal axis) dipping to S. E. 30° and quarried for lime.

The township road runs just south of the pit which is roughly 100′ × 60′ × 40′ or about 9000 cubic yards of excavation, though now filled up with water and mud to within 15 feet of the top.

Not having been worked for years, the sides are greatly washed down and show only a little fine and rolled ore.

As was the custom in those days only the lump ore was used, owing to scarcity of washing water, and the product of this mine is described as having been so clean and free from clay as to be almost entirely removed.

Considering its position in a narrow trench exposed to all the drainage of higher country to the east, which found its way to Spring creek through this ravine, the absence of clay and the presence of a large quantity of flint and rock bowlders will be readily explained. Pipe ore was reported in bottom 6 to 8 feet thick, before operations were stopped by water.

It is not improbable if this be the case, that the bulk of the material now being stripped further west along trench, was derived from here, for it bears all the characteristics of

a wash deposit, occurring as layers of ore between rounded sandstone and limestone bowlders. In some places now being stripped (Oct., 1883), the ore is barely 18 inches thick, while increasing to 5 and 6 feet. Some excellent material was taken from an old screening floor here (where the coarser lumps were divided from the fine and rejected particles,) which washed about 1 to 3.

All the ore mined or scrubbed here is passed through a jig after washing, erected at the western brow of the ridge, where also the ore from several neighboring pits is prepared.

East, towards Valentine's line, the surface show continues in excellent shape, sometimes with 4 to 6 feet of dirt cover and again coming up to the surface.

The old work leads directly N. W. into a long trench $800' \times 40' \times 9'$ filled with mud and water.

A considerable amount of surface ore of the same general character was taken out of here about 5 years ago.

At the west end of this and on the *north* flank of the small hill dividing the old workings just described and the present surface excavations, is the washer.

It is claimed that this trench washed 1:5, which would furnish about 4,000 tons of ore, allowing $2\frac{1}{2}$ tons weight to the cubic yard. It still shows fair wash ore in the sides and it is proposed in the near future to excavate it further and transport material by a tram-road to the washer.

On the south side of the small hill just mentioned and close to the Fishing creek road, the present workings are located. On July 31st, when visited, it showed surface scratching over an area of $100' \times 50' \times 60'$ or about 1000 cubic yards.

It has every indication of being a derived deposit.

The best show is in the south face, where there is only about 6 inches of top dirt and about 6 feet of ore, mixed with rounded pieces of limestone and flint. The north face is cut down about 10 feet, but is mostly flint and sand rock bowlders. The west side shows 4 feet of ore under 3 feet of surface drift.

The ore is mostly a hard dark hematite with some light

ore in yellow clay. The present wash record of this material shows about 1 : 8 or 9 and could not be worked at all without jigging. To the north the ore is pretty well cut off. Further east towards the long trench on the north side of the hill some additional old workings are exposed. But the wash must have been light, as the limestone shows in the bottom at some places at a depth of only 8 feet.

South of the road, a draft was followed S. E. through the Harris tract to Milliken's house on the Nigh bank road.

The ravine and neighboring slopes showed a good deal of wash ore—thick in spots but almost entirely absent elsewhere.

It is possible that this whole hill, confined within the triangular tract bounded by the three roads, will show a greater or less body of ore, as it is directly in the range of the Taylor-Gatesburg-Fishing Creek horizon.

Taking into account the great erosion which this region has been exposed to, and in the absence of a single pit to prove its depth or persistency, it would be folly to speculate on its future ; but the company should feel justified from surface indications to sink shafts in parallel lines N. W. and S. E. across the tract, though this should be done well up from the hollow where the washed ore and sand occur which shows less appearance of a continuous surface outcrop.

Plant. The washer is run entirely on surface ore, whose rocky character prevents a very large daily output, making (July 31, 1883,) only about 10 tons with a double 25′ shaft. Its full capacity with this ore is about 15 tons.

The wash well is 157′ deep, filled up to 85 feet and with a 10 foot column of water.

The pump is of the regular oil-well walking beam pattern with 3′ stroke, and making 34 strokes per minute. A 35 h. p. engine runs both washer and pumps.

The washed ore, after being picked of its large flint masses, is divided into two sizes, lump and fine ore.

It is then passed through a rotatory sieve and falls on to a Bradford jig, where the ore, flint and slate are separated

according to their various specific gravities, the ore falling to the bottom.

In order to make the jig continuous in its action, self-acting rakes are arranged by which the flint and stone are raked off the surface.

As there is very little slate in this ore, the flint and ore are readily separated by differences of specific gravity, so that the machine here gives entire satisfaction. The jig-screen has $\frac{1}{4}''$ mesh and separates into two sizes, each size having a flint and an ore bin.

Mr. A. S. McCreath, chemist of the Survey, at Harrisburg, made the following analyses of ore sampled in 1881 from the old workings:

Sample 10 lbs. Dried at 212° F.

Sesquioxide of iron, (Fe_2O_3),	59.642
Sesquioxide of manganese, (Mn_2O_3),	.288
Alumina, (Al_2O_3),	1.470
Lime, (CaO),	2.520
Magnesia, (MgO),	1.131
Sulphuric acid, (SO_3),	.052
Phosphoric acid, (P_2O_5),	.236
Water, (H_2O),	10.932
Insoluble residue,	24.020
Total,	100.291
Iron,	41.750
Manganese,	.201
Sulphur,	.021
Phosphorous,	.103
Phos. in 100 parts of iron,	.246

The hill crest to the east of the washer, extending to the north of the Gatesburg and Taylor banks, shows some old workings. Barometric elevation 927′ A. T. The ore is more or less continuous to Valentine's line on the east, though greatly mixed with flint.

North from the washer, on hill summit, a shaft was put down 10 feet and drifted N. E. in yellow ochreous ore. It is abandoned now, though some good stuff still shows in drift. The clay is very heavy here, and with present facilities could not be very advantageously worked in washer.

West from here along the crest, which dies towards the Jacksonville road, there are several shafts 15′ to 20′ deep,

showing but little flint but a good deal of tough yellow clay mixed with fine ore.

This clay becomes very thick 50′ further west, cutting out the ore entirely and confining it to the N. and S. sides of the ridge.

Limestone crops here, dipping S. E. 15°, under which in some old drifts some fair results have been obtained.

Much of this ore went to the old Eagle furnace built in 1817, and some to the new Pleasant furnace at Curtin, built in 1847.

The ore is not as good as that in the hollows below.

I regard the whole of this knoll as precarious ground, from the fact that limestone rock is found everywhere at short distances below the surface, and the material—ore and clay—found here is derived from a source further east.

This theory would explain the occurrence of good heavy wash ore and large flint masses in the hollows, where they have remained by reason of their greater weight, while the light earth clay and fine ore has been carried to the flanks of the small ridge.

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2. *Jackson bank*, (*Bellefonte Ore Company.*) This mine is situated about 2 miles east of Bellefonte, on the north side of the limestone ridge and anticlinal axis just referred to, and not far south of the Jacksonville valley road.

The property under lease contains about 70 acres, part of the Barhart farm of 400 acres.

It has been operated about two years, (Aug. 4, 1883,) and was first worked by carts, skinned to a depth of about 10′ over a surface 300′ N. E. and S. W. and 200′ N. W. and S. E., or about 21,000 cu. yds. of excavation.

An incline plane was afterwards put down and mining is now being pursued to a depth of 15 or 20 feet below original surface, though but comparatively little ground has been worked to that depth.

Some few exposures of decomposed non-ferriferous sandy limestone occur in the bank especially in the north face, where pipe ore has been found occurring along a narrow ledge of limestone apparently dipping 80° to the N. W.

South 50′ in the centre of the excavation, the dip is only 20°–30° S. E. in a limestone knoll, around which ore has been removed.

A good many shafts have been sunk from the bottom of the mine to a depth of from 10–25 feet. Most of them showed excellent prospects. Much of the ore along the south part of the mine is a heavy black needle ore, frequently found in large lumps, lying in a trench between two limestone hills.

The show is best in the south and west faces, and the mud dam at the latter side of the draft, obviously conceals some of the best ore-ground.

The top covering of sand and flint varies from 2′ to 5′ being thickest in the north face, where the ore is lightest and less abundant.

The ore probably runs through the draft, increasing in bulk west towards Curtin's line and has been tested east towards the Hoy and Red banks for 300 yards beyond engine-house, though the outcrop is narrow.

The original royalty here was $1.00 per ton, but with a reduction of 50 per cent at present writing, the company claim to be able to mine and deliver ore in wagons at Bellefonte for $2.10 a ton.

The general ore body is flinty and must be jigged. There has been 15,000 to 18,000 tons of ore already mined (Aug. 4, 1883). The mine has a good future.

I present two analyses of this ore by A. S. McCreath.

No. 1, May 12, 1880 from samples taken from 14 trial pits.

No. 2. Sept. 1881, from 20 lbs. of washed ore of which McCreath writes: "As shipped this ore may run richer in iron, for it is carefully hand picked after being washed." In addition to this hand picking, all the ore is jigged now, which will considerably increase the iron percentage.

	(1)	(2)
Sesquioxide of iron,	78.678	66.000
" " manganese,	.517	.744
" " cobalt,	trace.	—
Alumina,	.864	1.245
Lime,	.490	.410
Magnesia,	.266	.472
Sulphuric acid,	.032	.030

Phosphoric acid,	.600	.490
Water,	13.240	10.216
Insoluble residue,	5.290	20.590
Total,	99.977	100.197
Metallic iron,	55.075	46.200
" manganese,	.360	.518
Sulphur,	.013	.012
Phosphorous,	.262	.103
Phos. in 100 parts iron,	—	.246

Plant. One unusually good well 197′ deep, cribbed to a depth of 100′ and bored by a diamond drill 97′ more. Water column 100′. Pump has 38 revolutions per minute and is run usually on a 4′ stroke though geared for 4½′. Usual flow of water 180 gallons per minute.

36 h. p. engine for inclined plane, pump and washers. One pair 40 h. p. flue boilers. One pair double washers 25′ long; capacity 60 tons. The delivery shaft is raised 6 inches above the receiver so as to retard the ore flow for thorough cleansing. The washers are octagonal wooden shafts.

Mine cars dump the ore directly into the washer from a platform above, opening at the end and dumping at an angle of 45°. The cars are weighted so as to be readily adjusted after discharging. The washers show good work here, very little clay passing into delivery shaft, which receives wash water from a sluice box alongside.

The ore is picked of large flint masses at the mouth of the shaft before passing into the screen. The latter is divided into three sets of meshes for water, sand and ore under ½ inch. All that passes out of the screen is hand-picked on a platform and transferred to wheelbarrows and thence to the ore dump.

The fine ore and flint is carried up to the jig pans by a Pater Noster chain and jigged into two sizes. A Bradford separator is used here, whose operations have already been described.

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3. *Red Bank* (Curtin Bros). This mine was visited July 31, 1883. It is about ¼ mile N. E. of the Bellefonte Ore Company's mine and close to the north base of the Lime-

stone ridge. It apparently lies a little to the north of the Jackson mine horizon. The mine derived its name from the blood red color of a great deal of its clay.

The mine is an irregular-shaped hole, probably averaging 30′ deep over a rectangular surface 500′ E. and W. and 450′ N. and S. The best show lies in the south and west sides of the pit, often separated by bunches of red clay and again rising to the surface with little or no stripping.

Thus the top covering of clay and sand will often amount to 12 or 15 feet and again only to 2 or 3 feet.

The west face shows a mass of blood-red ore and clay, the latter very rich, and comparatively free from silicious matter.

A sparry bed of material with ore runs N. W. and S. E. through the mine, but the rest of the waste is very loamy.

The ore is raised directly to the washer on an inclined plane.

The show around the plane—located on the north side—is lean, and shows the same general character as that of Jackson's mine. Limestone comes in here, and from it some excellent large pipes were extracted about October 18, very different from the lump hematite found to the south against the hill. The property has been tested 200′ further N. W. with encouraging results, and to a depth of 50′–60′ in the mine. The ore is of excellent quality, and washes readily. The deposit, however, seems to be very irregular, and cheap ore can only be won by careful mining.

The washed ore is claimed to run 55 per cent in iron, and is highly spoken of in the furnace workings of Messrs. Curtin. The following is McCreath's analysis of a sample of 215 pieces dried at 212° F. He writes that the "sand" from this bank (which is seen lying around the engine-house and is not used in furnace) yields 34.80 per cent of iron:

Protoxide of iron, (FeO),	.289
Sesquioxide of iron,	75.301
Sesquioxide of manganese,	.278
Oxide of cobalt,	.060
Oxide of zinc,	.030
Alumina,	1.163
Lime,	1.600

Magnesia,	.401
Sulphuric acid,	.112
Phosphoric acid,	.293
Water,	11.322
Insoluble residue,	9.570
Total,	100.419
Metallic iron,	53.000
Metallic manganese,	.194
Sulphur,	.045
Phosphorous,	.128
Phos. in 100 parts iron,	.241

Plant. The plant here is well arranged. Consists of a single 28′ washer, capacity of 40 tons a day. The engine is the poorest feature, being very old and of only 35 h. p. to do hoisting, washing and pumping.

There are two wells 224′ deep, with standing column of 40′ of water. Two flue boilers 25′ long, with a large heating surface. The ore being very low in silica is quickly washed, and is hauled through the gap in Bald Eagle mountain 2½ miles to the Pleasant furnace at Curtin on B. E. V. R. R.

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4. *Hoy Bank.* This bank located about 100 yards N. W. of Red bank, and probably on the same range, was idle when visited, and greatly filled up with mud and water, concealing all appearance of ore.

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5. *Kaufman or Dysart Bank*, on east side of public road from Red bank was also abandoned, and nothing could be seen or learned about its ore prospects. It, however, serves to mark the eastern limit of this ore horizon as the Jacksonville valley ores, while apparently *geographically* coextensive with those already described, occur in rocks at a lower *geological* horizon, brought up by the rise of the Nittany valley axis in the Sand ridge "barrens."

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6. *Hamilton Bank.*—Passing to the south side of the limestone ridge the next mine in this Bellefonte group of ore banks is the *Hamilton bank*, located at the junction of the Fishing creek road and the road over the hill through Curtin's gap.

Between this bank and Curtin's line on the west the Messrs. Valentine have worked the same outcrop and deposit, and under the same name as the Curtin *Fishing Creek bank.* It shows on this property a shallow pit of pipe ore, cut off on the north by a limestone ridge, but occupying a considerable acreage along the low ground through which the road passes. The place was formerly worked for the old charcoal furnaces, and after being robbed of its lump surface ore, was abandoned, according to the then prevailing custom, for cheaper localities. The existence of ore here has been proved to a great depth, and much favorably located territory is now being used as a mud dam for the waste from the Gatesburg bank, higher up the cove.

Much of the ore occurring in the ravine to the N. W. was no doubt derived from here, from whence the ore outcrop extends almost uninterruptedly for a mile E. N. E. through the Hamilton, Gatesburg and Taylor banks, marking one of the most persistent horizons in this district.

These ores all occur in limestone, and are situated close to but on the *south* side of the anticlinal.

They are 2½ miles from the edge of the slate of III, along the base of Nittany mountain, and the intervening limestone rocks show dips of 15°–20°.

Allowing an averaging dip of 15° between them and the mountain, for 2½ miles we get a thickness of 3,200 feet of No. II here—or in other words the ores of this Hamilton–Galesburg–Taylor range are about 3,000′ below the top of II.

The mines already described are probably *near* or *in* the same horizon, occurring on the *north* side of the axis and with *apparently* less vertical distance from the slates on account of the steep and overturned dips of the limestone.

No work has been carried on at the Hamilton bank for years, though it is claimed that a shaft 175′ deep still showed a good quality of pipe ore when abandoned on account of water. The sides of the surface pits on each side of road show good ore indications.

7. *Gatesburg bank.*—This mine is located about 3 miles east of Bellefonte and 1050′ A. T., or at an elevation of about 300 feet above the town. It lies midway between the Hamilton and Taylor banks, of which it really forms an integral part.

This tract contains about 5 acres of land, and though the present bank has been worked for over 50 years, only about ½ an acre of ground seems to have been disturbed.

The excavation consists of a roughly oval pit 300 feet each way, averaging 30′ deep or say $100 \times 100 \times 10 = 100{,}000$ cubic yards of excavated material.

The washers show a general average of 1 : 5, which would give, after due allowances, 25,000 cubic yards of ore, or 50,000 tons, allowing two tons of ore to the cubic yard.

The surface crop is excellent, extending N. E. to the Taylor bank, from which it is separated by one 800-foot field in which the indications are very favorable.

Northward the ore extends to the crest of the limestone ridge, which probably marks the Nittany Valley axis, and which cuts off the best part of the ore.

Both here, however, and further west on Curtin's property, as already stated, the ridge has been successfully tested, though it everywhere shows more sand and flint covering than the hollows north and south of it.

The dip of the limestone on the crest is to the south-east.

South of the bank wash-ore shows well up on the hill on south side of road, 200 yards distant.

West the deposit joins the Hamilton bank.

I well know that it is a most hazardous undertaking to calculate the future output of a hematite bank, for the almost endless occurrence of clay banks, "horses" of rock, and mixed flint and sand render the result, to a great degree, problematical.

But, judging both from the average experience elsewhere, and from the appearance of this individual property, which has been worked in some portions to a depth of 50′–60′, and *tested* to a depth of 80′, in addition to the various trial shafts 10′–30′ deep, sunk outside the mine proper, I am led to the conclusion that a large quantity of ore is yet to be raised here.

The ore is taken out by an incline plane descending from the washer to the bottom of the bank.

Clay banks and broken ledges of limestone are to be seen in the faces, but are not a prominent feature.

A 20′ shaft in bottom of pit catches all the surface drainage, which is pumped to the surface by a small injector. The shaft is all in ore.

The best show when visited (July 16, 1883,) was in the north face, where ore washing fully 1 : 4 by test was exposed.

The east face shows some rotten limestone intercalated with an argillaceous slate, all of which readily decomposes to a soft clay in the pit, passes through the washer easily, and offers no obstruction to mining.

In the west face a drift has been driven 30′ into red clay holding good wash-ore, the idea being to extend the drift under the road to the Hamilton works.

The ore is a broken, fine-grained pipe, occasionally occurring in large lumps, but usually so far disintegrated as to look like so much fine red earth when freshly mined. The ore is mined for about 90 cents per ton, the property being held in fee simple by the Valentine estate. The Elmira Iron Company, of New York, are large consumers of this ore, sometimes taking from 1000 to 1500 tons per month over and above what is reserved by the Messrs. Valentine for their own furnace use.

Though I have seen still more flattering analyses of this ore by reputable chemists, I present, without comment, three analyses by McCreath, which sufficiently well show the excellent character of this ore:

No. 1, sample 223 pieces washed ore, Sept., 1881.
No. 2, sample of the "sand" or fine ore, Sept. 1881. Sampled by McCreath. Dried at 212° F.
No. 3, sample wash ore from furnace pile, Sept. 1883. Sampled by Messrs. Valentine.

	1.	2.	3.
Ferrous oxide, . . .	.160	.160	—
Ferric oxide, . .	71.485	63.321	71.540
Manganic oxide, . .	.143	.185	.133
Cobaltic oxide, . .	.170	.010	—

Alumina, ...	1.240	.829	.956
Lime, ...	1.340	.780	.340
Magnesia, ...	.464	.414	.421
Sulphuric acid, . .	.070	.135	.065
Phosphoric acid, . .	.320	.341	.329
Water, ...	11.314	10.512	10.903, combined. 3.511, hygroscopic.
Insoluble residue, .	13.670	23.000	11.772
Total, ...	100.441	99.622	99.970
Metalic iron, . . .	50.200	44.450	50.078
Metalic manganese,	.100	.129	.093
Sulphur, ...	.054	.028	.026
Phosphorous, . . .	.140	.149	.144
Phosphorous in 100 parts iron, . . .	.278	.335	.287

While the analyses prove this ore to be too "cold-short" for Bessemer iron, yet in charcoal cold-blast furnaces it makes a very superior neutral product.

A comparison of the two analyses, Nos. 1 and 3, speaks well for the persistent character of this ore, for the samples were taken two years apart, and both under similar circumstances. This ore can be placed in Bellefonte at $1 25 per ton.

Plant consists of a double washer. each shaft being 20′ long, thus giving 40′ of traveling surface.

The shafts are octagonal wooden beams, armed with iron teeth, and turn out an average of 35 to 40 tons of clean ore daily. Water for washing is obtained from two wells 235′ deep and 5′ apart, with a standing column of 38′. They have a regular capacity of about 2000 barrels daily. A 35 horse-power engine furnishes power for both washing and pump. No jig is used here.

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8. *The Taylor bank*, located N. E. of the Gatesburg, is a virtual continuation of that deposit, lying at the eastern end of the same cove.

The pit is opened about 300′ N. E. and S. W., 150′ N. W. and S. E. and to a depth of about 30′, or $100 \times 50 \times 100 =$ 50,000 cu. yds., or say 10,000 cubic yards or 20,000 tons of ore at a wash of 1 : 5.

The ore is hauled out of the cut by mules along a tramway around the hill to the washer, located there to secure

drainage down the cove to the north and thence by a stream towards Curtin gap, in Bald Eagle mountain. It is questionable whether the settling dam, located in a ravine between the limestone ridge and the mine, is not badly situated, as successful tests for ore have been made along both sides of cove. Indeed, the question of a proper site for mud dams in many parts of this ore belt is frequently the hardest one to decide—not where to locate for ore.

At this bank the ore practically begins at the surface, only a few inches of top soil overlying it. The ore is generally mixed with a dark red clay containing but little flint. The elevation by barometer is 10′ higher than Gatesburg.

The deposit is greatest N. E. and S. W. The cut showed some little clay in north face at time of examination and a "horse" of clay on east side which has been left untouched. Excavation east of this has developed first-class ore.

The main body of ore lies south of the cove. The north ridge is stony and probably cuts off the ore in that direction.

North of the washer 70 feet, No. II crops out, dipping S. E. 20°. It crops again in a small pit on the north side of small lane, dipping 22° S. E. This limestone, however, seems to be wedged in between ore, for the well at washer went down 120′ before striking rock in place. Shafting has been carried down 52′ from bottom of mine, all in good wash ore.

The tram road has a grade of 4 feet in 100 or just sufficient to be overcome by one mule with 4 cars.

The cove to the north slopes rapidly N. E. to the edge of the Sand ridge "barrens, in which lower measures are brought up just east of the public road.

The Taylor bank ore is all pipe, broken at the surface but found larger in the bottom, and is cheaply mined ($1.00 per ton). McCreath's analysis of 263 pieces this ore, dried at 212° F. and sampled in Sept., 1881, gives:

Sesquioxide of iron,	65.321
" " manganese,	.237
" " cobalt,	.070
Oxide of zinc,	.010
Alumina,	1.986
Lime,	1.090
Magnesia,	.367

Sulphuric acid,	.055
Phosphoric acid,	.423
Water,	12.194
Insoluble residue,	18.480
Total,	100.233
Metallic iron,	45.725
" manganese,	.165
Sulphur,	.022
Phosphorus,	.185
Phos. in 100 parts Fe,	.404

Another sample of this ore was taken at the same time and for the same purpose as the Gatesburg—Sept. 1883, and analysed by McCreath, with the following result:—

Sesquioxide of iron,	70.583
Sesquioxide of manganese,	.206
Alumina,	.905
Lime,	.330
Magnesia,	.367
Sulphuric acid,	.050
Phosphoric acid,	.318
Water—combined,	10.233
Water—hygroscopic,	2.643
Siliceous matter,	14.350
Total,	99.985
Iron,	49.408
Manganese,	.144
Sulphur,	.020
Phosphorus,	.139
Phos. in 100 parts Fe,	.281

While this analysis shows a marked increase of iron (nearly 4 per cent,) and a decrease of phosphorus, it establishes the general constancy of the character of these ores over considerable periods of mining.

This property has been likewise fully tested. It is continuous with the Gatesburg bank, to which it belongs geologically.

Plant here consists of a double 24′ washer, capacity 45 tons. Two wells 244′ and 251′ deep with a standing column of 75′ water. Both wells are 8′ shafts with 5′ working barrels. 40 h. p. engine runs pumps and washer.

South of this last range of ores ½ mile and *geologically* from 800–1000 feet high in the limestone series, there is another horizon of pipe ores, whose character is best seen in

9. *The Nigh Bank.* This tract, also owned by Messrs. Valentines & Co., contains about 31 acres, and is situated about 3 miles S. E. of Bellefonte in Spring township, like all those already mentioned.

Its elevation above tide is about that of the Gatesburg bank, or 1050′, the valley rising southwards as Nittany mountain is approached.

This tract was made historically famous as the scene of sinking the first artesian well in this county by Mr. Robt. Valentine, which important step led to a renewed life and vigor in mining throughout this whole district, so filled with sink-holes and destitute of water.

Before this time, all the ore mined in this county had to be transported to the banks of streams or carried unwashed to the furnace, or more often simply screened on large screening floors and the large lumps alone carried to the furnace and broken up there.

Many of these old screening floors still exist and the tailings accumulated there over considerable areas 5′–10′ thick are all capable of utilization *after* washing.

At that time the location of the Nigh bank was conspicuously inauspicious, and we can judge of the good quality of its ore from the fact of its having been worked so many years without any facilities for washing its product. Located on high ground midway between Logan's branch and Little Fishing creek, the ore would necessarily have to travel long distances to undergo the washing process.

The developed area (July 16, 1883,) extends N. E. from the township road at M. Love's house for about 300 yards, with a width (N. 50° W., and S. 50° E.,) of about 150 yards.

The outcrop is abundant for about 150 yards additional to the S. E. down into cove, and has been tested in many pits 10′–30′ deep.

North-east the ore "blossom" extends very distinctly for 200 yards across adjoining fields of Dr. Hale and J. Kaufman, in which Valentines & Co. control the ore rights.

To the north a low limestone ridge weakens the deposit, though a good surface show extends well up its crest.

From its position in a hollow, the bank is difficult to drain

without pumping, so that it has been worked N. E. from the public road at the washer, in a series of terraces, leaving pits as the work advances to catch the water.

Much valuable territory has thus been occupied which could soon be released by a proper system of drainage. At present all the ore mined is being carried out the cut with carts, which necessarily limits the production to a great extent.

In the bank the show is especially good to the N. E., where work is being carried on at present; but mainly because fresh exposures are made there which the surface wash covers in the lower parts of the mine.

There is a clean face of ore there (July 16, 1883,) but slightly mixed with clay 30′ high with most excellent material in the bottom.

On the north side the wash ore is very good, but the red clay with it is very tough and "balls" in the washer.

The show is good, however, from surface down to water at 22′.

Large bowlders of decomposed limestone can be seen in various parts of the opening, but they do not seem to displace the ore at all, and have been worked around similar to the Taylor and the Hecla bank near Hublersburg.

The old cuts along the north face are pretty well filled with water, but show good faces of ore north to Love's dwelling, which is probably located on a good body of ore.

The south face of the mine shows limestone bowlders also, and is covered with a thick surface of screenings from former operations.

Towards the south-east, in the next field, but still on the *north* side of the cove, a shaft has been put down 50′ in ore. The dirt pile from this hole shows excellent pipe ore very free from siliceous matter.

Numerous other holes from 20′–30′ deep have been put down on this tract with varying but encouraging results. Only about five acres of the tract seem to have been mined, and the results are about as follows:

Excavation 300×150×8=360,000 cubic yards material, much of which will wash 1 : 4. At an average of 1 : 5, this

gives 72,000 cubic yards. With due allowance for barren spots and clay banks, probably 125,000 tons of ore have been raised here. From surface outcrops and test pits this mine may be expected to turn out probably three times the above, as the surface deposit of wash ore extends over ground 700 yards long and averaging 250 yards wide.

These estimates, however, are based entirely on the supposition that future mining will develop as prolific ground as formerly, and are by no means decisive.

The following are McCreath's analyses of this ore, which is well adopted for boiler iron :

No. 1. 258 pieces from ore pile ; sampled by McCreath Sept., 1881 ; dried at No. 212° F.

No. 2. Sampled by Messrs Valentine from furnace pile Sept., 1883.

	(1)	(2)
Protoxide of iron,	.289	—
Sesquioxide,	72.285	72.500
" manganese,	.206	.103
" cobalt,	.110	—
Oxide of zinc,	.010	—
Alumina,	1.220	.723
Lime,	1.010	.310
Magnesia,	.540	.468
Sulphuric acid,	.070	.057
Phosphoric acid,	.252	.247
Water, Combined,	10.342	10.050
Water, Hygroscopic,		2,590
Siliceous matter,	13.570	12.770
Total,	99.904	99.818
Metallic iron,	50.285	50.750
Metallic maganese,	.144	.072
Sulphur,	.028	.023
Phosphorus,	.111	.108
Phosphorus in 100 parts iron,	.216	.213

These two analyses speak for themselves. This ore is used extensively by the Messrs. Valentine at their Bellefonte iron works, and the furnace record running on this ore solely shows a ton of pig metal repeatedly to have been made out of 2⅛ tons of ore.

Plant. There is one double 25′ washer here, giving 50′ of traveling surface, and cleaning 35 to 40 tons a day.

Two wells supply a constant amount of the purest water. One well is 180′ deep; the other 200′ deep.

Their record shows mixed ore and clay for 60′–70′, and then limestone. The washing apparatus is of the most simple construction, and seems entirely adequate to the work it is called upon to perform.

It and the wells are both run by a 50 h. p. engine, 16 inch cylinder, and 2 foot stroke. The wells are of the regular oil-well pattern, having walking-beam attachment, and pumping into a cistern 180 gallons per minute.

Steam is furnished by one pair 50 h. p. boilers, 16′ long, 4′ 2″ diameter, with thirty-six $3\frac{3}{4}$″ tubes.

There is ample room for enlargement of plant, as the demand for ore increases, and with the introduction of an inclined plane N. E. of the present plant, the production could be increased five-fold, besides being vastly more convenient.

Though mining is being actually carried on at but one place on this horizon the ore bed has an extensive and prolific outcrop westward for several miles.

Ann Patton Tract.

West of the public road passing the Nigh bank, on the Messrs. Valentine's *Ann Patton* tract of 400 acres, pipe ore exists over a considerable area.

This tract lies midway between the Nigh bank and the old Logan mines of the Messrs. Curtin, on Logan's branch, 2 miles south of Bellefonte.

The low country through which the Fishing creek road to Bellefonte passes shows a comparatively weak crop. But rising on the hill 400 yards S. 60° W. from Milliken's house excellent "blossom" of pipe ore, free from foreign matter, appears.

When visited, July 17, 1883, the fields had been recently in grass and grain, and in the absence of any open pits here, no very reliable estimates of the extent of this surface crop could be made. But it can be distinctly traced from the point first named for 300 yards S. W. to the divide leading down to the Lewistown pike.

The line of deepest and best deposit runs about 50′ south of Dr. Hale's house, marked on map.

Though a limestone ridge cuts off the ore to the south, the extent of this surface deposit can be put down at 300 yards N. E. and S. W. and 100 yards N. W. and S. E.

For three quarters of a mile west from this tract the land slopes into the valley of Logan's branch to Spring creek. The large surface crop here has yielded to the general denudation of this region, and has been swept northwards through the Bellefonte gap by the power of the eroding waters.

But the existence of the bed in place, which apparently furnishes the surface crop to the east, where it is still buried to a great extent, is evidenced in the magnificent pipes taken out of the old Logan mine.

All the ore in this low country has been found *in situ* between walls of south-east dipping limestone.

10. *Logan bank*, (*Curtin Bros.*) Though this bank has been long idle on account of the difficulty encountered in keeping the old workings clear of water, it has played an important part in the past and only awaits modern mining appliances and adequate pumping machinery to furnish a large amount of excellent ore to its owners.

Lying about 2 miles south of Bellefonte and chiefly opened on the east side of Logan branch, a bed of pipe ore from two to ten feet thick was explored here to a depth of 120 feet in numerous places.

The outcrop extends from the Valentine line on the east along public road, west down draft and across the J. Irvin property, to be again opened in the *Lindsay Coates* tract of Messrs. Valentine on west side of main stream.

The wash deposit extends over hill (east side of creek) for nearly 300 yds. N. and S. and has been grubbed for ore in a multitude of places from 6′ to 20′ deep until the hillside presents the appearance of an open graveyard.

A prominent limestone ridge cuts off the ore to the north, though *north* of it some successful pits have been sunk, probably on the *Gatesburg-Taylor horizon.*

Most of the ore in this property has been won by under-

ground workings, drifts having been run in N. E. 100 yds. from flat at forks of road.

North and south of this line a great deal of surface ore has been dug by contractors and sent to Curtin's furnace, though no work has been done here during the last five years.

A series of successful shafts likewise furnished a great deal of ore from the Irvin property on the west side of small road leading up draft from the pike.

Water has always been an obstacle here, and nothing but careful systematic mining will yield economical results.

Much of the surface shows a great deal of flint mixed with the ore, and any surface operations will require jigging. The ore from the *pipe bed*, however, is very clean, and gives excellent results in the furnace.

The land just referred to shows No. II sandy magnesian limestone dipping S. E. 25°.

The Bellefonte back road to the east shows outcrops of No. II near Miller and Humes' places dipping N. W. 40°, so that the Nittany anticlinal axis passes just north of the property, about a mile distant.

Lindsay Coates' tract, (Valentine & Co.)

11. Passing to west side of creek the ground rises abruptly to a height of 120 feet above level of Logan's branch.

The land here is only high comparatively, owing to the great erosion brought about by the rapid flow of Logan's branch. This elevated ground, from the creek west for over a mile includes the *Lindsay Coates tract*, which I regard as one of the best undeveloped pieces of territory in the county.

I do not hesitate in saying that it is one the best and most extensive *surface shows* I have seen in Nittany valley, whether for quantity of ore over a given area or for the purity of the deposit.

The existence of the bed in place has been extensively proved many years ago by a drift run into the hill S. W. from creek level. Ore from this drift was run out on small cars right to the mouth of the old Logan furnace, which stood until 1843 on Logan's branch, just at the base of this

hill and near the present site of Hick's Cement works. The Messrs. Valentine state that a bed of pipe ore was found between regularly S. E. dipping limestones (35°–40°). The bed was 6′ thick, often pinching, as is characteristic of these deposits, along the line of strike as well as dip.

Upon coming against a hard, flinty bed of limestone in the old drift, it was decided to do some stoping.

Stopes were accordingly carried up in places nearly to the surface.

Meanwhile a shaft had been sunk in the excellent surface deposit on the top of the hill for 100′±, coming on to the solid bed, which was followed by a winze from the bottom of the shaft to the old drift.

The *Lindsay Coates tract* contains 215 acres.

The topographical position of the ore body is well marked, and does not need a practiced eye to define.

This is a deeply-marked groove or furrow on top of the hill, bearing about N. 50° E. and S. 50° W., and rising and shoaling at the same time S. W., just beyond the line of the next adjoining *Uriah Woolman tract.*

Two gentle hills on either side of it—north and south—mark the position of outcropping limestone, which practically limits the extent of the surface deposit.

Throughout probably 60 acres of this tract a splendid crop may be found, literally a sheet of ore, 1500 yards long and 200 yards wide.

A shaft 30′ deep on north side of basin showed mixed ore and clay to the bottom, and many smaller trial pits 5 to 10 feet deep show excellent results.

The deposit is wider at Logan's branch than at the Woolman line, narrowing from 250 to 150 yards.

The small summit referred to above, marking the shoaling of the ore, by no means cuts it off entirely.

It is, however, weaker and more flinty there.

The summit is about 200′ (barometer) above Logan's branch.

The deposit can be traced west through the Woolman tract, with rich showing to the south of the school-house on the Boalsburg pike.

Some recent trial shafts sunk here by Mr. Abraham Valentine revealed even greater richness than the surface show indicated.

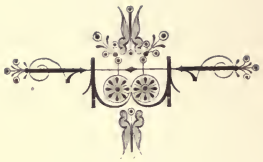
Crossing the pike at the red brick house of Mr. A. Schwartz the *surface* deposit is lost in the deep gully back of the school-house. But 100 yards west of the pike, in the bottom of the ravine, just north-east of Mr. Reynolds', some excellent pipe ore has been removed from the bed in place. A deep shaft was put down here some years ago, and pipes 4 to 5 feet long removed.

Water again drowned out operations here, but sufficient was done to prove the presence of the bed *in sitû*, and in a line with the other deposits.

The elevation of the surface at the shaft above tide (barometer) is 1024'; Bellefonte, 744'.

Some little surface ore shows on side hills here, but is generally mixed with two-thirds flint.

This will give the Woolman tract, however, east of pike, a deposit 500 yards long and 100–150 yards wide.



Chapter VII.

Brown hematite ores of No. II, continued.

B. Jacksonville Valley group.

The ore banks of this group are all confined to Marion township, and lie on the north side of the Sand ridge, though everywhere related to the sandy measures of this ridge or to limestones interbedded with them.

12. The *Zimmerman bank*, the first opening nearest the Spring township line, is located about 4½ miles E. N. E. from Bellefonte and about ½ mile south of the *north* road leading through the valley.

The bank was idle on July 18, 1883, and showed a roughly oval pit 150′ N. E. and S. W. and 100′ N. W. and S. E., and 20 feet deep. The elevation at mine is about 800′ A. T.

The sides were greatly washed and rather stony. The ore is apparently a finely divided pipe though occasionally showing compact masses.

A great deal of this harder variety however, is accompanied with a hard white crystalline substance, probably chalcedony, filling honeycomb cavities in the ore mass, and composed mostly of silica, with small quantities of lime and magnesia.

This is hurtful to the ore, making it hard to flux, and requiring careful selection of the ore for furnace use.

This ore has been used at Curtin's furnace and Milesburg iron works. There was about 50 tons on the dump July 18. All the ore was washed on the ground by water brought through pipes from a spring on the *north* side of the valley road ½ a mile away.

13. The *Darrah bank* (McCoy & Linn), is situated ½ mile east of Zimmerman's, and separated by the Lewis farms, through which the ore crop is continuous but narrow and weak. It is on the same range, however, and about an equal distance in from the road.

It lies along north flank of Sand ridge, but entirely in siliceous blue limestones, interbedded with more sandy measures and all dipping *S. E.* (overturned) into the hill at angles of 20°–25°.

The bank has been but slightly worked owing to the difficulty in getting water. A well was sunk 240′ deep in clay, passing through 10′ of ore at a depth of 100 feet, but owing to bad management of the drillers, constant break-downs led to its abandonment.

The elevation of the well mouth is by barometer 250′ above the level of the creek below in the valley, so that the well was probably abandoned a little too soon.

Though but little mining has been done, the ground has been considerably tested, so that the outcrop here may be identified with more or less omission west through the Lewis, Zimmerman, Harter, Tibbens and Brockerhoff farms to the nose of the hill, where some little opening has also been done.

A distinct cove runs up from the valley to the Darrah bank and it is in the continuation of this cove that developments have been made.

The lowest opening is a small pit 50′×25′×6′, from which some finely divided pipe ore was thrown out.

The second cut is 200 yards further S. W., right up against face of hill, and is a narrow trench 20′ deep following trend of rocks. These are dark blue flaggy limestones dipping 25° south-east into the hill.

The upper cut is 200′ long, 60′ wide and 20′ deep with the same general characteristics.

Innumerable pits surround these main openings, but the deposit is evidently a narrow one, with but little surface wash, and mainly confined to the rock, dipping with it into the hill.

The ore is accompanied with a fine, aluminous clay, a

decomposed product, probably, of an intercalated slate. Mr. McCoy speaks highly of the behavior of this ore in the furnace use.

The following analysis of McCreath's sample of 93 pieces taken Sept., 1881, and dried tat 212° F., will show the character of the ore:

Sesquioxide of iron,	71.142
" " manganese,	.568
Alumina,	1.124
Lime,	.400
Magnesia,	.392
Sulphuric acid,	.100
Phosphoric "	.423
Water,	11.102
Insoluble matter,	14.830
Total,	100.081
Metallic iron,	49.800
" manganese,	.396
Sulphur,	.040
Phosphorus,	.185
Phosphorus in 100 parts iron,	.371

(14.) *The McCalmont bank* is the next opening E. N. E. though fully 3 miles from the Darrah bank.

The intervening farms of S. Vanada, O. P. Orr and J. McCalmont all show some little ore, though largely mixed with sand and débris from the "barrens."

It is probable, however, that all these ores along the north flank of Sand ridge are referable to one horizon, and that low down in II, lower than the Gatesburg-Taylor ores.

This bank is located along the north flank of the ridge, and about 200 feet below its crest and about 850′ (barometer).

The bank has evidently been long abandoned. It shows a flat filled up and grass-grown pit, $100 \times 20 \times 3 = 6000$ cu. yds. of excavation. Its washed sides show considerable hard lump ore mixed with pipe, though the latter predominates. In 1838, when operated, this bank yielded 40 tons of pipe ore a day from a shaft 25 feet deep.

(15.) *The Butler bank* is one mile to the east and in sight of this mine, and 1 mile south of Jacksonville, on property of Judge Irwin. Like most of the mines in lower Nittany val-

ley, this bank was idle when examined, August 18, 1883, and much of the statistical information gathered was furnished by Messrs. McCoy and Divens, both of whom have been long identified with mining operations here.

The bank is about 100 yards east of the public road from Howard to Hublersburg, and is by barometer 380′ above Howard, or 1059′ A. T.

The hole is roughly oval, $50 \times 50 \times 15 = 37{,}500$ cu. yds.

A shaft was put down 90′ by Judge Divens, who first opened it, and reports the shipment of about 8000 tons to Ralston, above Williamsport.

Most of it was a liver colored, hard hematite peculiar to the sandy "barrens," which required but little cleaning.

After being screened of its dirt and fine ore, which still remain as a huge pile at the mine, the lump ore was shipped in boats to Lock Haven and thence by rail to Ralston.

The ore occurs in place here. The bed was drifted E. and W. from bottom of pit, and the bulk of the ore removed in that way. The surface deposit was 60 wide′, thinning in a wedge shape toward the hillside.

Limestone shows in both N. and S. faces of bank, dipping 50° S. E. The cut has not been worked for many years, and most of the cheap ore has been removed.

The sides are greatly washed, and though the mine is considerably north of the "ridge," the sand has been spread over the surface from 15 to 20 feet deep, effectually covering the crop.

The ore contains a considerable amount of sulphur, and would wash about 1: 6.

Some little exploration has been done on west side of road, Jos. Long's property, but the developments have been long since closed up. The Butler ore is claimed to run from 45–50 per cent. of iron.

Eastward these ores are becoming everywhere covered with more sand and clay, owing to the sinking of the Nittany valley axis and decrease in the dip of the rocks.

(16.) *The Hoy and Smith banks* are about 2 miles east

from the Butler bank. They are both abandoned, but are located on geologically colored county map.

The first is on property of Geo. S. Hoy on the north side of Sand ridge and about 400 yds. S. from the valley road.

Pipe ore of a very good quality was found here about four years ago. A drift was run south into the hill for about 30′ and 6′ deep, open at top, from which Judge Divens took out quite a number of tons. Most of this was sold to future operators of Jacksonville, who sank three shafts further south to strike bed.

One of these, a windlass shaft 30′ deep, went through 20′ of clay and sand and drove north from bottom of shaft until the bed was struck.

The rocks carrying the ore, however, are dipping steeply (50°) S. E., and the ore bed from 3′–8′ thick crops to the *north* of these shafts. Some of this ore was shipped to Milesburg, and the rest to the Mill Hall furnaces.

The *Smith bank*, still further east, is said to have shown up well, but little could be learned about it. It is on Joseph Long's property and is abandoned.

17. The *Beck bank* (property of Howard Furnace Co.) lies about 2 miles east of Jacksonville and is the next development in this range eastward.

Elevation by barometer 325′ above Bellefonte, or 1070′.

It was idle when visited, Aug. 6, work having ceased about the middle of July.

Excavation shows 300′ N. E. and S. W., 100′ N. and S., and from 10′–40′ deep. This will give $100 \times 30 \times 10 = 30{,}000$ cu. yds.

The bank lies on a flat with a slight cove to the south of it and between it and Sand ridge. Its rocks are all overturned, dipping steeply S. E., and are not far from the overturned arch of the anticlinal axis.

A shaft close to the east end of the bank went through 35′ of excellent pipe ore wash. Water is scarce. One well 200′ north of present well was carried down 600′± through limestone without finding water, entailing great expense.

The present well was sunk 150′ through sandy measures and 82′ through limestone before getting water.

The bank is worked by an incline plane, but the tracks in bottom were all covered with water, concealing the surface.

The engine-house is awkwardly located, the track having to take a sharp bend to work the present west face.

It was no doubt intended to work the territory directly north of it, which has been temporarily abandoned for richer ground.

The most recent work was apparently done in the west face, where some hard liver-colored hematite has been found, occurring under a thick covering of sand and gravel detritus.

The south and east faces are sandy, showing also bunches of white clay. The north face exhibits most ore.

The engine-house was closed. There is a single 24′ washer here, raised 6 inches at the delivery end.

Mr. McCreath sampled this mine in the fall of 1881.

The following is his analysis of 153 pieces dried at 212° F.:

Sesquioxide of iron,	58.000
" " manganese,	1.624
Alumina,	2.340
Lime,	.370
Magnesia,	.306
Sulphuric acid,	.075
Phosphoric acid,	.373
Water,	10.950
Insoluble matter,	25.920
Total,	99.958

Metallic iron,	40.600
" manganese,	1.131
Sulphur,	.030
Phosphorus,	.163
Phos. in 100 parts iron,	.401

The analysis is not very flattering, due more I think to bad washing than to any inherent deficiency in the ore. A percentage of 25.920 of "insoluble residue" is not common to well-prepared ores in this county.

18. *The Washington Furnace bank.* Some of the best ore in the valley is found ½ mile further east at the *Wash-*

ington Furnace bank, opened on both sides of the road leading over Sand ridge to Nittany Hall.

It is one of the oldest banks in Nittany valley and has yielded some of the best ore. It was idle when visited Aug. 6, 1883.

Various openings extend for nearly a mile along the north flank of Sand ridge, the first one on the west being about ½ mile east of Beck's bank.

The main work seems to have been done close to the road on the *west* side where a deep open cut shows probably 600′ N. E. and S. W., 200′ N. W. and S. E. and 50′ deep, or an excavation of about 220,000 cubic yards.

Several masses of sandy gray limestone, non-ferriferous, occur in the south face dipping about S. 40° E. 45° towards hill.

The faces are all washed down and expose little or no ore. At all events, but little cheap ore can be taken from this bank.

From here N. E. along this belt, there are numerous openings, almost continuous for 1500 yards.

Indeed, the outcrop may be followed to the Clinton county line where ore was mined to some extent on P. McDowell's farm. The ore is everywhere an excellent pipe.

About 50 yards N. E. from the road an old engine-house and washer formerly stood, just east of the shanty occupied by Mr. Doolen.

The elevation here (barometric) was about 1000 A. T. East from here there is a small pit which yielded about 200 tons, now pretty well filled with water.

This is on property of Delaney heirs, a strip of 14 acres lying between the two Washington furnace properties and on which there is still claimed to exist a considerable amount of ore.

From a pile of 25 or 30 tons lying around bank, I judge the ore of this pit to have been a lump hematite, unlike the pipe ore, but equally as good.

There is a well here 165 feet deep in limestone.

In the hollow and flat north of Delaney's house the ore

has again been extensively worked over the surface but to no great depth.

There are two long trenches here pointing and narrowing N. E. and S. W., but not directly joined.

The ore is pipe and occurs mixed with broken limestone and flint. The product of these pits was washed in the hollow towards Clinton county.

A fair show of ore is seen in the west end of the eastern pit, but the sides generally are much washed and obscured. In some places a depth of 20 feet has been reached, but frequently the original surface is still left intact in profitless knobs in the banks.

Very little massive pipe ore is to be seen. No work has been carried on here for 8 or 9 years.

A sample of 106 pieces from deep cut west of public road gave the following results on analysis by A. S. McCreath :

Sesquioxide of iron,	75.071
" " manganese,	.268
Alumina,	.642
Lime,	.670
Magnesia,	.648
Sulphuric acid,	.060
Phosphoric acid,	.231
Water,	11.030
Insoluble matter,	11.760
Total,	100.380
Metallic iron,	52.550
" manganese,	.187
Sulphur,	.024
Phosphorus,	.101
Phosphorus in 100 parts of iron,	.191

Chapter VIII.

Brown Hematite Ores of No. II continued.

C. Hublersburg Valley Group.

Passing now to the south side of the Sand ridge barrens, we meet with a persistent range of practically similar ores extending from the country north of Zion to the Clinton county line.

They occupy a similar *geological* horizon to those occurring along the north flank of the ridge, being accompanied by similar rocks in the *south* limb of the anticlinal. To take them up in the line of their development from west to east we have first

19. The *Field bank* of McCoy & Linn, situated about 2 miles N. E. of Zion and about the same distance east of the end of the Sand ridge.

Between this bank and the Spring township line, several attempts have been made to find ore in paying quantities, but without any marked success.

Favorable surface indications exist on the George Fry tract of the Messrs. Valentine and in some old ore pits on A. T. Zimmerman's farm. But the surface is generally very stony and barren and the ores are probably covered with a considerable amount of sand and wash material.

At Zimmerman's, cherty limestone dips S. E. 40°.

The Field bank is on property of Ambrose McMullen, but the ore rights are owned by Milesburg Iron Works. It lies about 250 yards south of the Sand ridge crest and 850′ A. T.

It shows a roughly oval bank 100′ N. E. and S. W., 75′ N. W. and S. E. and 20′ deep. The bottom is now filled with water, and though long idleness has allowed the sides

to become very much covered with flint and clay, some very good hematite ore is still exposed in the east face.

No pipe ore was seen, but a heavy liver-colored hematite like that occuring in the western end of the county characterizes the mine product; showing under a cover of about 18 inches of sandy soil *talus* from the "ridge" to the north.

The surface deposit is about 75 yards wide, cut off south by a limestone ridge, and extending east 300 yards to the McKinney bank.

It has been proved on the Dunkle farm also.

This mine was first opened about 1860, and was actively worked for ten years, during which time much of the large lump ore was hauled to the old Hecla furnace at the base of Nittany mountain.

The abandonment of this furnace led to a cessation of mining here and elsewhere through the region, while a similar action on the part of the managers of Washington furnace completely demoralized the industry of this valley, until during 1883 only the Hecla bank was being worked.

Mr. Frank McCoy speaks highly of the character of this ore when used at Hecla, where all the washing was done.

The want of railroad communication is seriously felt through this region, but outside the securing of a charter for the Bellefonte and Nittany Valley R. R. from Bellefonte to Mill Hall but little seems to have been done to open up this very desirable ore field.

(20.) *The McKinney bank* is the next opening, east 300 yards, on land of Lindsay Mehaffey and Mrs. Bush.

Sand ridge, which hitherto has maintained a straight and nearly unbroken crest line, becomes greatly furrowed here and its crest quite knobby.

The ore bank must lie about ½ mile south from its summit, and reposes between two of these furrows formed by hard limestone ribs which have resisted erosion.

Of this very old bank Prof. Rogers says, in Vol. I, page 500: "McKinney bank, opposite Mount Hecla furnace, * * * yields over a space of two acres small masses of ore in clay and within less than 2′ of the surface. One shaft was sunk through clay 3′, ore 22′, and white clay and sand 20′.

"One variety of ore was a dull, brown oxide, not in the pipe form; the other existed in oblong round balls, containing frequently pure alumina, and sometimes water, and lined within with scales of black hematite. The latter variety was estimated to be 4′ thick, and made excellent iron." * * *

Very little in addition to the above can be said, as no regular mining has been conducted here since 1870.

At present (July 18, 1883) the developments consist of a rather circular hole 100 yards N. and S. and 125 yards E. and W. and about 35′ deep.

The middle of the pit is filled with water, mostly surface drainage, which circumstance had been recently utilized by an Irishman named Dolan, who contracted for his ore and rigged up a windlass washer at the bottom of the pit, hauling only his cleaned ore out of the bank.

The surface south-east of the bank is very flat, an immense screening floor having formerly existed there, upon which much good wash ore still remains.

A clay cone shows near the south entrance 30′ high, partially mixed with lump ore.

In the cut the ore shows from the bottom to within two feet of the surface.

Much of the large lump, screened on the surface, was taken to Hecla furnace until its abandonment in 1866.

The property is evidently capable of much development with proper hoisting machinery and suitable washing wells. As it stands there is little opportunity for cheap mining.

In drifting formerly from the south side of the hill towards the cut, a band of hard black ore was met with, locally called "black band." This may be Prof. Rogers' "second variety"; but the drift has long since fallen in, so that no verification of this statement could be made.

I should judge from the excavation that there has been at least 40,000 tons of ore removed from here, and yet the property seems an excellent one for a large operation still.

(21.) *The Quinn bank*, located on Andrew Quinn's land, is but a short distance east of the McKinney opening.

The ore rights here are owned by the Milesburg Iron Works.

It is a shallow pit, 15′ deep, in same ore as the McKinney, and about 250 yards to the N. E. of it.

The ore seems rather leaner and more flinty than the larger bank, but the Quinn bank has only been worked slightly, and not at all since Hecla furnace went out of blast, at which time the prospects are said to have been very good.

Without railroad communication it is too expensive to work and haul the ore to Milesburg, though the bank is favorably situated for cheap mining.

The cleaned ore shows from 45–48 per cent. iron in furnace working. Excellent natural facilities for a mud dam exist here, though formerly the ore was all taken to Hecla before washing.

The hill is grooved here by a trench running up between the mine and Kreps' house.

(22.) *Red bank.* A small pit on the same ore has been opened further east on the property of Dr. Rotherick.

The bank is small and has not been worked for years. The excavation has been about 675 cubic yards. No name is known for this bank, but years ago when mined for Hecla it was known as the *Red bank*, on account of the color of its ore and the soil arising from its decomposition.

The pit, though small, has excellent indications of a large body of ore. A clean face of compact hematite shows on the east side 10′ thick without any cover at all. This bank is worthy of development. It is about 150 yards north of the

(23.) *Hecla Bank* (Milesburg Iron Works), situated about 1¾ miles west from Hublersburg. This is an old opening and in the time of the first survey, it received the following description. See Vol. I, p, 499.

"Mt. Hecla bank, 2 miles N. E. of Hecla furnace, has in 1838, supplied two furnaces for 12 years and was when seen 200 feet long and 40 feet deep. Drifts had been run on pipe ore veins 2′ to 5′ thick. The mass of ore consists

of detached lumps and pebbles of black oxide of iron, imbedded in ferruginous loam. Small beds of red oxide of iron occurred and also an argillaceous oxide, brown and yellow, in alternate layers, like some varieties of stalagmite. Masses of black clay colored with vegetable matter were to be seen with the white clay."

Much of what Prof. Rogers says of the ores and clay in the above paragraph can still be verified, and the bank as a whole is one of the best places in the county to study the varying character of these valley hematites.

The bank is the property of McCoy and Linn, who purchased it with the Hecla furnace property. The developments now extend over about 3 acres of ground, parts of which are worked to considerable depths.

The original workings are hidden by the present mud dam. A shaft had formerly been put down there for 120 feet from which drifts were run east and west to mine the ore. It was the caving in of the workings around this shaft, burying three men, that led to the abandonment of underground mining, and the utilization of the large cavity made there for the present settling dam. It is nevertheless unfortunately located and must cover up a valuable body of ore.

The excavation now being worked, is an irregular area $300 \times 300 \times 10 = 900{,}000$ cu. yds., though many parts of the pit are worked to fully 50 feet.

But even at the above estimate, with the washers showing a record of 1 : 3 or 1 : 4 the past production of this one part of the mine must have been considerable. And yet the mine shows equally well for future development. All the rocks exposed in the mine dip S. E. at angles of 30°–40°, and the usual arrangement of non-ferriferous limestone layers enclosing decomposed argillaceous ferruginous deposits of of pipe and shelly ore are repeatedly exhibited in the bank.

The north side seems pretty well exhausted of cheap ore. No other system of mining has been pursued within recent years than to follow the streaks and seams of pipe ore without removing the lean clays and decomposed limestone rocks, though it is highly probable that a mining and wash-

ing of the whole material would show profitable results and secure, with good machinery, a large output of ore.

The more recent developments lie to the west and southwest of the washer, consisting of a narrow cut 60×90 feet on top and 50′ deep.

An incline plane was put down here, and the ore raised by horse windlass. But the plane is entirely on ore, and much valuable territory is again temporarily untouched.

Excellent pipe ore was being raised from here on July 18, 1883, occurring underneath and behind the rotten limestones that put out from the south face of the hole. Mining is carried on between the limestone beds, sometimes enclosing ore material just thick enough to allow of the passage of a man's body, and again thickening to 5 and 6 feet, but always confined to these walls of rotten limestone, and co-extensive with them, at least, as far as the depth of the mine will permit one to judge.

Further west on the same line, but divided from the east cut by a few yards of territory, there is a 40′ pit of a similar character. It shows a cover of about 10′ of ferruginous clay, under which 30′ of broken pipe ore is exposed down to the bottom.

Some little work had recently been done in the old or north side of the workings, where in a cut $150 \times 50 \times 10$ about 55,000 cubic yards of ore material had been excavated. The ore from this part of the mine was similar to the brown, liver colored hematite of the Sand ridge. The dividing line of the two varieties is at about 200 feet north of the works.

From this place a drift was run north toward Sand ridge with good results.

Each side of this large bank has its distinctive features.

The pipe ores on the south are allied to limestone and accompanied by a ferruginous yellow clay; the harder hematites on the north are associated with more sandy layers and their clay is white and usually barren.

Over the pipe ores there often occurs a shelly ore, showing thin plates in seams of limestone, rich in iron, but diffi-

cult to wash owing to its tendency to float off with the mud and water.

The outcrop of this bank can be traced west through several fields, good in bulk, though slightly more flinty on the surface than in the open bank.

The bank has been worked continuously for 50 or 60 years, and even since *Hecla furnace* was dismantled Messrs. McCoy & Linn have found it profitable to haul this ore from 8 to 10 miles to Milesburg, where in their cold blast charcoal furnace it seems excellently adapted for neutral boiler plate iron.

The washers seem to show less flint to be separated from this ore than any other of McCoy's operations in the valley, so that the large percentage of insoluble matter, 18.620 per cent, noted in Mr. McCreath's analysis, is hard to account for.

The sample was taken by Mr. McCreath in September, 1881, and dried at 212° F.

Sesquioxide of iron,	66.071
Sesquioxide of manganese,	.962
Alumina,	1.054
Lime,	.550
Magnesia,	.648
Sulphuric acid,	.100
Phosphoric acid,	.284
Water,	11.804
Insoluble matter,	18.620
Total,	100 093
Iron,	46.250
Manganese,	.670
Sulphur,	.040
Phosphorous,	.124
Phosphorous in 100 parts iron,	.268

Plant. There is one well on the property 186′ deep, 50′ column of water. The boring passed through 31 feet before striking rock; then limestone 60′ and ore 30′, and finally limestone to bottom. The well gives 70 gallons per minute. One forty horse-power engine is used for pumping and washing. Cylinder 12″ diameter, 2′ stroke. One double shaft washer 22′ long, with the delivery shaft raised six inches. The washer cleans about twenty tons a day.

One 18′ tubular boiler supplies steam.

24. *Howard bank* (Howard Furnace Company) lies about ⅝ mile N. E. of Hecla, and on slightly higher ground. It belongs to the same horizon, however. It is a very old opening, and though idle when visited (July 18, 1883,) its record has been a rather active one.

It shows a deep oval pit, about 1800′ in circumference and 600′ in diameter, the greatest depth being about 100′. There has probably been 600,000 to 800,000 cubic yards of material removed from this deep pit. No work having been done since the spring of 1833, the bank did not look very well, being washed considerably.

The south side showed most rock and clay and the east most ore, a good 30′ face of pipe ore being uncovered there. No. II shows in south face dipping S. E. 32°.

The ore was brought up by an incline plane to a washer, turning out 25 to 40 tons a day. The pit water was pumped by a ⅝-inch iron pipe.

There is a drift in the N. E. face at bottom of pit, which runs a considerable distance N. E., and extends thence by cross gangways east and west. Mule cars were run into these drifts. A fine deposit of pipe ore was said to exist there when mining was stopped.

Some drifting was also done through the clay and rock on south side, for what purpose I cannot say, as the indications are anything but favorable in that direction. A sample of 20 pounds of this ore was analyzed by Mr. McCreath with the following results:

Sesquioxide of iron,	75.821
Sesquioxide of manganese,	.258
Alumina,	.850
Lime,	.500
Magnesia,	.724
Sulphuric acid,	.077
Phosphoric acid,	.329
Water,	12.340
Insoluble matter,	9.330
Total,	100.229

Metallic iron,	53.075
Metallic manganese,	.180
Sulphur,	.031
Phosphorous,	.144
Phosphorous in 100 parts iron,	.271

This shows an excellent quality of ore, which is likewise highly spoken of by the proprietors of the Howard furnace, who have taken most of the product of this bank.

No evidence of the existence of the hard hematites of Sandy ridge, spoken of in connection with mines further west, could be detected here, and they have probably disappeared by reason of the subsidence eastward of the axis which elevated them to daylight as far east as the Hecla bank.

East from that point to the Clinton county line there seems to be but one persistent range of ores—all of them pipe ores of good quality—and all apparently referable to the Nigh bank horizon, about 2500′ below the slates of III. No ore has been found higher in No. II at this end of the valley as a glance at the map will indicate.

25. *Voneda Bank.* For a little over a mile east from the Howard bank no developments have been made, until just N. of Hublersburg the *Voneda bank* on D. Voneda's farm merits attention.

It was idle when visited Aug. 2, 1883, no work having been done since the last lessees, Curtin Bros., abandoned the mine about two years ago.

The ore lies in a shallow ravine south of the Sand ridge and north of a low limestone hill.

There are two openings in the same draft, the smaller one being 200′ N. W. of the main one.

The excavation of the small pit has been about $15 \times 15 \times 3 = 675$ cubic yards.

The first work done here was by the owner, Voneda, who put down a shaft 80′ deep, passing through outcropping pipe ore 10′ thick *in situ*. The dip was very slight, and the same bed is worked in the south cut lower down.

Curtin Bros. commenced working here about eight years ago, leasing at 80 cents per ton for the first 2000 tons.

They washed the ore in a single-shaft horse washer with water brought from a Sand ridge stream.

The surface looks lean and sandy, though some good ore evidently remains beneath.

No. 2 opening to the south is very irregular in shape and depth and has been robbed of most of its cheap ore. The excavation shows about 2000 cubic yards.

There is a great deal of surface wash here, especially along the north face, which shows fully 12 feet of stony and sandy top soil. In places this grades downwards into larger bodies of clay extending to the bottom of the bank.

The quality of the washed ore is excellent, but the washing must have been very expensive.

The best show is in the N. E. corner of the *south* pit though still better prospects exist along cove N. W. on to the adjoining farm.

On the next farm east, (Miller's), though apparently a little further to the south of this horizon, some 400 tons of crop wash of excellent lump pipe ore were removed to Washington furnace by two men working only thirteen days.

The Voneda farm ore, analyzed by Mr. McCreath, is as follows: Sample 20 lbs. wash ore from pile at washer. Dried at 212° F.

Sesquioxide of iron,	75.214
Sesquioxide of manganese,	.308
Alumina,	.989
Lime,	.290
Magnesia,	.655
Sulphuric acid,	.087
Phosphoric acid,	.339
Water,	11.844
Insoluble residue,	10.330
Total,	100.056
Iron,	52.650
Manganese,	.215
Sulphur,	.035
Phosphorus,	.148
Phosphorus in 100 parts iron,	.281

26. *Schwartz bank.* In a direct continuation eastward of the Voneda–Miller deposit of pipe ore, some work was done on the two farms of *J. and L. Schwartz*, no tests having been made on the intervening Bartholomew estate.

The outcrop shows on both sides of Schwartz's lane, 100 yards north of the valley road and about 1 mile east of Hublersburg.

Both holes are covered up now. The surface soil is sandy and covers the real limestone floor to a depth of 8–10 feet. The ore was followed for 40′ on a south-east slope of 36°. The crop was only 8 inches thick, widening to 2½ feet when work stopped on account of water.

The ore is of excellent quality and was readily mined, occurring in well-preserved pipes.

27. *Candy farm.* East from Schwartz's, the Candy farm was slightly prospected by the Gordon's of Bellefonte, but nothing much developed.

28. *H. Beck farm.* Further east near Snydertown the *Henry Beck* farm shows several old pits.

Work was done here 60 years ago. The surface ore was first found in a draft about 200 yards north of road and afterwards a slope was put down 60′ on a 4′ bed of pipe ore dipping S. E. about 35°.

Water was struck at that point, and having no means then of eliminating it, the slope was abandoned.

Some ore was also raised from a shaft put down a little south of the crop, evidently obtained from the same bed.

All this early ore was taken to Hecla. The last mining here was carried on in the interest of Wharton Morris of Mill Hall.

29. *Huston bank No. 1*, on the same range and about 1 mile east of Beck's, is the next opening along the south base of the flattening Sand ridge.

It is on the property of the Huston heirs and was first opened by Judge Divens in 1863 for Hecla furnace and afterwards carried on for Milesburg Iron Works. It is 1 mile east of Snydertown.

A shaft was put down about about 60′ south of the open cut at crop, through which both ore and water were raised. The bed frequently reached 15′ in thickness as reported by Mr. Divens, and dipped 30° S. E.

Limestone crops on private land leading into the bank with the same dip.

The ore was followed for 120′–150′ on this slope, and about 2,000 tons were raised here before operations were stopped by water. The last mining was done here about 6 years ago, when the crop was cleaned out in the open pit 20×20×4, or 1600 cubic yards, washing 1 : 3 and giving about 1000 tons of clean ore. The contour of the country is very flat, rising slowly towards Sand ridge ½ mile north.

East from this bank some shafting was done on Rodgers farm and some little ore taken out—insignificant in amount, but important as proving the continuation of the deposit eastward.

30. *The Snavely bank*, on property of Henry Snavely, is about 500 yards north from valley road and ¾ miles north of Nittany P. O.

This mine was first worked 50–60 years ago for Washington furnace. The last prospecting was done ten years ago by Scranton parties, who reported the bed worked out to a depth of 60′ on a 30° S. E. slope, and a thickness of 7′ to the bed in water at that point. The ore was raised by horsepower, winding the rope around a large drum.

The appearance of some ore on the dump was excellent and it is claimed to show 50 per cent of iron in furnace working. However that may be, the slope is well timbered and in good condition yet; advantages in the way of a good settling dam exist naturally, so that it would seem a very desirable locality for mining in this section of the county, with railroad facilities secured. A small 15 or 20 horsepower engine would suffice to keep the mine dry, and as the mouth of the slope is only about 50 feet above Fishing creek, there could be a constant supply of wash water pumped up to washer.

31. *Barlow and Day's Mine* is situated in the next adjoining field east and only about 500′ from the Snavely slope. It was originally opened by Henderson & Co., of Baltimore, and from the appearance of things work has been abandoned for some time.

It was also worked for Washington furnace.

The property is only about 500′ wide E. and W., and seems to have been entirely robbed of its surface crop.

The dip is very slight here, averaging only 20° S. E.

There are three separate pits on the property divided from each other by bunches of non-ferruginous S. E. dipping limestone, which also shows in the pits.

Two of the pits show about $35 \times 25 \times 7 = 6000$ cubic yards of excavation. The other is small $10 \times 6 \times 3 = 180$ cubic yards.

There is an old engine-house on property from which inclines extend N. N. W. into the two large pits. A single 28′ washer is also in the plant,

The engine-house is about 40′ south of the pit and just south of it a well was sunk by John Fallon, of Phila. (who had leased the property from its New York owners). The well was carried down 50′–60′, but the pump was not powerful enough to keep the well dry.

Some 8,000 to 10,000 tons of ore were mined here by various parties, an analysis of which will be found below. Future ore is to be sought for south of the pit.

The barometric elevation of the bank is 322′ above Howard or 1000′ A. T., and 72′ above Little Fishing creek, which runs along the base of the limestone ridge holding these ores.

Sample, 110 pieces of ore lying around bank, analysed by Mr. McCreath. Dried at 212° F.

Sesquioxide of iron,	78.071
Sesquioxide of manganese,	.423
Alumina,	.538
Lime,	.660
Magnesia,	.635
Sulphuric acid,	.080
Phosphoric acid,	.222
Water,	12.206
Insoluble matter,	7.520
Total,	100.355

Iron,	54.650
Manganese,	.295
Sulphur,	.032
Phosphorus,	.097
Phos. in 100 parts iron,	.177

32. *Huston bank, No. 2*, is the last and most eastern opening on this range, and is situated close to the Clinton county line.

It is on land of Thomas Huston heirs, and adjoins the Barlow and Day property on the east.

The crop has been removed for a length of 300′ E. and W.; 30′ wide N. and S., and 12′ deep, or $100 \times 10 \times 4 = 4000$ cu. yds.

The mine has been idle for some time. Judge Divens sank a shaft 30 years ago 90′ deep to a bed of pipe ore 8′ thick and about 60′ south of the open cut.

The ore was washed in Fishing creek, being hauled down a draft east of the mine, which cuts down the hills 50′. By barometer the mine is about 987′ A. T.

The description of this mine concludes the line of ore deposits south of "Sand ridge" to the Clinton county line; and while it has not been possible to give much detailed information of the various openings, owing to the general stagnation of mining during the season of 1883 and the deep covering of wash that overlies the deposit, still enough was seen to demonstrate the fact that the pipe ore deposits at least seem to occur in regularly interstratified beds between parallel walls of limestone. They vary in width both in the line of strike and dip, and frequently pinch out altogether; yet they are opened in a sufficient number of places to almost assert the continuity of the range from the Hecla bank to the Clinton county line.

Almost every farm in that distance shows more or less favorable indications of ore, which would, no doubt, be more noticeable if not covered up with an abundance of sand detritus from the ridge on the north. Erosion has removed much of the surface deposit, so that no extensive basin of wash ore characterizes this range along the Fishing creek valley as they do further west in Spring township.

But the existence of the bed *in sitû* has been proved in many places by slopes on the ore and the possibility of reaching it by shafts sunk through overlying non-ferriferous limestone layers has likewise been effected in several of the mines.

Unfortunately, cessation of mining prevented a single personal examination of the underground workings, but all the evidence obtained on the surface from the many who had worked in them was reliable, and leads to the conviction that the pipes, while confined to a regular bed, do not conform to parallelism with the adjacent limestone walls, but stand rather at an angle to the roof and floor in stalactite and stalagmite form, or as thin shells or plates in decomposed clays.

No occurrence of undecomposed pipes of sulphuret of iron has been noticed in this part of the valley such as would give some weight to the theory of the formation of this ore; but further on in the description of the Sinking creek mine of the Penn's Valley Mining Company that fact can be positively asserted.

The presence or absence of the distinctively heavy hematite ores of the "Barrens," which are so largely mined in the western part of the county, can not be asserted now for want of sufficient testing; but it is a matter of doubt whether the vertical elevation of the anticlinal axis has been sufficiently great here to elevate the horizon of these ores to daylight east of Hecla; for from that point into Clinton county the anticlinal is certainly dying rapidly and gradually covering its crest with higher layers of limestone. In any event it is problematical whether the *lowest* western ores—those of Scotia and Juniata—are brought to the surface at all. The character of the hematites found in the Field, Quinn, and McKinney banks, etc., allies them closely in appearance to the Pond, Lambourn, and Desert banks in the western part of the county.

Little Fishing creek offers a natural outlet to Clinton county, and a railroad located along its valley would be within easy reach of this range of 50 per cent. ores.

Nittany valley, on the south side of Sand Ridge, from Hublersburg east, is very smooth, showing gradual slopes to the creek, and rising gently to the mountains on the south.

Chapter IX.

Brown hematite ores of No. II, continued.

D. Buffalo Run Group.

Buffalo run valley, for five miles west of Bellefonte, is practically devoid of ore developments.

The steep dips of its rocks have everywhere led to a rapid erosion of its surface, so that topographically it is a deeply-marked groove between the Bald Eagle mountain on the north and the high land of the Nittany valley axis on the south.

Between Bellefonte and Fillmore, on the Benner-Patton line, the axis is everywhere from $\frac{1}{2}$–$\frac{3}{4}$ miles south of the valley road, and whatever ore there is occurs between the axis and this road.

33. On the Lutz farm, two miles west of Bellefonte, some 20 or 30 tons of pipe ore were removed by a shaft.

34. The Brocrenhoff, Blair, and Wagner farms likewise show surface croppings, though flinty and not very abundant.

35. Fair surface wash ore was also ploughed through on the Alexander and Reynolds farms.

36. A trial shaft on Clark's farm developed 15 feet of wash ore, and a series of pits on the Farman farm showed from 10 to 20 feet of lump and wash ore.

But the developments on all these farms are meager, and, in general, the erosion through this part of the valley has been so great as to leave a very weak and flinty surface deposit.

So, in driving along the Buffalo run road, the gutters frequently show the presence of fine pipe wash. But it is all

apparently derived from the bed *in sitû* further south, which was first regularly located and tested in

37. *Hunter's mine*, on lands of B. Hunter, about 1 mile east of the little village of Fillmore. The bank is situated a short distance south of the Buffalo run road, in a ravine leading up to McKnight's farm.

On this land a splendid exposure of No. II blue limestone is seen well up the hillside on the east side of the ravine dipping N. 12° W. 22°.

The ravine leads back of the little knoll made by this limestone ledge and at its head the mine is located. It shows a rather shallow pit from which the surface ore was robbed, with the faces pretty well concealed with dirt and sand.

The ore occurs between limestone rocks and about 50 tons of good lump ore remained on the dump when visited on August 1st, 1883. This was taken from a new shaft sunk by Mr. Hunter in 1881 from the bottom of the open pit 40′± deep. The ore is very clean and occurs in large pipes and is readily removed.

Water was encountered at about 40′–50′ and stopped further mining. The completion of the B. & B. R. R. R. will no doubt lead to further developments here, and from the description I have received I have no doubt that the mine will prove of value to the owners and to the student wishing to study the nature of these deposits.

An analysis of a *single piece* sent to Mr. A. S. McCreath by Mr. Hunter yielded as follows :—

Sesquioxide of iron,	78.571
" " manganese,	.014
Alumina,	1.206
Lime,	.620
Magnesia,	.547
Sulphuric acid,	.070
Phosphoric acid,	.357
Water,	11.156
Insoluble matter,	7.650
Total,	100.191
Metallic iron,	55.000
" manganese,	.010
Sulphur,	.028
Phosphorus,	.156
Phos. in 100 parts iron,	.283

38. Pipe ore of this range is next seen in the Patton-Benner township line road, just south of the M. E. Church at Fillmore, where it has been uncovered in the road cut in limestone dipping N. W. 15°–20°.

In Patton township along Buffalo run road, about ¼ miles west of Fillmore, is a good exposure of thin bedded limestone at J. Tressler's house, dipping N. 35° W. 20°–22°.

Blue crystalline limestone is again twice exposed in railroad cuts in the valley north, dipping N. 28° W. 25°, in a low hill which marks the position of an encouraging wash deposit of heavy hematite through the farms of Kephart, Brockerhoff, Sellers, Green, Hale, Gray, and Waddle, to the railroad cut on Jacob Behrer's farm where an extensive deposit of lump ore in a ferruginous white clay is exposed.

39. *Crust bank*, on the Musser farm of McCoy and Linn, is a pipe ore deposit on same range as the Hunter bank. It is about ¼ miles S. W. of Fillmore, and on north side of main Nittany axis, which is well exposed on the ridge south of the bank, throwing off gentle 6° dips N. W. and S. E., and rising thence westward to bring up the sand measures in Chestnut or Buck ridge.

Some of the oldest work in the county was done here, though all the deep shafts have long since been filled up.

There is an open pit here bearing trees in the bottom of 20 years' growth. The cut is about 150′ long, E. and W., 50′ wide, and at present (July 27, 1883) 20′ deep, and has furnished about 5000 cubic yards of material.

Limestone shows in the north face dipping about 10° N. W., and considerable underground mining has apparently been done here.

40. On four farms here—Crust, Musser, Reaser, and Pennington—the ore rights of which belong to the Milesburg Iron Works, as far west as the Thompson property line, Mr. Frank McCoy states that fully 300 shafts have been put down from 3 to 26 feet deep, in all of which more or less ore was found. All these trial pits were in limestone.

The "Barrens" of Chestnut ridge, after flattening with the anticlinal 2 miles west, near the Pond bank, die into a

rolling county in the neighborhood of the Markle bank, an opening on the *south* side of the anticlinal a short distance west of the Crust bank.

The country here is considerably broken up into coves and small rolling hills.

The cove south of the Pond bank can be traced east through the four Thompson farms—Fair, Zones, Alto, and Crust—until, on reaching the Pennington farm, this main cove is sub-divided into a series of small ravines and hills.

The most marked of these ravines extends down a private lane to Gray's house on Buffalo run road, and holds a heavy hematite wash from the Markle bank.

The whole character of the ore changes in going west from here, just as it did in the eastern end of the county.

The straw-colored pipe ores of the Hunter, Crust, and Markle banks give place to the heavy liver-colored hematites of the "Barrens," and this change has been brought about similarly in both places, viz: By the rising of the anticlinal axis, lifting older and lower rocks to the surface with their characteristic ores, from off the surface of which the higher limestone rocks with their pipe ores have been eroded. Hence, though we find the pipe ores of the Hunter, Crust, and Markle banks in the same *geographical* range or line as the heavy hematites of the Pond, Lambourn, and Newall mines, the *geological* horizon of the latter is considerably *lower* than that of the former by reason of the rise of the axis in that direction. On no other structural ground can I account for the difference of these ores, separated by about two miles of territory.

The change, however, seems to be a gradual one, for as the sandy soil of the barrens becomes more and more calcareous, the ores become more shelly and open, until becoming true pipe ores in the limestone. Thus the north range of low hills on the four farms under discussion carries quite an extensive deposit of pipe ore, varying from 30′ of wash along the center of the basin, about midway between the public roads, to 3′ or 4′ on the north and south, where the limestone comes to the surface.

This deposit here seems to be remarkably free from foreign matter—flint, spar, etc.,—and would wash readily, yielding from 45–50 per cent. iron.

The line of the Bellefonte and Buffalo Run R. R. is not over ½ mile distant, which makes this field one of probable future importance.

On the adjoining property west, owned by Messrs. Thompson, some little prospecting has also been done.

The four farms included in it are all bounded south by the public road.

41. On the *Fair farm*, 200 yards north of road, two holes within 20 feet of each other have been put down respectively 25 and 50 feet.

Some excellent material has been thrown out here.

Test pits were sunk 50 yards to N. W., but the surface in all these farms was so thickly covered with clover at the time of inspection that it was impossible to tell much about the character of the deposit. A short distance north of these holes the ground seemed very flinty. Beyond this ore was claimed, but I saw no indications of it.

Mr. Thompson claims to have sunk 65 to 70 shafts through these farms, which developed from 6′ to 50′ of ore.

42. *Zones' farm* to the east has a shaft 30′ deep, duplicated with smaller ones, all in wash and lump hematite. Water was met with in all of them.

The contour of the country here is very uneven, indicating sink holes and underground water courses.

The ore show is slight, through about 200 yards N. and S.

43. The *Alto farm* has not been tested at all, but wherever the ground was superficially broken in ploughing, the presence of the same deposit, and of about equal extent, was claimed. The surface is flinty.

44. The *Crust farm* is next east, about 110 rods wide, and has been tested in 4 small pits besides the development at the Markle bank. These have been sunk across 400′ of territory with an excellent show of ore, a fine dark red and black hematite. Limestone was also struck in this field.

45. The *Markle bank*, on this farm, lies south 100′ from the farm house, and on the south side of the anticlinal.

It has been long abandoned, and was worked for the old Centre furnace from 1842–1858.

The open pit shows an excavation $25 \times 10 \times 7 = 1750$ cu. yds.

In 1882 pits were sunk, which are said to have proved the ore territory 600′ N. and S. and 250′ E. and W. and from 6′ to 40′ deep.

The ore is a fine grained hematite and apparently grading into pipe in the next farm east.

It is exceedingly free from impurity and flinty matter, having been carted to Centre furnace, 3 miles, as mined, requiring very little or no washing. Analyses of it by John Thompson, Esq., are reported as showing 50–55 per cent. iron.

Natural advantages for a mud dam exist here, but water is scarce and would have to be obtained by artesian wells.

46. The *Pond bank* is the first opening met going west and entering the sandy measures of the barrens. It is situated on the Pond or Gross farm of 211 acres, immediately adjoining the Fair farm on the west, and located right on the arch of the anticlinal, and about 1½ miles west of the Markle bank; at about 1230 A. T. by barometer.

West of it is the large Iron Ore tract of nearly 1000 acres, which divides it from the River Hill tract of 311 acres, upon which Messrs. Carnegie are carrying on their large operations at the Scotia mines.

The Pond bank is owned by the Milesburg Iron Works, and is distant about ¼ mile from the main line of the B. and B. R. R. R. at W. Reed's, and connected there by a branch line into the mines.

It has also another outlet by road to the railroad east of Waddle's, where all the ore hitherto mined at the bank has been washed in Buffalo run.

The excavations are quite extensive here as work has been carried on more or less constantly since the early part of the century when the ore was used by Gen. Huston at his old

Centre furnace, and almost continuously by the Milesburg Iron Works since the partition of the Centre and Hecla furnace properties.

Three large open pits have been worked to a depth of 50–60 feet, and in addition to these several smaller ones have been opened and the property tested for fully 500 yards each way.

Several inclines formerly existed here for raising the ore, and immense screening floors still cover very choice ground to a depth of 4 or 5 feet.

A characteristic feature of all the hematite banks of the "barrens" is well displayed in this bank, consisting of a band or dyke of white clay 40 feet wide, decomposed from a gray slaty limestone, running N. E. and S. W. through the bank and in which no ore can be found.

It marks the position of a former non-ferruginous argillaceous limestone layer, on top and beneath which the concentrated iron salts have deposited their iron.

In many other places in these immense holes, local clay banks and "horses" of partially decomposed sandy limestone rock come in for a time to cut off the ore; but elsewhere splendid faces of ore continuing from the surface down to the bottom can be seen.

When visited early in August, 1883, but little work had been done on account of harvest time.

The west pit was filled with water to within 20 feet of the surface. The north cut, 150 yards long, N. and S., was also idle and pretty well washed.

Much excellent lump ore, some of it bomb-shell hollow masses, not commonly seen through this valley, though so marked an occurrence through the Great Valley, could be seen in the bottom, though the true surface of the sides was pretty well covered with washed sand and clay. It is in this cut that the clay bank above referred to can be best seen, for it has been left almost untouched throughout the length of the opening.

All the work being done was carried on in the south pit, which had been worked in benches irregularly wherever the best and most available ore could be obtained.

Quite a pile—probably 200 tons—lay on the dump ready for shipment to Milesburg.

Much of the rejected lump ore on the waste dump showed a considerable percentage of feldspathic material, strongly resembling the chalcedonic quartz mentioned in the Darrah bank, though more opaque.

While this ore, so accompanied, is capable of being used in a good coke or anthracite furnace, it cannot be worked through a small cold-blast charcoal furnace, running mainly for *quality* rather than *quantity* of metal.

The general character of the ore is a small lump hematite resembling the Darrah and Zimmerman bank ores in the eastern end of the county, a middle grade as it were between the extremes of coarse lump ore at Scotia and Tow hill, and the fine pipe ores of the limestone rocks.

For mixture with these soft pipe ores, the Pond bank ore is admirably adapted, and such has been its special use at the Milesburg Iron Works.

Much of the cheap ore has been mined from these pits by present methods of horse and cart working; but there is ample untouched surface for a large output of ore with better machinery, and the bank will no doubt rank high as a producer after the completion of the railroad. The character of the deposit is irregular and it would seem advisable to proceed to a systematic development of the whole mass rather than the "hogging" hitherto pursued.

The following (No. 1) is McCreath's analysis of this ore. Sampled Sept. 1881. 20 lbs. of ore dried at 212° F

Sesquioxide of iron,	63.143
" " manganese,	.392
Alumina,	2.254
Lime,	.630
Magnesia,	.371
Sulphuric acid.	.057
Phosphoric acid,	.300
Water,	11.810
Insoluble matter,	20.980
Total,	99.937
Iron,	44.200
Manganese,	.273

Sulphur,	.023
Phosphorous,	.131
Phos. in 100 parts iron,	.296

Continuing west from Pond bank the B. & B. R. R. R., in crossing the summit, cuts through quite an extensive deposit of hematite ore and clay on the same farm.

The cut commences just south-east of W. Reed's house, shown on map, entering first on a bed of disintegrated white sand 8′ thick, and shortly afterwards passing through a splendid showing of surface ore for fully 500 feet.

The cut averages about 10′ deep, and, after cleaving some beautifully corrugated and twisted beds of black sand, clay, and ore, finally exposes a face of excellent wash hematite. This is on the same horizon as Pond bank, and should be an excellent place for digging cheap ore.

Much of the material from the cut has been used to make the fill north towards Reed's house, and the excavated material used in the railroad embankment shows much good lump ore.

South-east from here, along railroad, and towards the road leading into the Ackley bank, there is another cut on the *Gross farm* where the show is not so good. About the same character of surface is passed through, but the face shows mainly dark sand and clay, carrying ore streaks one foot thick with occasional pockets, all covered with a heavy wash of light sand. About ¼ mile west from railroad at Reed's house, and higher up on hill is the old

47. *Newell bank*, which is apparently on the same range *geologically* as the Pond, Tar Hollow, and Desert banks, whose ores it closely resembles.

The opening is on land of Captain Hunter. The ore rights here and on William Reed's farm to the east (which also shows excellent surface deposits) are reserved by McCoy & Linn of the Milesburg Iron Works.

The property is a most advantageously located one for mining and shipping ore.

The surface is thickly covered with wash ore, with little or no accompanying sandstone rock all through the Newell

property and also on to the Reed lands, though the latter is not so rich.

The width of this deposit as traced by outcrop N. and S., is about 200 yards, extending from the cove at Newell's house high up the south flank of the hill dividing this deposit from the Lambourn bank on Buffalo run road.

Ore was formerly mined here in considerable quantity for the Julian furnace in Bald Eagle valley, and a recent pit put down in the old floor turned out excellent material.

The bank is about 100′ above the railroad. By driving an open cut west from a point near the property line between Reed and Hunter, a 60′ face of ore could be worked at the bank, and ore taken out with sufficient grade to dump immediately into cars on the railroad from a trestle above.

Excellent natural features exist for a mud dam, and, by comparison of elevations of bank and creek, sufficient water could probably be obtained by a well about 200 feet deep.

48. *Lambourn bank* (Milesburg Iron Works) in Patton township, about 10½ miles west of Bellefonte, is the next bank of importance in this group.

It is situated close to the Buffalo Run road, and about 100 yards south of the railroad in valley, on land owned by Moses Thompson. It was idle when visited, in July, 1883, no work having been done there since the previous fall.

The excavation shows a long and narrow cut along the north flank of the hill and anticlinal, which latter is apparently overturned here, as siliceous limestone ledges show in the south face, dipping S. E. 42° *into* hill.

The cut is about 400 yards N. E. and S. W., and 20 yards wide, and 15 deep, though the bottom has been covered with about 4 feet of mud.

The sides also were considerably washed, so that very little could be judged of the character of the ore.

Most of the screenings from the old workings have been used in grading the railroad, and but little or no ore remained at the dump.

The ore deposit seems to follow the trend of the rocks,

and the general appearance of the bank resembles that of the Darrah bank in Marion township.

On the south side of cut, and near its western extremity, Mr. McCoy states that a shaft was put down 40′ from the bottom of the pit, all in ore of a pipe character.

If correct, this fact is of importance as bearing upon the similar genesis of the two varieties.

In a knob of soil left standing on the north side of the cut, the original surface can be seen, and shows fine ore under a cover of 18 inches of sand, and excellent lump ore from 4 feet down to bottom.

Shafts from 50 to 60 feet deep have been put down in the east end of cut, and excellent lump ore taken out from drifts run from them.

These lumps were principally sought for in the mines, owing to the distance to the washer preventing the fine ore being economically mined.

Mr. McCoy says that in washing this ore he found little or no flint, the refuse material being chiefly a rotten or "deaf limestone," though Mr. McCreath's analysis below shows a very large percentage of "insoluble matter."

The surface show at the Lambourn bank extends north of the road into field for about 200 feet towards Buffalo run, though the creek basin itself shows no ore at all.

The analysis shows, in addition to the unusual percentage of "insoluble matter," a marked increase of manganese and phosphorus over other ores of this region.

It was sampled in September, 1881, 115 pieces dried at 212° F.

Sesquioxide of iron,	57.500
" " " manganese,	1.36
Alumina,	1.150
Lime,	.760
Magnesia,	.500
Sulphuric acid,	.005
Phosphoric acid,	836
Water,	10.060
Insoluble matter,	28.010
Total,	100.188

Metallic iron,	40.250
" " manganese,	.965
Sulphur,	.002
Phosphorus,	.365
Phos. in 100 parts iron,	.906

The extensive developments that have been made here and the large use of this ore warrants the belief that while it is decidedly a cold-short ore, its iron percentage will average larger than the above.

49. *Gray Bank.*—Going west about 1 mile along Buffalo run railroad, the continuation of the Lambourn horizon is indicated in the old *Gray bank*, located like the Lambourn along the north base of the same siliceous limestone hill and rather north of the "Barrens" proper.

The pit shows about 20′ deep with a good covering of top clay. No work has been done there for 40 years, though the record of a 60′ shaft shows clay for 8′ and then mixed clay, wash and lump ore for about 40′, and finally limestone. Westward this horizon develops the *Desert* and *Hard banks.*

50. *Tar Hollow Bank.*—On south side of this hill, about ¼ mile south of the Gray bank is the *Tar Hollow bank*, probably geologically related to the Newell and Pond horizon.

The absence of any reliable dips through this generally sandy district makes it difficult to locate the anticlinal definitely. But if I am right in supposing it to pass close to the Pond bank, the banks last mentioned lie considerably lower in the No. II limestone formation than those along the Buffalo run road.

The Tar Hollow bank is on land of S. T. Gray, who informed me that no work had been done here for 30 years, the Messrs. Curtin being probably the last operators for the old Martha furnace in Bald Eagle valley. Work had been carried on over about 8 acres of ground, though at present none of the pits seemed to be over 25′ deep. The Celtic Company did some comparatively recent testing outside of the old pits but no great amount of ore was raised.

James Pierpoint, Esq., furnished me with the following analysis:—

Iron,	44.340
Phosphorus,	.072
Insoluble matter,	22.020

51. *Desert Bank.*—West 1¼ miles from the Gray bank and at the present terminus of branch to Buffalo Run R. R., near the Patton-Half Moon township line, the Celtic Iron Co. have opened up the *Desert bank* on land of J. & G. Mattern.

The main opening is close to George Mattern's house and about 2¼ miles east of Storm town.

The ore rights are owned by John Thompson, Esq., of Martha furnace.

Much of the land now taken up by farmers along the Nittany valley was originally owned by the iron furnaces along the Bald Eagle valley.

These corporations in selling out their lands in small bodies, always reserved the ore rights less 12½ cents per ton royalty allowed the farmers for damages, etc. While this arrangement gives the lessor undisputed right to excavate any property to the detriment of the farming interests, it also embarrasses the sale of land in fee simple, and has assisted more than anything else in retarding the development of good land by reason of this multiplication of proprietors.

The Celtic Co. have tested an area of 500 yards E. and W. and 200 yards N. and S., with fully 100 shafts, and have pretty well defined the limits of the deposit in this field. In the adjoining land east, owned in fee simple by Mattern, prospecting has been done to a much more limited degree, but shows fair results south of the limestone ridge, north of road. There seems to be but little stripping necessary, and the deposit shows good rich lump ore.

No estimate of tonnage could be made here, as no ore has been washed, nor was any record of the shafts obtainable; but from what I saw turned out in the trial pits, the wash will probably show 1 to 5, and there is certainly some very deep ore here.

The windlass shaft just above the original open pit was

down 78′ on July 11, 1883, two thirds of which is in ore, most of it good lump.

Some drifting was done from the bottom, and probably 400 tons of lump ore raised.

There is altogether some 800 tons on dump at the various shafts awaiting shipment, 200 tons having been screened.

But little of this was taken from the old pit nearest the road, about 15′ deep, which shows some lean wash ore in north face, and a nose of sandy limestone in the south, dipping apparently N. 38° E. 60°.

Many of the shafts are claimed to have shown good results at 50 and 60 feet, and the average of all pits is about 30′.

The range is limited by a limestone crest on the north and the old pit on the south, feathering in both directions, and evidently carrying the deepest ore at the windlass shaft. The show is leanest towards the north-west, where the deposit has become decidedly mixed with clay and flint.

The property certainly merits attention, now that railroad communication is assured, and it will, no doubt, be an important producer in the near future, though its ore is cold-short.

Several analyses of ore from this deposit have been made at different times, and the results will be found appended.

No. 1.—Sample of 94 pieces mixed and dried at 212° F., September, 1881, is by A. S. McCreath:

Sesquioxide of iron,	67.142
" " " manganese,	.443
Alumina,	1.250
Lime,	.730
Magnesia,	.389
Sulphuric acid,	.005
Phosphoric "	.717
Water,	12.094
Insoluble matter,	17.310
Total,	100.080
Metallic iron,	47.000
" manganese,	.309
Sulphur,	.002
Phosphorus,	.313
Phos. in 100 parts iron,	.666

Mr. John I. Thompson, of Lemont, analysed ore from shaft No. 5 for the Celtic Co. at various times, and sends me the following analysis of "sample clean, dark-brown ore some porous with enclosed sand:"

Moisture,	2.090
Combined water,	12.240
Insoluble residue, silica,	13.505
Insoluble residue, alumina,	2.400
Insoluble residue, lime,	.078
Insoluble residue, magnesia,	.147
Oxide of iron,	68 266
Oxide of manganese,	.189
Phosphoric acid,	.964
Sulphur,	.011
Lime,	.065
Magnesia,	.081
Alumina,	.285
Total,	100..315
Iron,	47.780
Phosphorus,	.421
Phos. in 100 parts iron,	.881

Mr. James Pierpoint, Supt. Juniata Mining Co., who had charge of the prospecting for the Celtic Co., kindly forwards the following analyses of ore from this locality. No. 1 labeled Hartsock bank (probably extension of Desert bank). No. 2, Miles Mattern's farm, Patton township. Nos. 3 and 4, Trial shafts on George Mattern's farm. No. 5, Desert bank.

	(1)	(2)	(3)	(4)	(5)
Iron,	38.560	50.000	45.393	51.263	44.289
Phosprous,	.309	.208	.350	·291	.286
Insoluble matter,	35.140	10.220	18.620	15.640	23.840

52. *Hard bank* (Celtic Co.), in Half Moon township, also idle, is located on same range and side hill about ½ mile west of Desert bank.

The pit is about 175′ long, 60′ wide and 20′ deep. Originally worked by Curtin Bros. for Martha furnace, and afterwards by John Thompson. Only wash ore is reported here, which lies rather deep and is covered with considerable surface soil. Mr. Pierpoint furnishes the following analyses:—

	(1)	(2)
Iron,	43.763	49.864
Phosphorus,	.208	.231
Insoluble matter,	25.380	15.380

From this bank west the continuity of this range is considerably gapped, owing in a great measure probably to the erosion brought about by steep and overturned dips in the anticlinal in this part of the valley.

Consequently the territory around Stormstown, if we except one or two weak outcrops south on the Scotia road, is quite barren through the valley of Half Moon run as far west as the village of Loveville. Here quite extensive developments have been made in the old

53. *Love Bank*, now *Dunkirk Mining Co.'s bank*, situated about 4 miles S. W. of Stormstown, and mostly confined to a hollow leading up S. W. from Half Moon run at Loveville.

An exhaustive description of the various openings here as they appeared in 1873 can be found in Prof. J. P. Lesley's report on the lands of Lyon, Shorb & Co., in which will be found his topographical sketch-map of the locality which sufficiently illustrates the condition of things now.*

The Chestnut ridge "barrens" lie to the south of the openings, and a narrow but prominent ridge of blue limestone cuts off the ore to the north.

North of this latter ridge some little pipe ore has been found in higher limestone rocks, showing sink-holes, and considerably broken up.

Limestone in this hill dips S. 30°–35° E. 45°–50°, and is of a hard crystalline character. The dip is probably overturned.

The ravine to the south between the two hills is about 300 yards wide and forms a good natural basin for the settling dams nearer the village.

The excavation proper is confined to about one acre of ground, though the company owns a 300-acre farm and have tested about 3 acres in one field around the works. It is here that the surface show is most abundant, thinning perceptibly east.

The ore, judging from the results obtained in trial pits,

*Appended to this report.

rides up the south flank of the limestone ridge nearly to its flat crest, but undoubtedly thins in that direction.

It shows well westward towards Col. Beck's farm, where considerable lump ore was taken from an old bank, though this opening appears to be rather a continuation of the ores occurring along the north flank of the limestone ridge.

If I am right in interpreting the dips along this ridge as *overturned*, these ores while *apparently underlying* the limestone really *overlie* it.

Considerable ore was taken from this range for Hannah furnace from shafts 50′–80′ deep along a ¼ mile of territory. But these openings are all abandoned and filled up now.

The ravine south of the hill has been tested at different times almost from the public road for 400 yards S. W.

Shafts near the bottom of the hollow found pipe and hematite ore at about 35 feet, but no great amount of surface wash was discovered until within the bounds of the present excavation.

The old works were always abandoned on striking water at about 80′, and nothing could be learned of their results.

The record of five comparatively recent pits sunk along west side of pit were furnished me by the superintendent in July, 1883. One thus located well up the flank of the limestone ridge showed no ore at all. The others show the great variation of these deposits, as they are not over 50 feet apart. The following are the results:

Shaft No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Wash ore, 3′	Clay, 12′	Clay and	Good wash ore, 21′	
Clay, 5′	Good ore, 15′	limestone	Clay, 3′	Mixed wash
Mixed ore and	Clay, 4′		Large lumps, 3′	and lump
clay, 33′	Ore lumps, 9′+		Fine ore & clay, 3′	ore, 15

On the south-west side shafts were carried down 25′–30′, all showing 6–8 feet top wash ore, under which good lump ore is reported. In the whole deposit wash and lump ore are equally prevalent, the lump ore being about the size of a man's fist.

There was then a pile of about 600 tons on dump, about equally divided, all of which had passed through the washer.

There seems to be no regularity in the ore layers at all, each shaft showing a variation of barren and rich ground, and all demonstrating the presence of rounded, water-worn material.

The main reliance of the bank is in this surface wash ore deposit, which, while being spread over considerable areas and occurring at considerable depths in places, is very variable.

The composition of this ore is well illustrated by the two following analyses:

No. 1, sample of 125 pieces of washed ore, collected in 1881 by Mr. McCreath and dried at 212° F.

No. 2, from Prof. Lesley's report, analysed by Dr. Persifor Frazer, and sampled at the large pit north of the farm road in the sketch map.

No. 1.

Sesquioxide of iron,	66.178
Sesquioxide of manganese,	.361
Alumina,	3.250
Lime,	.250
Magnesia,	.421
Sulphuric acid,	.082
Phosphoric acid,	.455
Water,	10.970
Insoluble matter,	17.600
Total,	99.567
Metallic iron,	46.325
Metallic manganese,	.252
Sulphur,	.033
Phosphorus	.199
Phosphorus in 100 parts iron,	.410

No. 2.

Metallic iron,	45.36
Alumina,	16.53
Lime,	0.58
Silica,	6.63
Sulphur,	0.04
Phosphoric acid,	0.05

There is a double 25′ washer at bank into which material is dumped direct from the mine cars.

Water is abundant, pumped from Half Moon creek 2500′ distant. Washing is simple, as no tough clay occurs with the ore, the foreign ingredient being mostly sand. One forty

horse-power engine runs the washer. The ore is screened after passing through the washer and the flint is separated on a wide rubber belt before jigging.

Ore is shipped from Loveville siding on L. & T. R. R., about one mile from bank, which is 1200′ above tide level. No ore was washed here until the summer of 1881.

Artesian wells.—Some interesting results were obtained here in sinking two wells for water supply.

Both wells were failures.

1. One sunk near the engine house, 538′ deep, struck lime stone at 35′. This was put down by Haller & Co., with Allegheny steel drill.

2. The Diamond Drill Co. bored a 6-inch core 500′ S. W. of engine house near the west end of the present workings. It was 1102 feet deep and the last core of limestone is in the company's office at Loveville.

They went 160′ through clay and good wash ore, striking the latter at about 125′, and the rest in limestone.

This is the last development noted on this range and is not far from the Huntingdon county line.

The irregularity of the deposit makes mining here rather expensive, though the ore material will show a good wash record.

The lack of railroad facilities and the competition of the superior Juniata and Scotia ores also operate adversely to mining activity.

Chapter X.

Brown Hematite Ores of No. II, continued.

E. The Barrens Group.

This group comprises the Juniata, Scotia, Lytle, Ackley mines and others.

The ores of these banks—which are lower geologically than any other in the district, occurring, probably, 5000′+ below No. III slate—vary in appearance from a dark-colored, often black hematite with a pitch-like lustre, rich in iron, to a lighter, liver-colored, compact hematite, not so rich. In composition they vary *usually* from 44–52 per cent. iron and 0.08–0.20 per cent. phosphorus.

While the origin of these vast deposits in the sandy measures of the "Barrens" is still an open question, it is worthy of notice that in all the developed banks examined there was no tendency to a formation of a regular bed.

The ores rather seem to occupy an irregular shaped estuary scooped out of limestone, having its lean and rich spots, and in places showing bands of non-ferruginous clay entirely devoid of ore, but with good territory on either side of it. The true bottom of this basin is always limestone, though interstratified sand beds probably limit the ore, and the surface soil is sandy and harsh.

The heavier ores lie in the bottom; the more finely divided and lighter varieties towards the top of the deposit.

I can imagine soluble iron salts to have been originally caught in the porous sandstone layers interstratified with the limestones, and afterwards oxidized by organic matter brought in by the waters which slowly dissolved the whole formation and threw the siliceous members down as loose sand and filled the limestone crevice with hematite ore.

54. *Juniata Mining Company bank*, in Half Moon township, locally known as the *Tow Hill mines*, is situated on lands of the Pennsylvania Furnace Company, about two miles south of Stormstown, and on *south* flank of Chestnut or Buck ridge.

The company consists of Pittsburgh men, Messrs. Bennett, Chalfant, Oliver, and others, with Mr. James Pierpoint as superintendent, to whom I am indebted for much of the information which follows.

Operations were commenced here in the winter of 1881, on a tract of about 450 acres leased from the Pennsylvania Furnace Company, though mining had been formerly carried on here many years ago in several small and shallow pits known as the Pond, Floyd, California, Bull, and Hannah furnace banks, to supply the Pennsylvania furnace. Lump ore was mostly selected from them and screened at the mines, so that much good, fine ore, considered refuse then, is to be found on the various screening floors through the "barrens."

Most of these small banks are described in Prof. Lesley's report, in the appendix to this volume, to which the reader is referred, as they have, in most cases, been long since abandoned for larger operations at the base of the hill.

Two local maps showing their position well up on the "barren" ridge will there be found.

The ore tract, as proved by the present company, is about $1\frac{1}{4}$ miles N. E. and S. W., and $\frac{1}{2}$ mile N. W. and S. E., fully $\frac{3}{4}$ of the former distance being tested with pits from 10′–30′ deep.

Being essentially a wash ore deposit, it will vary greatly in richness in different parts of this area.

On leaving these limits the whole surface becomes barren and sandy; each individual shaft shows a different record, which seems natural if we view the deposit as a wash, and the rounded character of its accompanying flint and sand, as well as the ore itself, warrants that belief.

But in each of these shafts there is more or less show of ore, promising well in places elsewhere lean and sandy.

And the ore itself will show every grade of character and color, loosely aggregated in a mass of clay and sand.

A narrow sand and clay belt, perfectly barren, and containing variegated tough clays, cuts the present excavation throughout its entire length, and is even distinguished further on in both directions.

It is parallel to the trend of the rocks N. E. and S. W., and divides the ores in the flat or hollow from those irregular deposits occurring well up on the hillside, shown in figures.

These *clay banks* are a feature in almost all the ore banks of the "barrens" in Centre county, and have been likewise noted as occurring at the large Springfield bank* in Blair county, which evidently occurs in precisely similar rocks and at a parallel horizon.

55. The first work done by the present company in this field was at the end of the L. & T. R. R. branch into mine. An incline was put down here from the washers to a trench from 50 or 60 feet long and 20 feet wide.

The ore here however was found to be similar to various crops further south along the railroad, sandy and flinty and exposed to an excessive surface drainage from the higher ground to the north.

56. They next re-opened the old *Floyd pit* 300′ E. and W., 150′ N. and S., and 20′ deep, situated about 200 yards north against side hill, where a considerable amount of ore was taken out by pick and shovel. The ore was condemned as being lean and flinty. Very little was to be seen there, as the sides were greatly washed.

Mr. Pierpoint furnishes the following partial analysis:—

Iron,	47.621
Phosphorus,	19.183
Insoluble matter,	.063

The present workings are situated about ½ mile from the washer and in low ground at the base of the hill to the north.

*An interesting description of this mine will be found in Report T, page 157, *et seq.*

After thoroughly testing this ground with pits and some little hand digging, the company resolved to employ one of Southey & Co.'s steam excavators, and, so far as this bank is concerned, the decision was a wise one.

It is claimed that they do the work of 40 men, and require 3 men inside, a fireman, engineer, and dumper; 2 men on top of the bank to loosen the crust left by steam scoop; 2 at bottom and 3 men for loading.

The vertical reach of the scoop is about 18′ and its capacity about 550 cubic yards of excavation per day of 10 hours. It consumes $\frac{1}{2}$ ton of fuel per day. The original cost of a machine of this size is about $7,000.

On July 23d, 1883, when last visited, this excavation was about 125 yards long, 40 wide, and 5 deep, or 25,000 cubic yards. The ore seemed to be bearing north towards hill and the future work of the excavator will be advanced in that direction.

A description of the appearance of this opening during any one visit would be as useless as a map of the excavation itself, for such is the amount of work done by the excavators that in my two visits a week apart, the work of the machine had eliminated a tough purple and white clay and which hardly paid for washing and had gotten into most excellent material which showed scarcely any flint, (a usual accompaniment of these ores) and which gave the jigs comparatively little work.

This statement will probably illustrate the excessively variable character of these deposits, so that with the exercise of the greatest foresight, but little real information of what a day's work will bring forth is realized.

The system of the company has usually been to sink trial pits 15′–20′ deep in the direction they are working, for the excavator cannot choose its ground when once at work, but turns everything before it into the mine cars.

The west face, when last seen, was lean and sandy, while south of the entrance to the pit most excellent lump ore was embedded in white clay.

The bottom of the mine was apparently half hard lump ore, some of it too large to handle well, which, when washed

on the next level will average the mine's output excellently, being rich in iron and heavy. Much of this lump ore is occasionally mixed in with the surface strippings, and is separated before the bulk of the material passes into the washers.

From the western extremity of the opening the ore crop could be distinctly traced by its "blossom" for some distance, besides having been tested by many shafts. There is evidently an enormous deposit of this wash ore here, and the place is so situated as to be capable of a much larger development. The cost of mining and loading in cars is about $1 50 per ton exclusive of royalties.

The ore runs about .080 per cent. (*average*) in phosphorous, as against .040 at Scotia, but the low amount, if any, of manganese makes this ore valuable for foundry iron, and it is greatly on this ore that R. H. Powell & Co., (who are large consumers,) are said to have made their reputation in foundry irons.

A sample of the washed ore was taken from a series of loaded cars at the mines by Mr. James Pierpoint, which I forwarded to Mr. A. S. McCreath. He reports the following results. Sample, 80 pieces, dried at 212° F.:

Sesquioxide of iron,	60.785
" " " manganese,	.103
Alumina,	2.795
Lime,	.230
Magnesia,	.227
Sulphuric acid,	.015
Phosphoric acid,	.259
Water,	9.748
Siliceous matter,	25.610
Total,	99.772
Metallic iron,	42.550
Metallic manganese,	.072
Sulphur,	.006
Phosphorus,	.113
Phosphorous in 100 parts iron,	.265

The high percentage of siliceous matter and phosphorous in this sample affords another striking example of the variable constitution of these ores, usually averaging 45 per cent metallic iron and below 0.1 per cent of phosphorus.

The bulk of the work here is of course done by the excavator, but the company has arranged for individual contract labor at the old pits around the main work, paying $1 per ton for screened ore at the mine. Very little of this ore can be shipped alone, owing to its being imperfectly cleaned. A short description of these pits is appended.

57. *Pond Bank*, the furthest east of the old Pennsylvania furnace workings, is about 200 yards south of the incline plane, in the same hollow as the main excavation.

It shows now a pit 100′×50′×20′ (grass-grown and long since abandoned) in which, however, some recent trial shafts showed good prospects.

In Prof. Lesley's report of 1873 it is described as "honeycombed, rather light, easy smelting-ore, dipping southeast." * *

If the following analysis copied from that report represents anything like the average grade of ore, the place should receive more attention. Dr. Genth, who made the analysis says: "Two of the four specimens received were of a dark-brown, porous amorphous ore, with very little lustre, more or less mixed with reddish and yellowish ochreous ore; the third piece was of a pale brown and contained small quantities of fibrous ore; the fourth was an ochreous ore of a pale brown and yellowish color. An average of these four samples gave:

Ferric oxide,	78.68
Manganic oxide,	0.42
Alumina,	2.89
Magnesia,	0.20
Phosphoric acid,	0.16
Silicic acid,	3.17
Quartz,	1.71
Water,	12.77
	100.00
Metallic iron,	55.08
Phosphorus,	0.07
Phosphorus in 100 parts iron,	0.127

From the character of sample such an analysis might be expected. Mr. Pierpoint furnishes the following two, which more nearly represent the average: (Pa. Steel Co.)

	(1)	(2)
Iron,	47.880	43.689
Phosphorus,	.080	.091
Insoluble matter,	—	23.966

58. The *Red bank* is on the hill side 200 yards north of present workings and it seems to indicate the line of deepest ore, though separated by the clay and sand band already alluded to.

It lies close to the road leading to Gatesburg, 300 yards further along which white, thick-bedded sandy limestone dips S 30° E. 28°.

The pit shows 5′–10′ of sand covering, wash from the hill top, under which good ore comes in. The excavation is about 100′ N. and S., 50′ E and W. 15′ deep. The east and west sides show very well with about 4′–10′ of wash ore, separated by a clay band from rather siliceous red ore in bottom.

The north and south ends are lean and show considerable clay. South-west 100 feet from here a shaft 54 feet deep showed ore still in bottom.

An average of 5 samples was analysed by Dr. F. A. Genth:

Ferric oxide,	65.44
Manganic oxide,	0.13
Cobaltic oxide,	trace.
Alumina,	5.31
Magnesia,	0.16
Lime,	trace.
Phosphoric acid,	0.21
Silicic acid,	6.76
Quartz,	12.78
Water,	9.21
Total,	100.00
Metallic iron,	45.81
Phosphorus,	0.09
Phos. in 100 parts iron,	0.195

Dr. Genth described it as "generally an amorphous compact ore, with considerable admixture of sand. Some is more porous and has the cavities lined with fibrous limonite, and more or less filled with clay. Emits, when breathed upon, a strong argillaceous odor."

Mr. Pierpoint furnishes two partial analyses:

	No. 1. Red Bank.	No. 2. Red Bank, west opening.
Iron,	52.879	51.313
Phosphorous,	.049	.070
Insoluble matter,	10.880	12.840

59. *California bank* is a small pit 60′ N. and S., 30′ E. and W. and 10′ deep, about 200 yards south-west of Red Bank, on same strike. It shows considerable loose lump ore, cleaner than the Red bank.

Its position is shown in Prof. Lesley's sketch map. He says of it in his report of 1873 that "it receives its name from the richness of its ore, before it was abandoned 20 or 25 years ago, on account of its distance from Pennsylvania furnace, the abundance of water and lack of pumping apparatus, the refractory character of its mineral in the cold-blast charcoal stack, and especially the abundance of good ore at the furnace itself. Pits of standing water show 20 feet of wash ore in their walls."

60. *Hannah Furnace bank* still higher up the hill to the N.E., and about 1425′ above tide, and east of the Gatesburg bank, was abandoned long ago. Prof. Lesley describes it as showing 15′–20′ of good, dark, abundant wash ore in the side walls, and coming close to the surface. Mr. Pierpoint furnishes the following analysis of this ore:

Iron, 52.360; phosphorous, .086; insoluble matter, 12.228.

61. The *Bull* and *Hartsock banks* lie half a mile east, and show about 60,000 cubic yards of excavation, though now greatly filled up. They lie close to south-east dipping limestone on the ridge, and appear to be detached pockets, though occurring in the line of strike of the other banks just mentioned. A mass of barren sand occurs between the openings. The ores are generally of a dark, black, sandy texture, high in iron.

Average of five samples sent Dr. Genth, taken from an old ore pile at the bank, gave the following result on an analysis:

Ferric oxide,	74.85
Manganic oxide,	.029
Cobaltic oxide,	.021
Alumina,	.242
Magnesia,	.012
Lime,	trace.
Phosphoric acid,	.024
Silicic acid,	.415
Quartz,	.592
Water,	11.80
Total,	100.000

Metallic iron,	52.40
Phosphorus,	0.105
Phosphorus in 100 parts of iron,	0.200

Mr. Pierpoint sends the two following analyses made from samples collected when prospecting this territory in 1881:

	(1)	(2) Pa. Steel Co.
Iron,	54.260	45.960
Phosphorus,	.084	.088
Insoluble matter,	—	23.733

Various other small and nameless pits have furnished more or less ore. The entire tract can be relied upon for a 40–45 per cent ore.

The system of development carried on at present gives the operators every advantage of drainage and an easy grade for carrying their ores to the washers by means of a narrow-guage steam road and a small engine, pulling a train of 20 cars to the foot of the incline plane, whence it is hoisted to the washers.

Plant.—The hoisting engines consist of one pair of 12″×20″ engines with an 8′ drum and a 1″ steel wire rope.

From the head of the plane a mule train of four cars is conveyed to the washers. The cars hold about one cubic yard of material and open at the side, dumping at an angle of 45° on to a grate with bars about 3″ apart, at present armed with railroad iron ties.

Unlike the Scotia *slanting* bars, the grate here is *horizontal*, and the material is *not* played upon with water. This seems to be an advantage over the plan pursued at Scotia, for the earth and clay do not become sticky and plastic,

and by a little raking all the fine material readily passes through the bars to the washer, and requires only about half the force at the grate. The large ore lumps are thus separated from the finer material, and are taken directly to the cars after being picked of flint balls.

The washing apparatus consists of two pairs of double shafts, each geared to a separate engine, so that they can be run independently.

These shafts are 26 feet long, thus giving 52 feet of traveling surface to each washer. The power for each is a reversing engine 12×24, so geared that when any large lumps of material get caught in the scoops of the washer, clogging the movement of the shaft, the engine can be readily reversed until the large lumps fall back. A steam whistle gives the engineer a signal when this clogging occurs.

This saves many breakages and delays.

The washed material is passed into a revolving, truncated, cone-shaped screen, where again the largest pieces of ore and flint *not* passing through a 1-inch mesh are passed out the mouth of the screen, picked of flint by hand, and taken to the cars.

Everything that passes through the meshes of the screen is partially washed of its clay, mud, and fine silt (which is carried off to settling dam), and drops into a receiving trough, to be carried by wide rubber belts to the jig house, being partially picked of its flint by boys as it passes along slowly.

The jig house is supplied with four screens set one below the other in the same vertical plane, furnished with meshes so sized by experience that each jig receives about the same amount of material, though of different sizes. Most of the flint being rounded or globular, is readily separated from the heavier ore material in these jigs. The jig platforms receiving the mixed material, separate it by difference of specific gravity into ore and flint, each passing into its separate compartment.

The jigs here have a combined capacity of 40–50 tons a day, or about $\frac{1}{3}$ the total product of the mine.

The jigged material is raised by cups on a Pater Noster

chain to bins leading directly into cars on the railroad siding. These bins have a capacity of about 100 tons, so that material can be stored there until ready for shipment and drawn at will.

The boiler house is supplied with a battery of three tubular 30′ boilers, each having two tubes, which allows of their being readily cleaned.

The water for them is drawn from a separate tank of pure, clean water, holding about 10,000 gallons, which also supplies sprays of water to washers.

There are, in addition, three tanks with a capacity of 28,000 to 30.000 gallons, supplied by wells for washing purposes. These wells are about 330′ deep, with a standing column of 45–50 feet of water, in all of which solid rock (limestone) was struck at about 265 feet.

If this is the same limestone that crops on the ridge to the north, it dips pretty strongly south-east to attain such a depth here, while the same fact illustrates the depth of the cavern into which has been collected the vast mass of clay, sand, and wash ore already described.

Each well has a separate engine, so that they can be worked independently. Nos. 1 and 3 are geared engines, with 4′ stroke ; No. 2 is the old oil well pattern with 32″ stroke, though apparently throwing as large a stream as either of the other two.

Another important feature of the water supply here is the cistern located about ¼ mile below the washer on the railroad track. This cistern is supplied with water from a settling dam, located in a wide, natural ravine, and as it covers much superficial area, the surface water from it is drawn off at dam almost perfectly clarified. After being caught in the cistern, drawn off by a flood-gate at the breast of the dam, the water is pumped up 90′ through a 7″ wrought-iron pipe to the tank at the washer. The power is furnished by a Nelson and Snyder double-plunger pump, 18×36 steam cylinder and 12×36 water cylinder.

By this means a constant supply of good water is obtained, and at a great saving over the deep wells using 10 times the amount of fuel.

It is the only place in the county that I have noticed this important utilization of the waste water.

The whole plant is compact and well constructed, and shows economical work and good results.

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62. *Scotia Ore Banks* (Carnegie Bros. & Co.) is in the same synclinal as the Juniata mines, between the Chestnut ridge and Gatesburg anticlinals and 2 miles eastward. It lies in the south-west corner of Patton township at the present terminus of the Lewisburg and Tyrone Railroad, and about 3 miles south of Matternville, in the Buffalo run valley.

The land upon which the operation is located, about 300 acres, was formerly owned by the Centre furnace, except a small portion near the washers, which was purchased from the Pennsylvania furnace property.

The present company commenced work in 1881, though considerable lump ore was carried away from here by the Irwins for Centre furnace, when the bank was known by the name of the River Hill tract. Much that has been said concerning the characteristics of the Juniata mine deposit are equally applicable here, for the two banks are in identically similar rocks, have been formed by the same agencies, and have similar ores, (though the Scotia ores show only about half the percentage of phosphorus,) and are *topographically* similarly situated.

The same variation in richness and leanness of the deposit in different places exists and within the tested area of 1½ miles N. E. and S. W. and ¼ mile N. W. and S. E. every trial shaft is reasonably certain to show more or less ore. Outside this limit the same barren, sandy waste, is to be remarked.

Massive sand rocks, disintegrating into a white sand, crop on the hillside around the bank, and no doubt make the bottom rock to the ore, though the Scotia wells nearly 400′ deep in limestone, prove conclusively that the theory of this sand rock being the bottom of No. II, if not the top member of the next lowest formation (Potsdam sandstone No. I) is quite untenable.

The occurrence of non-ferruginous tough white clay and sandy layers is also to be remarked here, and such have been left untouched in the long (Momson ?) cut at the mine, while excellent wash ore has been taken from behind them.

In former times, when worked for Centre furnace, this ore was screened and the large lumps alone conveyed to the furnace, in consequence of which the refuse of these screenings 4′ thick (all of which will wash well) covers the original surface over considerable areas. The ore is of all characters and grades and is usually rounded and water-worn as are the accompanying flint balls.

The trial pits over the property do not usually strike solid rock, but sand and clay mixed with wash ore and large lumps.

The same system of working as pursued at Juniata is adopted here, and everything scooped out by the excavator is passed through the washers except the large hand-picked lumps.

The clays are of all colors—purple, red, brown, and white—frequently found mixed with sandstone pieces and flint, and generally tough and refractory in their behavior in the washers.

The scarcity of bomb-shell ore and real pipe ore is noticeable, most of the ore being of a heavy dark brown to black hematite, often carrying sand.

The first work here was done by horse and cart, though at present two large excavators are at work in the two largest cuts on the property, each with a capacity of 550 cubic yards of material per day.

Though visited several times in July and again in September, 1883, but little statistical information could be obtained from parties at the mines, though these would so closely resemble those already given at the Juniata mine as not to need repetition here.

The two cuts worked here, each by a separate excavator, are some distance from the washers, to which the ore is conveyed by a narrow guage steam road nearly a mile distant.

In July, 1883, work was being principally carried on in

the *Momson* (?) cut, then about 300 yards N. E. and S. W., 25 yards wide N. W. and S. E., and 8 yards deep.

The rapidity with which these banks are excavated by steam power will, of course, modify any description that is given of them.

At that time a good 25-foot face of wash ore, carrying occasionally thin clay bands, was being cut down along the south face.

The north side of the excavation, along which several clay banks had been left, appeared much leaner, and the excavator had been stopped there owing to the sandy character of the material.

No better proof of the variability of these ore banks can be cited than in this instance, where, in a test pit 80′ deep, sunk but a few yards north of this lean face, excellent wash ore was found throughout.

The most encouraging show of ore was towards the southwest, the east end towards washers being lean and rocky.

A general section of this cut would show about 4′ of fine ore screenings, 8′ of fine wash ore and clay, and the rest 12 feet of clay and lump ore, with the latter in bottom of excavation.

63. *Irwin cut.* The old original workings on this property, known as the *Irwin cut*, from which ore was taken for Centre furnace, is located about 300 yards further N. E.

A large pile of refuse fine ore left at that time when the large lumps alone were removed has been washed profitably by the present company.

The pit is roughly oval, 125 yards N. E. and S. W., 40 yards N. W. and S. E., and 10 yards deep. But little knowledge of the ground below 30′ could be obtained, as all test holes sunk from the bottom of the mine struck spurting water when still in good ore ground.

The show for a handsome return here is excellent, and though considerable delay was incurred in preparing the mine for the work of the excavator, the company was just beginning to utilize the machine with encouraging results when the locality was last visited in the fall of 1883. The

faces all showed from 6′–8′ of sand cover, and then good wash and lump ore to the bottom.

The lump is loaded on a separate wharf and shipped directly to Pittsburgh. Altogether 75,000 tons have been a year's product here, 25,000 being clear lump and the remainder passing through the washers.

64. *Gray's farm.* Pits have been sunk 40–50 rods east on to P. D. Gray's farm, though no results could be obtained of their success or failure.

A considerable amount of ore must have been taken in the days of the Centre furnace to judge from the size of this old cut.

Mr. Bullion, the superintendent at the mines, claims the average run of the washers to show one ton of clean ore to every three cubic yards of material, or a wash of about one sixth, allowing a cubic yard of clean ore to weigh two tons.

The loaded cars are hauled up a long trestle with a grade of 2′ in 100′ to the washers.

These latter comprise two sets of three 26′ iron cylinders armed with teeth. Each set of shafts has its separate engine, with 14″ cylinder and 24″ stroke. These engines may also be geared to run the screens, of which there are two, one for each washer.

The loaded cars are run in, two at a time, on to a revolving platform, where the clamped cars are turned over 180°, and dump their material on to inclined grate bars, both of which features differ from the Juniata plant.

These bars are about ½″ thick and are set 3″ apart. Small streams of water play on them automatically, while the material is being raked by hand and the larger lumps (flint and ore) removed.

The water frequently makes the clay "ball ' at the grates, and prevents the rapid passage of the material, and I question if there is not a disadvantage in so working, instead of passing the raw stuff through dry.

In other particulars there is no essential difference between the arrangement of the Scotia and Juniata plant. and both are models of their kind.

There are five artesian wells on the property, one of which is unproductive

One of these is located near the mine and the water is conveyed by board tubing to the tank at the washers. Two others, Nos. 1 and 2, are located about 200′ from plant, and are 365′ deep, with a standing column of 35′ of water. Nos. 3 and 4, not far distant, are 400′ deep. These four all pump into a reservoir, whence the water is forced to a large tank on top of the washer for distribution to various parts of the works. The well pumps have 4½′ stroke and are run 21 strokes per minute.

65. The *Red bank* is further south-west and close to the Half Moon line. This though now pretty well filled up and abandoned, furnished considerable ore to Centre furnace, and is reported to contain still a large body. The ore is of excellent quality and will no doubt receive attention from the company as the work advances in that direction.

All these openings were sampled by Mr. A. S. McCreath shortly after the company began work, and his results are as follows, all samples being dried at 212° F.

No. 1. Scotia bank, (Momson cut). Sample 135 pieces.

No. 2. Scotia bank, (Red bank). Sample 173 pieces.

No. 3. Scotia bank, (Irwin cut). Sample 495 pieces *clean lump.*

No. 4. Scotia bank, Screened wash ore.

	(1)	(2)	(3)	(4)
Sesquioxide of iron,	70.285	75.357	75.643	64.821
" " manganese,	.298	.485	.578	.392
" " cobalt,	—	—	.010	.030
Alumina,	1.765	1.670	.851	2.973
Lime,	.320	.250	.660	.650
Magnesia,	.418	.324	.136	.180
Sulphuric acid,	.140	.307	.235	.175
Phosphoric acid,	.146	.191	.116	.116
Water,	10.404	9.256	9.669	9.584
Insoluble matter,	16.180	12.050	11.450	20.730
Total,	99.956	99.890	99.348	99.651
Iron,	49.200	52.750	52.950	45.375
Manganese,	.208	.338	.403	.273
Sulphur,	.056	.123	.094	.070
Phosphorus,	.064	.086	.051	.051
Phos. in 100 parts iron,	.130	.163	.096	.112

These analyses show these ores to carry a low enough percentage of phosphorus to fit them for Bessemer work.

They show an excellent average of iron, and compare advantageously with the results obtained from various analyses of the famous *Springfield bank* in Blair county.

The improvements made in the washers since the above samples were taken, are said to show a considerable reduction of silica or insoluble matter in the washed ore. Comparatively little bomb shell ore has been met with yet, and the presence of crystals of iron pyrites not noted.

About 1½ miles north-east, in the same township, and at about the same geological and topographical position as those two large banks just described, are several ore banks in the "barrens" which have enjoyed a splendid reputation for their ores and have furnished a considerable tonnage to the old Centre furnace. They are all abandoned now, but the early completion of the Bellefonte and Buffalo Run R. R., whose graded line is branched thus far, warrants the belief that this whole field will receive such attention as its past history would seem to warrant.

66. In the *Ackley bank*, the first of these, about 1400′ above tide, as marked on map, quite a stunted growth of brush is visible. Indeed, so much have these old banks been changed by time as to have made their very names the subject of controversy by different people, and their identification on the part of a stranger a matter of considerable difficulty. No ore has been removed from here since Centre furnace closed in 1858.

The pit is roughly 60′ E. and W., 150′ N. and S., and filled up with mud and water to within 15′ of surface.

The south face shows some ore where rain-water had washed down the clay and sand ; but outside of this, comparatively little of this highly spoken of bank is not covered by a thick mass of sand and clay. The mine was considerably deeper and hard lump hematite was drifted for. It is estimated that at least 10,000 cubic yards of material have been excavated here. The ore exposed in S. E. face shows

considerable good-size lump. It is also remarkably clean and free from the sand so intimately mixed with the ore at Scotia and Juniata.

There is an immense screening floor here as well as at the other banks in the "barrens," much of which could be advantageously washed.

67. Carnegie Bros. & Co. had an option on considerable territory hereabouts in connection with the *River Hill tract*, and the evidences of their numerous test holes can still be seen. These, however, were all filled in by agreement, and no record of them could be obtained. As yet no great body of ore such as that spread out at the two larger mines has been defined in this part of the "barrens," the openings being largely covered with sand and not showing much surface outcrop.

The following excellent analysis of this ore by Mr. McCreath is from sample of 110 pieces, dried at 212° F., September, 1881:

Sesquioxide of iron,	75.107
" " " manganese,	.113
Alumina,	.927
Lime,	.480
Magnesia,	.346
Sulphuric acid,	.015
Phosphoric "	.158
Water,	11.772
Insoluble matter,	11.410
Total,	100.328
Iron,	52.575
Manganese,	.079
Sulphur,	.006
Phosphorus,	.069
Phosphorus in 100 parts iron,	.131

68. The *Lytle Bank*, 1323′ A. T., on the "Iron Ore Tract" of Moses Thompson, is about ½ mile N. E. of the Ackley bank and rather in the flat than on the side hill. Work has long since been stopped here also and the cut filled up with water to within 15′ feet of the surface.

The wash ore along the south and west faces is very good.

The north face shows little or nothing except a heavy covering of sand, and the east face is not cut down at all, being left for the teams to enter the bank. The cut is about 100′ E. and W. and 60′ N. and S.

Only lump was taken to Centre furnace and in consequence a large screening floor marks the place of shipment. The lump ore was also drifted for here.

Some of Messrs. Carnegie's pits (8 or 10) were located around the bank and the open ones all about show 4′ of sand cover and then ore and clay in varying proportions.

The following is Mr. McCreath's analysis of 117 pieces of ore lying around bank, dried at 212° F., Sept., 1881:

Sesquioxide of iron,	68.928
" manganese,	.226
Alumina,	1.927
Lime,	.520
Magnesia,	.317
Sulphuric acid,	.027
Phosphoric acid,	.249
Water,	11.186
Insoluble matter,	16.510
Total,	99.890
Iron,	48.250
Manganese,	.158
Sulphur,	.011
Phosphorus,	.109
Phosphorus in 100 parts iron,	.226

69. *Scott bank*, on the same property, is a continuation 200 yards east of the Lytle opening and 20 feet lower. From its size and appearance it could not have yielded much ore. It shows about $50 \times 40 \times 6$ feet.

The sides are all grass-grown. Some trial pits sunk here show fair results to a point 100′ north of bank, beyond which they are all barren and sandy.

The ore is a brown and yellow hematite, and shows some distinct differences from the ores west, due no doubt to the "barrens," becoming less sandy and more calcareous.

In a hole 60′ north there is 20′ of excellent reddish ore.

South of Chestnut ridge, and in the hollow between this anticlinal and the short Gatesburg ridge, there seems to be another ore horizon, occurring somewhat higher than the Scotia-Juniata deposits, but hardly developed at all in this county. Its ores may all be referred to the "barrens."

70. *Whorrel bank.* An old operation formerly existed on lands of Pennsylvania Furnace Co. about 400 yards from L. & T. R. R. and west of Half Moon run, 1½ miles south-west of the village of Gatesburg, known as the *Whorrel bank*. The openings here were almost entirely closed up by débris and wash from the sandy "barrens," though the outcrop west of the creek was considerable.

Prof. Lesley, speaks of two open cuts on the Gatesburg road, showing a combined excavation in 1873 of 4400 cubic yards. "Both had standing water in the bottom and wash ore in the walls, while very heavy outcrops appear along the road, as well as along the cross-road leading up the ridge north to Lovetown, beyond which an old shaft struck the underlying sand rocks." They are about 1190′ A. T.

The double excavation to the south showed "30,000 cu. yds., separated by a stratum of limestone dipping S. 30° E. 26°–50°, the ore underlying, overlying, and surrounding one end of it. The wash ore in the side walls does not look rich." Of the sample selected for analysis Dr. Genth says:

"Two pieces of a fine brown amorphous ore of various shades, between yellowish and dark brown; some portions showing a slight pitchy luster; the greater part is dull. Has a strong argillaceous odor when breathed upon."

The analysis of an average sample gave:

Ferric oxide,	69.71
Manganic oxide,	0.46
Cobaltic oxide,	trace.
Alumina,	3.37
Magnesia,	0.08
Lime,	trace.
Phosphoric acid,	0 97
Silicic acid,	3.51
Quartz,	9.60
Water,	12.30
Total,	100.00

Metallic iron,	48.80
Phosphorus,	0.43
Phosphorus in 100 parts iron,	0.87

This bank is evidently on same range as the *Wrye bank* in Huntingdon county close to the Centre county line.

In the gap in Gatesburg Ridge along Half Moon run there is a good show of wash ore (hematite) along road.

Frequent small deposits mark the road to Gatesburg, though usually accompanied with considerable sand.

At the cross roads at the village limestone is apparently dipping 65° to N. 70° W.; blue siliceous harsh stone accompanied with ore.

On road leading over Chestnut Ridge this dip soon changes to S. 12° E. 20° in rather argillaceous limestone.

The road cut here shows a fair face of good wash ore a short distance from an old bank close to roadside, which formerly furnished ore to Pennsylvania furnace.

Gatesburg ridge is only about 5 miles long in this county, and the subsidence of the anticlinal which caused it has produced a wide rolling sand flat between the longer Chestnut and Tad Pole ridges, still covered to a great extent with chestnut and oak timber and stunted pine

71. Two miles east of the end of this dying ridge, in a somewhat more open and cultivated country, encourging outcrops of liver-colored hematite occur in the McAllister, Garner, Snyder, Roop, and Grenoble farms, well exposed in the latter in cut of B., & B. R. R. R.

These properties are, however, all undeveloped, and the surface crop is considerably mixed with clay and sand.

South of Gatesburg, along road, in the valley of Half Moon run, good pipe ore has been taken out of several old pits in field near lime-kiln.

Similar ores can be found to a limited extent along Tad Pole run, but I pass now from these to the south side of Sand ridge.

Chapter XI.

Brown hematite ores of No. II, continued.

F. *Pennsylvania furnace and College groups.*

72. The *Bryson cut* or old *Pennsylvania ore bank*, for over half a century furnished Pennsylvania furnace on the Huntingdon county line with stock, which was mainly instrumental in making the superior reputation of Pennsylvania iron.

Like so many other banks in the county, work was entirely abandoned during the season of 1883, so that for much of the information which follows I am indebted to Mr. George Lyon, who visited the bank with me, and the voluminous account of this old operation in Prof. Lesley's report before mentioned.

A lease of this property was consummated late in the fall to some Pittsburgh parties, who intended mining and smelting ore here at the reconstructed Pennsylvania furnace.

The developments are all on the south side of the Sand or Tad Pole ridge anticlinal, a continuation of Spruce Creek ridge in Huntingdon county.

The Hostler ore bank of Huntingdon county is referred to the same horizon as the Bryson bank by Prof. Lesley, occurring in rocks of the middle division of the limestone series of No. II, and about 2500 feet below the slates of III. The Hostler bank, however, occurs on the north side of this anticlinal ridge in Cale Hollow, and shows steeply N. W. dipping rocks in various parts of the opening.

The Pennsylvania (Bryson) cut, on the other hand, shows

everywhere south-east dipping sandy dolomites averaging 40°, succeeded southward by white and blue limestones and finally, along the base of Tussey the soft, dove and blue limestones of the Trenton group, dipping gently (15° to 18°) under the Hudson river slates of III.

The Bryson bank ores are essentially pipe, finely disintegrated, and occurring in every conceivable form, whether in streaks of ore and clay, or in flattened scales, or bunched with sandy limestone, or in solid pipe masses; but everywhere showing a tendency to interstratification and pointing to their probable formation in place by the dissolution and leaching of the limestone rocks and the filling in of cavities with mixed sand, clay and iron ore. Comparatively little lime has been left in this ore, showing how thorough this solution has been, and the percentage of magnesia, though low, is probably due to its less solubility as compared with corresponding lime salt.

Very little of the quartz and flint grains found with the ore are water-worn or rounded, and so create at once a marked difference between these ores and those of the barrens in the Scotia-Juniata range. But it must be remembered that these latter ores are much lower down in the measures. When visited in July, 1883, no work had been done here since the fall of 1882, when Carnegie Bros. & Co. returned their lease of the property.

Much information concerning the appearance of this deposit is contained in Prof. Lesley's report. (See Appendix.) The present contour of the bank is but little changed since he sketched it in 1873–4.

The Messrs. Carnegie, while doing some little mining in the old workings south of the washer, turned most of their attention to the development of the *New bank* located east of the former and shown on map.

About 10 acres in all have been disturbed here.

Various estimates have been made by different parties of the original amount of ore contained in this deposit (which roughly measured may be taken at 500 yards N. W. and S. E., and 350 yards N. E. and S. W.), which vary from 200,000 tons up to 600,000 tons, with a possible output of even

1,000,000 tons, allowing for increased depths over 50 feet, etc. All such estimates are greatly affected by the frequent occurrence of limestone ledges, clay banks and lean faces, and are in every case when carried beyond the depth of the wash deposit and into the solid pipes in the bottom, merely speculative.

The average wash of the material is about 1 to 8 or 9, which will give 1 ton of ore to each 6 or 7 cubic yards of material, a cubic yard of ore being estimated to weigh only $1\frac{1}{4}$ tons.

The washers occasionally showed a record of 1 to 5, but this was when mining was being carried on in exceptional ground.

The majority of the more recent pits (some outside the limits above given) show a depth of only about 10′ of wash ore, under which clay and limestone occur.

Dr. Genth recognizes three varieties of limestone in this bank, and the results of his analyses are as follows;

	(1)	(2)	(3)
Carbonate of iron,	1.31	0.45	.118
" " manganese,	0.18	0.06	trace.
" " magnesia,	3.98	42.39	35.51
" " lime,	72.67	51.25	45.73
Quartz and silicic acid,	18.05	5.03	15.83
Alumina,	3.81	0.82	1.75
Total,	100.00	100.00	100.00
Metallic iron,	0.63	0.22	0.57
Magnesia,	1.90	20.19	16.91
Lime,	40.69	28.70	25.61

No. 1. Upper limestone, dark gray, compact, slightly crystalline. The atomic ratio between magnesia and lime is 1 : 15.

No. 2. Pale ash gray, very finely crystalline, rough to the touch like rotten stone, very friable and easily falling to powder. Atomic ratio between magnesia and lime is 1 : 1—a true dolomite.

No. 3. Yellowish gray, soft, rotten, feels rough to the touch, sandy; crystalline; has a laminated structure. Atomic ratio between magnesia and lime is .1 : 108—also a dolomite.

No. 3 is the most prevalent variety in the bank and it was probably the use of this stone for flux that gave such poor results in the furnace working.

Mr. Lyon states that the old charcoal plant was changed to a coke furnace with 11′ bosh, 43′ high and 8′ at tunnel head. Its record during Messrs. Carnegie's blast, according to Mr. Lyon, was unsuccessful, owing to the use of poor grade and carelessly washed ores—the better grades being shipped to Pittsburg—and poor limestone, so that it was a long time before any iron was drawn from the metal hole at all, passing over mostly with the cinder.

That company likewise abandoned the incline plane shown in diagram, and substituted a narrow-guage road running around the edge of the deposit, and reaching the washers by a considerable grade.

In 1881 it was estimated that the two washers would clean 140 tons of ore daily, allowing for good, rich wash.

The new washer erected by the Carnegies consisted of a trough 25′ long and about 10′ wide, divided lengthwise into three compartments in which revolved hexagonal shafts plated with iron and armed with iron teeth.

The wash material was dumped through a hopper in the trestle railway on to the first shaft, which was slightly raised above the others, into which was conveyed the stream of wash water.

The ore material was carried along the first shaft to the opposite end, where an aperture on one side admitted it to the second and in like manner to the third.

From the third shaft it passed on to a revolving screen with $\frac{1}{8}''$ mesh, and thence to a jigging machine for the purpose of removing the flint.

The great difficulty was met with here owing to the slight difference in specific gravity between this light pipe ore and flint. Moreover, much of the ore occurs in flat, plate-like scales, which, receiving the force of the water in the jigs on their under surface, tended to keep them suspended sufficiently long to float them off with the flint.

To obviate this, the screened material was dropped on to

four flat platform cars about 8′ square, where the flint was picked by boys.

The washers were run by a separate engine, the hoisting power being furnished by a double Worthington engine.

The deepest part of the old bank has been nearly exhausted of cheap ore, and shows several outcrops of siliceous sandy dolomite, very much broken, but dipping south-east. This rock is frequently ore-bearing, showing occasionally streaks from $_1{}^1\!/_8$ to several inches thick.

While occurring in the center of the deposit, they do not seem to have affected the ore which occurs above and below them and frequently interstratified with them.

Some 30 to 60 feet of stripping has been done here, but shafts sunk from the bottom of the open cut 30–40 feet deeper have proved the presence of good ore ground as yet untouched. In the days of early mining here fine exposures of pipes 40′ high are reported, though none such are to be seen to-day.

The best ground, when last visited seemed to be along the south side of the new workings, where really excellent wash ore still remained untouched in a face 30′ high. Good lump ore is reported all along the bottom of these workings, now covered with fine silt and mud, and in any future work this should be mined with the wash surface ore or that in the east end, thus making a cheap and rich average ore.

All the work so far has been done above ground, the floor being usually limestone.

The steam excavator was also tried here for a short time, but was not economical, owing to the frequent occurrence of limestone faces.

To be worked profitably, this machine requires a smooth face of ore, free from rocky boulders or limestone faces, and about 15′ high. These conditions are not apt to occur even in the most favorable pipe-ore deposits, and so far as the efficiency of the machine in these ores is concerned, there can be little doubt that the ore can be more cheaply mined by hand. A nose of limestone is not only a barrier to the progress of the machine, but it involves considerable ex-

pense in necessitating the shifting of the excavator to avoid the rock.

And if this be true of the *surface* pipe ore deposits, it becomes all the more an item of importance when a depth is is reached where these ores become interstratified with the limestone rocks.

For some reason this ore bank was not sampled by Mr. McCreath when he visited the various mines in the county during 1881, but Dr. Genth's analyses in Prof. Lesley's report will give some idea of the nature of the ore.

	(1)	(2)	(3)
Ferric oxide,	81.55	83.74	43.65
Manganese oxide,	0.10	0.31	1.55
Cobaltic oxide,	trace.	trace.	
Alumina,	1.49	0.33	2.43
Magnesia,	0.47	0.34	1.64
Lime,	trace.	trace.	0.12
Phosphoric acid,	0.16	0.14	0.27
Silicic acid,	2.98	2.57	5.19
Quartz,	1.55	0.44	36.52
Water,	11.70	12.13	8.63
Total,	100.00	100.00	100.00
Metallic iron,	57.10	58.62	30.56
Phosphorus,	0.07	0.06	0.12
Phosporous in 100 parts iron,	0.12	0.10	0.39

No. 1. Average of two samples. Amorphous brown compact ore mixed with ochreous yellowish or reddish ore; porous, some of the cavities lined with a very fine coating of fibrous ore.

No. 2. Amorphous porous ore, in columnar masses, the cavities filled with ferruginous clay.

No. 3. Sand rock.

Being hand samples, these analyses do not of course show what may be expected in actual average mining.

No. 3 is apparently the sandstone referred to holding thin streaks of ore and occurring in the body of the deposit.

An additional analysis of this ore by Edward Riley, F. C. S., an English chemist, made in 1871 gave:—

Silica,	10.84
Peroxide of iron,	73.18
Protoxide of iron,	.75
Alumina,	2.51
Oxide of manganese,	trace.
Carbonate of lime,	.20
" " magnesia,	1.20
Phosphoric acid,	.17
Combined water,*	9.09
Moisture,	1.81
Sulphur,	.05
Total,	99 80
Metallic iron,	51.81

North-east through Ferguson township for eight miles to the group of banks south of the State College various surface outcrops of ore show in the different farms along the south flank of the Spruce creek or Sand ridge anticlinal.

All evidences of this arch are lost approaching the College township line.

The succeeding synclinal of Nittany mountain has no opposing anticlinal in Ferguson township, the Penn's valley axis having died away against the mountain west of Boalsburg, so that Tussey on the south and the valley north to the Sand ridge show only south-east dips.

These points must be understood in tracing out the ore belts in this part of the valley.

And just here it may be pertinent to add that while it has not been found possible to follow any one ore range uninterruptedly for long distances lengthwise of the valley, yet deposits in that line are so frequent as to warrant their arrangement in ranges for convenience of description.

The anticlinals which have brought these ore deposits to daylight are accented like waves of the sea, and are alternately rising and falling along the line of their trend.

Erosion, likewise, has played its part in interrupting connection, so that no broad statement affecting the connection of ore deposits through wide areas is possible.

Nearly every farm from the Huntingdon county line to the State College along the flank of the Sand ridge shows ore

indications, none of which have been developed to any extent, owing to the large interest at Pennsylvania furnace.

70. Thus $1\frac{1}{4}$ miles N. E. of the Bryson bank some few pits have been sunk in a pipe-ore deposit on *Kechline's* lower farm.

In a quarry at his house north of the ore outcrop, dolomitic limestone dips S. 40° E. 32°.

The ore show is not very encouraging, nor is what there is of it very rich.

71. The crop at *Campbell's* and *Atlee's* farms is rather better, but the ore lies too high on the limestone ridge to warrant a belief in much depth to it. It is, moreover, very flinty.

72. At *John Bailey's* pieces of good lump ore are frequently turned up in ploughing, but no pits have been sunk here at all. The ore exposed at present is mainly confined to the gullies washed out of the limestone ridge.

73. At *Kustanbauter's* all of the six pits sunk have been placed high upon the flank of Sand ridge.

The deepest one and the highest on the ridge is about 20′ deep, and shows 2′–4′ of soil and the rest fair wash ore.

Two other pits show about 15′ of wash ore.

There is some little ore outcrop higher up the crest, but the show is very lean and unimportant.

The ore in the Kustanbauter pits lies nearer the surface than it does in the cove to the south, which probably accounts for their location.

The ore will wash about 1 in 9 or 10.

74. In *Kechline's fields*, especially towards N. E. in the cove at the south base of Sand ridge, there is an abundant showing of hematite ore mixed with a little large lump pipe ore.

The land lies pretty high and is devoid of water.

The ore lies mostly in the cove running parallel to the Whitehall road, and about $\frac{1}{2}$ mile north of it.

In addition to what few pits Kechline has put down, the Carnegies did some little prospecting.

These were mostly located on the high ground *south* of the cove, and all struck solid limestone in short distances.

The deposit is about 500 yards wide, outside measurement, and extends through three fields covering 8 or 10 acres, with good surface ore, some of it in large lump.

It cannot be called a clean one, having received considerable wash from the high ground on each side of it, and so little systematic work has been done here that the value of the deposit is entirely a matter for future investigation. The deepest shaft is about 30′ and records 12′ of surface dirt, and 18′ of ore to the limestone.

The ore is liver-colored and is said to resemble the *Kerr* and *Bredin* ore in Huntingdon county.

There is certainly an excellent show for ore here if it lies deep. Limestone dips S. 20° E. 30° on land near Kechline's house.

75. *The Miller farm*, next N. E. of Kechline's, against Sand Ridge, claims ore, but no prospecting has been done.

76. Through the *Harper farm* to Weaver's there are also good surface indications, but all the ores in this part of the range seem to lie low, owing, probably, to the sinking of the anticlinal which raised them, to the S. W.

77. North-east of the school-house at *M. Weaver's*, and just north of, but close to, the Whitehall road, the surface is strewn with a mass of ore, flinty in a great measure, but spread over a great area and promising.

It is probably a finely divided pipe ore, which is cut out north-west by a low and narrow limestone ridge, beyond which another show of ore comes in, extending thence in patches N. W. for sevêral hundred yards.

A small bank was opened up several years ago in the field where the deposit was richest, and a small amount of ore removed.

The quality of the deep ore could not be ascertained owing to a filling in of the old pits.

Weaver states that the limestone is 30′ under the surface at this place, and the interval is all good wash ore.

If true, the place should be thoroughly tested, for there is a broad outcrop here 300 or 400 yards wide and fully as long N. E. and S. W.

Weaver sank a few trial pits near the edge of field where the surface is lean and flinty. These pits showed a great deal of clay and but little ore.

78. The outcrop is more or less continuous on to *H. Snyder's* fields, but seems leaner there, located about 1¼ miles N. W. Pinegrove.

A short distance N. E. from here, and probably 8 miles from Pennsylvania furnace, and at the present terminus of the Bellefonte and Buffalo run railroad, is the

79. *Johnson bank.* This opening is located 2 miles S. W. of the State College, on land of Martin Brumgord, and is leased to Brown, McMullen, Divens & Co., comprising the Nittany Valley Mining Co.

Ex-Judge Divens directs the mining of ore here.

The old cut was originally worked for Centre furnace, which used only the lump ore. The refuse on the screening floor has been profitably washed by the present company.

A small cut has been made in one face of this old pit, which shows excellent hematite lump ore, (probably 1 to 3,) but getting below water in the pond they were soon swamped.

The present lessees have confined themselves mainly to the new workings N. E. of the engine-house, though when last seen the developments were meager.

Mining was commenced under a belief in the early completion of the B. & B. R. R. R., and as a result about 1000 tons of excellent well washed hematite lay on the dump awaiting shipment (August, 1883).

Little or no pipe ore has been found with the hematite, which is usually a dark, liver-colored amorphous hematite similar to the Streuble ore to be afterwards described.

The ore itself is rather flinty and cold-short.

Close to the engine-house on the east side of the farm lane a pit was opened 150′ × 80′ × 18′.

A shaft 30′ deep has been carried down at the south end

of the excavation, 12′ being covered with water and the other 18′ showing an excellent face of wash ore from top down. This will certainly wash 1 in 4.

Another shaft was sunk further north in this pit with an idea of draining the first. This has been apparently successful, though limestone was struck at about 5′, dipping S. E.

The east side of this pit shows a bunch of white clay, cutting out the ore, but which seems to be limited in extent.

Plans have been made for settling ponds in the hollow 50 yards N. W. towards the road, where the surface, while showing fair prospects, is decidedly more flinty.

Numerous prospect shafts have been sunk in the field to the N. E., E., and S. E. of the main pit, from 4 to 12 feet deep, all of which show from 4′ to 8′ of wash ore and clay of profitable richness. These have been carried 100 yards east from the pit, and certainly indicate the deepest part of the deposit to lie in a N. 80° E. direction towards I. Carl's farm.

Proceeding south-east the deposit shoaled up rapidly, until just where hill slopes down towards the valley at Pine Grove, limestone crops at the surface, cutting off the ore.

The whole field north of this however, is covered with ore, giving the company a superficial area of about 100 acres.

The company has likewise leased the Carl property to the east, where however, little or no prospecting has been done.

No record has been kept of the average run of the washers, though they claim to be able to make 60 tons of clean ore daily.

There is an excellent forty-horse-power engine, pumping water from a 176′ well with 46′ column of water, and also furnishing power for the washing-machines.

There is an excellent tubular boiler with a capacity of 2100 gallons and with a large heating surface.

South-west some favorable indications were seen, but all in spots and quite flinty.

Mr. McCreath sampled this ore bank in Sept., 1881, just after the present company began mining, and the following is the result of his analysis of 109 pieces dried at 212° F.

Sesquioxide of iron,	65.785
" " manganese,	.723
" " cobalt,	.050
Oxide of zinc,	.010
Alumina,	1.630
Lime,	1.110
Magnesia,	.389
Sulphuric acid,	.067
Phosphoric "	.455
Water,	9.620
Insoluble matter,	20.420
Total,	100.269

Iron,	46.050
Manganese,	.504
Sulphur,	.027
Phosphorus,	.199
Phosphorus in 100 parts iron,	.432

The ore costs about $1 to mine, and being more carefully prepared now, will no doubt show better than the above analysis.

80. *The Streuble Bank*, on land of C. H. Streuble and Sons, is about ½ a mile north of Johnson's mine, on *north* side of the Whitehall road, and 1 mile S. W. of the State College. It is entirely in limestone, at the east end of the Sand ridge anticlinal, though slightly on the south flank. The developments here consist of two pits; the old one, worked many years ago for Centre furnace, lies about 25 yards east of the new one.

The former shows a pit about 100′ E. and W., 80′ N. and S. and about 30′ deep. All the ore taken from here was surface wash ore, rather flinty and used at the old Centre furnace. The refuse fine ore from the old screenings was deposited where the new pit is now opened, and lies about 4′ thick over the surface.

From the bottom of the old pit a shaft was put down, which will illustrate what may be expected in deposits of this character. Its record shows 30′ of wash ore in fine lumps and clay washing 1 to 4 or 5; 18″of sand and clay, and 14′ through hard lump rock ore of a reddish-brown color to the bottom. The thickness of this latter stratum has not been determined, as it presents in the shaft a solid mass of

ore exceedingly hard and requiring blasting, so that work in it was abandoned until the completion of the railroad here.

From the bottom of the shaft drifts were extended about 4′ each way N. and S., and one east for 10′ *through* the ore bed, from which point gangways were driven 15′ each way parallel to the first drifts. A couple of hundred tons of this ore have been raised here, and, while more costly to mine, its increased richness and freedom from wash material will make it advantageous to work simultaneously with the surface deposit.

The new pit is shallow, not being anywhere over 15′ deep, and a section of the east face gave 2′ mixed sand and fine clay, 4′ of old refuse fine ore screenings, and the rest (9 feet) good wash ore.

The present outline (July, 1883) of the pit covers about ½ acre of ground, though the surface indications extend over a much larger area.

Indeed, the whole field, extending south to the road and east to B. Carl's place, is capable of judicious washing from 5′ to 10′, at any rate, though considerably mixed with flinty material towards the public road.

The new bank was opened in the summer of 1881, and, during the two years ensuing, 6000 tons of clean ore have been made. Both pits had been idle when last seen since the winter of 1882–83.

Philadelphia parties have recently leased this land at 40 cents per ton royalty, and active measures were being taken in the fall of 1883 towards thoroughly equipping these banks for a large production.

The machinery at the mine consisted of a double 26′ washer, octagonal wooden shafts braced with iron and armed with iron teeth, a 40-horse-power engine for both pumping and washing, and an excellent well 220′ deep with 112′ standing column of water.

The ore is of good quality, and, in addition to the developed area, many test shafts have been sunk by the

Messrs. Streuble, which warrant a belief in an extensive outcrop on this flat.

Very little, if any, pipe ore has been found here, which seems strange considering the geological position of this bank in the limestone of II; and most of the ore washed shows a dark brown amorphous ore, compact, and with judicious preparation yielding 45 to 50 per cent. of iron. The absence of manganese and the low amount of phosphorous in the rock ore (see analysis below) is to be noted.

Direct railroad communication with Bellefonte (18 miles) is assured by the construction of the B. & B. R. R., the ore having the advantage of an average down grade of 25 feet per mile. The elevation above tide at the bank is 1172.

The following analyses will show the general character of the ore:

No. 1, A. S. McCreath, 15 lbs. of *wash ore*, Sept., 1881. Dried at 212° F.

No. 2, John I. Thompson, sample from wash ore pile, July 30, 1881.

No. 3, John I. Thompson, lump ore from shaft.

	(1.)
Sesquioxide of iron,	63.642
Sesquioxide of manganese,	.195
Alumina,	1.826
Lime,	.290
Magnesia,	.544
Sulphuric acid,	.060
Phosphoric acid,	.263
Water,	10.212
Insoluble residue,	22 980
Total,	100.012
Metallic iron,	44.550
Metallic manganese,	.136
Sulphur,	.024
Phosphorus,	.115
Phosphorus in 100 parts iron,	.258

	(2.)	(3.)
Water,	11.46	15.090
Silica, }	16 51	8.660
Alumina, } Insoluble residue,	.80	.279
Lime, }	.18	.035
Magnesia, }	.06	.011
Sesquioxide of iron,	70.240	76.000

Sesquioxide of manganese,	.224	trace.
Alumina,	.043	.279
Sulphur,	.014	.013
Phosphoric acid,	.291	.091
Total,	99.822	100.179
Iron,	49.17	53.20
Phosphorus,	.127	.039

81. *Blair and Cooper banks.* These are two old and long abandoned pits on the Whipple farm, (formerly P. Lytle,) in College township, in the synclinal of Nittany mountain, just south of the State College, and east of the Streuble and Johnson mines.

The extent of these excavations is pretty well obscured now, not having been worked for 20 years ; but two or three thousand tons of lump ore were screened here between 1850–1855.

The ore crop is first noticed about 300 yards north-west of Whipple's house. Some pits have been recently sunk here, one of which, 30′ deep, shows good wash ore throughout, with the exception of a thin band of white clay coming in 12′ below the surface.

The ore is similar to the Johnson and Streuble deposit, being a heavy, liver-colored hematite, with but little signs of pipe structure. The outcrop shows fairly well, and though narrow, (75 yards wide N. and S.,) it can be pretty well followed for a considerable distance (400 yards N. W. and S. E.) along line of strike.

Blair bank. One hundred yards S. W. of 30′ shaft there is an old, grass-grown opening close to the Ferguson line, which probably marks the position of the old Blair bank.

The pit is 50′ × 25′ × 4′, and a recent opening here yielded some excellent lump ore. Quite a considerable amount of screenings covers the surface here.

Prospecting is too limited here to permit of any judgment as to quality or amount, but the surface show warrants further development. The elevation of the bank is about 90′ above Lemont.

The *Cooper bank* lies further N. E. (see map,) but nothing could be learned about it.

82. The *Puddington bank* is also within this College group of mines. This is located about ½ mile south of Houslerville P. O., on William Thompson's land, in College township.

There are two cuts, both in limestone and close to each other, the smaller lying about 100′ S. W. of the larger and higher on the hill.

They are both on a side hill close to the confluence of Spring creek and the Slab Cabin branch, and are really parts of one deposit. Both banks have been long abandoned, so that all signs of the old mud dam and washers are obliterated.

The pits themselves support quite a luxuriant growth of saplings and underbrush, effectually concealing the ore surfaces.

No regular work has been done here for 30 years. The hill rises rapidly westward. The largest opening measures approximately $30 \times 20 \times 5 = 3000$ cu. yds. The upper bank shows only about 540 cubic yards.

Limestone shows in this, dipping S. E. 20°, which probably led to its abandonment.

Most of this ore seems to be pipe and the faces of the pits, when scratched, show a fair abundance of it.

Some recent pits have been sunk higher on the hill and in the cove running down towards Houslerville, and show in many places excellent prospects. They are, however, only about 6–10 feet deep. In several of them clay bands of non-ferruginous matter were found at that depth, and they were not driven through.

In the deeper ones, located in the cove, the wash was excellent for ten feet.

These pits are spread over an area of 300×400 yards.

The creek affords excellent facilities for washing the ore material, and there is good ground for mud dams. These ores were formerly hauled to Centre furnace up to the time of its abandonment in 1858.

83. *The Big Hollow bank* lies fully 1¼ miles to the north-west, and as nothing but south-east dipping limestones intervene between the two openings, it evidently lies much lower in the limestone series and is more nearly related to the several sporadic ore deposits along Spring creek in Benner township.

The bank takes its name from the marked cove extending eastward towards Spring creek at Houslerville and rising gradually westward to the B. & B. R. R., whose graded line can be seen from the mine.

The opening is on property of Moses Thompson, about 2 miles north of the State College, and, like the many other banks dependent on Centre furnace, closed its active existence when that furnace went out of blast in 1858.

It is a shallow pit of pipe ore, in which limestone noses are a prominent feature. The present excavation is only 10′ deep; but, as it is reported to have supplied Centre furnace with a great deal of ore, it is presumably much filled in now. The hole is about $20\times8\times3=480$ cubic yards. Some prospecting has been done north of the road in the woods, but the shafts have all been filled up. At present the best surface show is around the school-house, though in the field south and down into the hollow I picked up some excellent lumps of pipe ore.

The pit itself shows much flint, and the surface deposit can have but little depth. The elevation is fully 75′ higher than Puddington and with no show for surface water.

South 300 yards across hollow some few trial shafts have been put down on a limestone ridge 8′ or 10′ deep, with some chances; but limestone crops at several places, dipping 14°–16° S. E., and but little surface ore may be expected.

Openings north-east of Pinegrove. Passing once more to the south side of the valley, an evidently higher range of ore-bearing limestones, not over 1000 feet below the slates of III, is indicated.

The ores are all pipe and are geographically south of the Whitehall road.

84. The most western outcrop of this ore is in a small 8′ pit near *Levi Kreps'* house, where some fair pipe ore was uncovered.

Ore was also met with in digging foundations for his house.

85. A feeble but increasing crop may be traced N. E. across Mitchell's, W. H. Bailey's, and Ard's fields to Weaver's, where excellent pipe ore was found.

North-east in a direct line from this outcrop is the

86. *Ross bank*, about 1 mile north of Pinegrove mills. It is on high ground north of Slab Cabin run, and probably marks the dying end of the Brush valley anticlinal, which sinks against Tussey mountain in this vicinity. The old opening was worked by General Irwin for Monroe furnace in Stone valley across Tussey, to which it supplied many hundreds of tons. It was said to be a decidedly red-short ore, and to have shown lumps of pyrites mixed with the ore. The largest cut is on land of J. D. Crepe, though the entire farm was originally owned by John Ross, from whom the bank takes its name.

The excavation is about 100′ × 100′ × 20′ or 7000 cubic yards. The bank has been abandoned for many years. The face shows good wash ore, all pipe, and a considerable amount of fine screened ore on dump.

There is a thick covering of earth and soil towards the creek north. The bank is fully 125 feet above the level of the creek at the bridge, where the little ore washed was cleaned at Crepe's house. Limestone comes to the surface on the farm road east of opening and outcrops almost continuously down to the valley at the base of Tussey, with S. 40° E. dips of 42°–20°.

The show for water at the bank is very poor.

Some prospecting has also been done 150 rods S. E., on the Ross farm by Bellefonte parties who report a shaft 65′ deep, finding excellent pipe ore beneath limestone, into which they drifted. The surface outcrop here is considerable.

87. The *Stover bank* on property of G. W. Hale, 1½ miles N. W. of Boalsburg, lies close to the Brush valley arch,

though slightly on its north flank. It is entirely in limestone rocks and about as high in the formation of II as the Ross bank.

The anticlinal can be well recognized just east of the bank on the road up branch of Cedar run, with dips of 48° N. W. and 12° S. E.

The bank shows only pipe ore, but though the pits have been abandoned the deposit is reported to have both considerable size and depth. Some work was done here about 5 years ago and the little ore raised was washed on Spring creek 100′+ vertically below the bank, and hauled 18 miles to Bellefonte to the Curtin works. Most of that carried away was selected large lump pipe ore. Considerable drifting was also done.

The limestone comes to the surface in the west cut dipping 40° N. W. Much of the development here was made between layers of limestone. The surface ore is excellent, and very free from flinty matter. Spring creek is ⅜ miles distant to the north-east.

There is a continuous show of ore to the south-west across the township road on to the Bricker (Scott and Mitchell) farm. Limestone also comes to the surface here in the woods on a low flat hill.

A small pit on the west side of the road here is said to have shown good results. The surface show, however, is meager being much better south-west on R. Goheen's and Ishler's farms (Meyers' estate) on the *south* side of the anticlinal.

The country is generally very high, but flat, and carries a considerable area of surface pipe ore.

In concluding this group of ores, it is evident that the Pennsylvania and Ross-Stover banks are *not* on the same horizon. That the latter lies much higher in the limestone series of II and ½ mile further south. This Pine Grove range cannot be traced with any distinctness south-west of the village, the ridge and anticlinal holding these ores dying away very perceptibly towards Beaver branch run and rising again beyond only in a small knoll, south-west of which the ridge is replaced by low land in which no ore is

reported. The Bryson (Pennsylvania bank) horizon is easily distinguished by is cove topography as well as surface outcrop, which is fairly continuous with the south flank of the Sand ridge anticlinal which flattens N. E. towards Nittany mountain.

Obviously the best of the deposits along the numerous farms mentioned is confined to this hollow and it is here that further prospecting should be done. The ridge to the south is No. II, and the limestone is in place only a few feet below the surface. The material at the surface is all flinty, but all the pits show tolerably good ore, which however can only be *profitably* washed with well water.

Chapter XII.

Brown Hematite Ores of No. II, continued.

G. Penn's Valley Group.

Under this heading may be classed all the remaining brown hematite deposits in the limestones of II in Penn's Valley. The comparative scarcity of developments here is due mainly to three facts, which must be born in mind when studying the economic features of the various limestones south of the grand Nittany mountain synclinal.

1. The comparative weakness of the anticlinal axes which have not been strong enough to bring to daylight more than one half the total thickness of No. II and consequently bury beneath the surface of the valleys the ores of the lower limestones.

2. The great erosion of this section of the county owing to the steep dips of the rocks, and the consequent obliteration of much of the surface deposit.

3. The absence of railroad communication and the more advantageously located position of the Nittany valley and "Barrens" ore banks with regard to outside demand.

Otherwise the people of Penn's valley have every reason to expect a good future. Their ores are clean and rich; they can be cheaply mined, and the completion of the Sunbury and Tyrone railroad *via* Lemont to Bellefonte will give them two outlets to their product and excite a healthy interest in prospecting and developing this field.

88. The *Ross Bank*, in Harris township, ½ mile north of Linden Hall, is an evident continuation east of the Stover-Ross deposit already mentioned. It is located on land of

James M. Ross, and close to the anticlinal arch of Brush valley, the axis passing just north of the opening.

The pit is on a flat about 100 yards S. W. of Ross' house. It is entirely in limestone and some excellent large pipes have been removed from a 64′ shaft to limestone rock at 45 feet.

About 20′ below surface a drift was run northwards 22′, reported all in ore. The rocks here dip south-east 12°–15°.

A short distance south-east another hole was put down to rock at 15′, all in ore, so that the surface deposit must be narrow and the basin deep. It can, however, be traced N. E. and S. W. for some distance, appearing again on the west side of the road in *Tressler's farm.*

The field on top of the Ross flat shows good surface indications, though not broad. Pits sunk further N. E. towards the hollow were unproductive. Tressler's land is well spoken of, but owing to a thick clover crop at the time of my visit, nothing much could be seen there.

Both places are rather inaccessible. No mining has been done here, and the test pits are too few to judge of the extent of the deposit. I regard the property, however, as one of future promise, and the excellent character of the ore as demonstrated by the following analysis by Mr. McCreath of 126 pieces of wash ore from trial shaft, sampled in Sept., 1881, and dried at 212° F., will speak for itself. The percentage of sulphur in the form of undecomposed iron pyrites is noticeable, and taken with the Sinking creek mine to be shortly described, is significant as bearing upon the original derivation of these pipe ores.

Bisulphide of iron,	.515
Protoxide of iron,	.353
Sesquioxide of iron,	75.892
Sesquioxide of manganese,	.433
Sesquioxide of cobalt,	.200
Alumina,	.955
Lime,	1.130
Magnesia,	.518
Sulphuric acid,	.022
Phosphoric acid,	.355
Water,	10.385
Insoluble matter,	9.610
Total,	100.365

Iron,	53.640
Manganese,	.302
Sulphur,	.284
Phosphorus,	.154
Phosphorus in 100 parts iron,	.237

89. The *Watson bank* lies 2 miles further east in Potter township and 2½ miles south-west of Centre Hall.

This bank is on property of Mrs. Margaret Gregg, but McCoy & Linn, of the Milesburg Iron Works, own all ore rights.

The anticlinal passes a little south of the bank, and is steadily bringing up lower measures in its rise towards Centre Hall, where it begins again to subside eastward.

The developments are roughly, $125 \times 100 \times 10 = 125{,}000$ cubic yards. The ore occurs entirely in limestone dipping steeply N. W. and within a ¼ mile of the margin the Hudson river slates of III along the south base of Nittany mountain.

The same system of mining is pursued here as at the Hecla bank in lower Nittany valley, chunks of limestone and lean clay being left in the bank, and the ore drifted for when it occurs between ledges of limestone.

In the bottom of the excavation there is an old shaft 120′ deep, which was mostly in ore according to Mr. McCoy, the ore being formerly hoisted by an incline plane.

The ore is pipe, of an excellent quality, as the analysis will show, much of it washing 1 to 2 or 3. But the greatest proof of its purity lies in the fact that though this bank has been worked with considerable constancy since 1800, there is scarcely any dirt pile to be seen, everything passing off as clay in the washers.

The surface deposit is considerable, and instead of the above figures a tract 600 yds. E. and W. and 400 N. and S. will better indicate the available wash territory.

It is the best show I have seen in Penn's Valley, and with railroad facilities a large output could be secured here.

Even without railroad communication it is considered profitable to mine small quantities of this ore at present, on account of its purity, and haul it across Nittany mountain 10–12 miles to the Milesburg furnace.

Only surface grubbing is being carried on here now, and the material is conveyed to a single shaft (20′ long) open horse-washer 300 yards distant in the hollow just below Gregg's house.

The wash water is caught in a dam, to which it is conveyed by sluice-boxes from a mountain spring.

Several mud dams have been erected in the flat below to thoroughly clarify the water before it enters a sink-hole on the south side of the valley road.

West, this deposit can be traced with more or less success through the following farms: John Sanky, John Bitner, Samuel Crozer, Joshua Potter, Geo. Leech, Shannon Boal to Jno. Ross, comprising a belt nearly 2 miles long, much of which invites prospecting.

East, one field there is a fine show of ore on Osman's farm as yet undeveloped, where several shafts 35′ deep report excellent results. The Van Valzah farm also claims ore.

The following analysis by Mr. McCreath from sample of 173 pieces of wash ore made in 1881 and dried at 212° F. hardly bears out Mr. McCoy's testimony of this ore in his furnace working, but no doubt is fairly representative of its quality at the time of sampling:

Protoxide of iron,	.482
Sesquioxide of iron,	65.964
" " " manganese,	.362
" " " cobalt,	.030
Oxide of zinc,	.260
Alumina,	1.609
Lime,	1 830
Magnesia,	1.120
Sulphuric acid,	.085
Phosphoric "	.311
Water,	12.375
Insoluble matter,	15.780
Total,	100.208
Metallic iron,	46.550
" manganese,	.252
Sulphur,	.034
Phosphorus,	.136
Phos. in 100 parts iron,	.292

90. *Emerick bank*, in Brush valley, ¼ mile east of Centre Hall, owes its position to the same anticlinal. The developments are meager, and consist of a few shallow trial pits 5 to 10 feet deep.

The surface show is poor. The ore is pipe, and what little surface ore there is is caught on high ground and within a very limited area.

East of Lingle's the whole surface show is lean and flinty and the limestone crops everywhere along the valley. I doubt if much other ore will be found further east. The following is Mr. McCreath's analysis of 115 pieces from trial shaft, September, 1881, dried at 212° F.:

Sesquioxide of iron,	68.714
" " " manganese,	1.654
" " " cobalt,	.040
Oxide of zinc,	.070
Alumina,	1.353
Lime,	1.320
Magnesia,	.295
Sulphuric acid,	.085
Phosphoric acid,	.313
Water,	12.566
Insoluble matter,	14.150
Total,	100.557
Metallic iron,	48.100
Manganese,	1.152
Sulphur,	.033
Phosphorus,	.137
Phos. in 100 parts iron,	.284

91. *J. P. Runkle* trial shaft is south of this range about 2 miles but in geologically similar rocks brought up by the Penn's valley anticlinal about ¾ miles north of Centre hill, in Potter township, and on the south side of the Penn's valley axis. The pit lies on very high ground between the synclinals of Brush mountain and Egg hill, and was carried down 30′ with 6′ of top soil. The ore is pipe as far as tested, of excellent quality.

Several large chunks of pipes 2′ to 3′ long have been removed as specimens.

The surface show is considerably mixed with a limestone

clay, and though weak, can be traced east into Henney's farm and west towards William Boal's and the Krumerine farms.

This deposit is cut off north by a limestone ridge at Brockerhoff's farm. The ore lies a little low, and may be 300–400 yards wide.

Col. James P. Coburn, of the Penn's Valley Mining Company, claims to own ore rights here, and says the property has been fully tested with pits now filled up. Ore was found in them to a depth of 40′, the shallowest being 6′ when limestone was struck.

The following is McCreath's analysis. Sample, 107 pieces wash ore from shaft, September, 1881, dried at 212° F.:

Protoxide of iron,	.128
Sesquioxide of iron,	74.428
" " " manganese,	trace.
" " " cobalt,	.110
Alumina,	1.286
Lime,	1.480
Magnesia,	1.138
Sulphuric acid,	.117
Phosphoric acid,	.343
Water,	13.720
Insoluble matter,	7.390
Total,	100.140
Iron,	52.200
Sulphur,	.047
Phosphorus,	.150
Phos. in 100 parts iron,	.287

92. The *Sinking Creek mine* or *Wagner bank* of the Penn's Valley Mining Company, Potter township, lies one mile east of Centre Hill and close to the edge of the Egg Hill slates on Sinking creek. It is on property of Bernard Wagner and was last worked by Gen. Irwin Gregg. The mine was idle when visited in July, 1883, and showed a narrow trench dug between ledges of No. II limestone, dipping S. 33° E. 52°–65°. The west branch of Sinking creek flows past the cut and its waters have been utilized for washing the ore.

The bank exhibits a characteristic pipe ore deposit, confined to limestone crevices and devoid of any surface crop.

The thickness of the ore bed is extremely irregular, but always furnishes a rich wash as mined.

The high percentage of iron in this case would make this ore extremely valuable were it not for the fact that the large pipes when broken nearly all show undecomposed cores of iron pyrites yet unoxidized, and creating a red-short iron.

The specimens examined show the presence of pyrites in all stages of decomposition.

The ore on the dump, about 100 tons, looks beautiful, occurring in large lump pipes, one of them weighing 1,500 pounds; but inside, are all made up of sulphuret of iron cores.

Trial shafts in adjacent fields show some little signs of ore but no wash ore is visible. From 4 to 6 feet of broken limestone covers the deposit. No better place exists in the county to study the character of these pipe ore deposits.

The bed varies from a few inches to 6′ thick. Drifting has been done north and south with some success.

The locality, however, is not favorable for cheap ore in the face of more advantageously located surface deposits.

Mr. Coburn states that a small *roll* was encountered in mining here and reports much ore taken out on a north dip. In fact, a drift run north 40′ developed a bench of ore 22′ thick which showed a slip at that point of 10′ or 12′ under which ore was again found.

The *roll* can only be local as it cannot be detected elsewhere, unless we connect the two steep N. W. dips of 50° and 80° in the public road with this arch.

There is a double washer here, 22′ long, which has cleaned as high as 60 tons a day. The teeth are fastened on to octagonal wooden shafts in the old style, being cast on an iron bar with 5 teeth to each bar.

The development is $300' \times 60' \times 20'$, only about one half of which is in ore.

The following two analyses are by Mr. McCreath. Sampled Sept. 1881, and dried at 212° F.

No. 1, 207 pieces of lump ore. No. 2, 189 pieces of wash ore at washer.

	(1)	(2)
Bisulphide of iron,	.800	.137
Protoxide of iron,	.642	.385
Sesquioxide of iron,	76.071	67.428
" " manganese,	.185	.014
" " cobalt,	.030	.050
Oxide of zinc,	.070	none.
Alumina,	1.838	1.674
Lime,	1.220	2.180
Magnesia,	.200	.594
Sulphuric acid,	.107	.125
Phosphoric acid,	,224	.288
Water,	11.778	10.870
Insoluble matter,	7.280	15.690
Carbonic oxide,	—	.730
Total,	100.455	100.165
Metallic iron,	54.123	47.564
Metallic manganese,	.129	.010
Sulphur,	.470	.123
Phosphorus,	.098	.126
Phos. in 100 parts iron,	.181	.265

Chapter XIII.

Iron Industries of Centre County.

The various iron ore mines, blast furnaces, rolling-mills, forges, etc., of Centre county represent an important industrial interest, but not by any means what it should be.

When the many advantages of the region are taken into consideration, the proximity of ore, coal, and flux; the numerous projected railroad facilities for moving both raw and refined products at competitive rates; the agricultural resources of the district rendering living both cheap and comfortable, and the abundant water power, it seems strange that Centre county should be so little advanced in this respect.

Historically, the county has played an important rôle in the past in the production of charcoal iron, and various picturesque ruins of little charcoal furnaces still dot its valleys.

Located for the most part through Bald Eagle valley, where the requisite water power was most readily obtained, the expense of hauling the Nittany valley hematites over the mountain, the scarcity of fuel, and the decreasing demand for charcoal iron in the various arts have led to the successive abandonment of most of these sites, while no effort has been made to replace them with more modern structures.

When it is stated that in this vast virgin field of ore territory capable at any moment of furnishing thousands of tons of excellent 40–50 per cent. ores, with an abundance of good limestone and coke from its Snow Shoe coal-fields, there is not a single coke or anthracite furnace erected (unless we except Pennsylvania furnace, which is really in Hun-

tingdon county,) the position of affairs will be readily understood.

The following historical account of early iron enterprises in the county may be of some interest. It is an extract from the report to the Centennial Commission, entitled "Iron Making in Pennsylvania":

"Centre furnace,* located about nine miles south-west of Bellefonte, was the second furnace erected in the Juniata valley or near its boundaries.

It was built in the summer of 1792 by Col. John Patton and Col. Samuel Miles. The first forge in Centre county was Rock forge, on Spring creek, four miles south-west of Bellefonte, built in 1793 by General Philip Benner, who subsequently originated other enterprises in the county, and became an extensive shipper of Juniata iron. He died in 1833, long before which his Rock forge enterprises had expanded into a rolling and slitting-mill, nail factory, furnace, etc.

* An interesting record of the ore used and product obtained at this old furnace between 1852 and 1858, when it was finally abandoned, was kindly furnished by Mr. J. I. Thompson, of Lemont, from the furnace books. Most of the ore was lump, which was carted to the furnace and roasted there so as to be broken into suitable sizes. The ore records for the years 1856–57–58 have been lost. The small amount of pig metal produced in 1854–55 and large ore tonnage was owing to the accumulation of stock, much of which yet remains on dump.

NAME OF BANK.	1852.	1853.	1854.	1855.	1856.	1857.	1858.
Puddington,	434	44	516	519			
River Hill, (Scotia,)	1,170	827	1,303	621			
Blair,	425		244				
Markle,	15						
Lambourn,	77	223	477	256			
Watson,	291	1,884	583	57			
Cooper,	165		129	1,115			
Jackson,		12					
Red Bank,		213	77				
Big Hollow,			325				
Gatesburg,			40				
Irwin,			140	418			
Robeson,			1	39			
Newell,				33			
Totals,	2,577	3,203	3,834	3,062			
Tons of pig metal produced,	939	1,274½	955½	737	613½	478	238

The furnace was built in 1816.

In 1795 Daniel Turner erected Spring Creek forge and in 1796 Miles Dunlap & Co. had Harmony forge, on Spring creek, in operation. Logan furnace, near Bellefonte, was built in 1800 by John Dunlap. In 1607 Roland Curtin erected a furnace on Bald Eagle creek, about 4 miles from Bellefonte, and in 1817 he built a furnace called Eagle. In 1831 a small rolling-mill was added for the manufacture of bar iron and nails. About 1820 Hardman Philips erected at Philipsburg a forge and screw factory, the latter one of the first of its kind in the country.

Cold Stream forge was erected about the same time by John Plumbe, Sr., in Rush township.

* * * For many years after the beginning of this century, Huntingdon and Centre counties constituted the principal iron producing district in the country, Pittsburgh and eastern cities manufacturing the iron which they produced.

This prominence in the production of iron was maintained until after 1842, when the tariff of that year and the discovery that iron could be made with anthracite and bituminous coal enabled other districts of the State and country to wrest from these counties their iron scepter."

Most of the enterprises referred to in this sketch have been abandoned now or transferred elsewhere; but that iron-making still engages the attention of a large portion of its population, is made evident from the following details of the still existing and active plants:

1st. *Logan's furnace*, Valentines & Co., located on what is known as the Forge tract of 275 acres, about ¾ miles southeast of Bellefonte. This furnace lies north of the original plant. The various buildings are all situated on the west side of Logan's branch, which rapidly flowing stream insures them abundant water power, in addition to supplying other industries such as Mann's axe factory, Hume's mill, Bellefonte car-works, Duncan & Co.'s machine works, etc.

The cold blast charcoal furnace has a 32′ stack, 8′ bosh drawn in to 2′ at tunnel head.

Blast is run by water power, though steam attachments

are on ground ready for use if required. The engine has two 40″ cylinder boilers, blowing cold air through one tuyere with 3″ nozzle.

The production is about 75 tons per week or about 3700 tons per year.

The charge is from 2⅛–2¼ tons of ore, 150 bushels of charcoal and 100 per cent weight of limestone, or from 50–100 lbs. per charge of 1000 lbs., the charge varying slightly with the character of the ore.

Nigh bank ore is almost exclusively used here now. The rolling-mill is run mostly on boiler and wire iron. The forge plant consists of six 36″ cylinder boilers and 12 heating ovens, two steam power cylinders, 4′ stroke, 44″ diameter.

The blast engine cylinders are 14″ diameter and 4′ stroke. Hammer engine, 12″ and 4′ stroke. Charcoal is hoisted by an incline to furnace top, being brought in cribs on flat gondola cars from the Allegheny mountains.

The present works require about 100,000 tons of charcoal a year, requiring about an acre of timber ground daily to produce, so that the day for charcoal furnaces in this sparsely-timbered district can be readily discounted.

2. *Milesburg Iron-Works.* (McCoy & Linn,) situated on Spring creek, in Boggs township, about 1 mile south of Milesburg. The furnace is about the same size as the Logan, just described, and similar to it in other respects. It was built about 1830. The rolling mill has 7 heating furnaces, 3 puddling furnaces with a capacity of 30 tons a week; 2 heating furnaces for blooms and billets, 3 trains of rolls, and 2 hammers; steam and water power. Most of the stock is sent to wire-mill, where it is made into all sizes of wires and bolts.

Some little is made into boiler plates. Capacity, 3000 net tons.

3. *Pleasant furnace*, (Curtin Bros. & Co.,) situated at Curtin Station, B. E. V. R. R., in Boggs township, known as Eagle Works. It was built in 1847, after the abandonment of Martha furnace. The forge here was built in 1810. The original Eagle furnace, 1 mile west, on site of present rolling-mill, was built early in the century, prior to the

erection of Martha. The furnace is 31′ high, 8½′ bosh, drawn in to 2′ at tunnel-head. Preparations were being made in the fall of 1883 for a renewal of hearth and an additional tuyere to be used either alternately or simultaneously with the single one then used. Open hearth, cold blast, water power. Blast was furnished by a Houston water-power wheel; 2cold-blast cylinders, each 62″×42″ and 4′ stroke.

The forge has 8 heating fires, using about 90 bushels charcoal to the ton. An old wooden undershot water-wheel furnished power for hammer, soon to be replaced by a Jenkins (Bellefonte) turbine wheel. Product chiefly bars for boiler plate.

Rolling-mill has 1 single puddling furnace, 1 heating furnace, 2 trains of rolls, and 1 squeezer. Capacity, 2000 tons.

4. *Howard furnace*, (Bernard Lauth & Co.,) located at Howard station, B. E. V. R. R., in Howard township. One stack 33′×8′, built in 1830; coke; annual capacity, 5000 tons. One stack 31′×8½′, built in 1833; charcoal cold blast; water power. Only the latter is now used. Boiler plate iron.

Rolling-mill was built in 1840; 6 single puddling furnaces, 2 heating furnaces, 3 trains of rolls, (one 16, one 12 and one 8-inch,) and 1 rotary squeezer; water power. Capacity, 3000 tons.

The old *Hecla furnace* (McCoy & Linn) was built in 1820. It was a cold blast charcoal stack, 32′×8′. but has been abandoned for a long time, until the site is barely visible.

Washington furnace and *Pennsylvania furnace* lie just outside the county line, in Clinton and Huntingdon counties.

The following estimates of cost in making a ton of metal at Bellefonte may fittingly close this chapter, and provide comparison with other districts.

They will all probably fall short of the results obtained in furnace practice, but have nevertheless been made on the usual basis of such calculations and are presented without comment for the judgment of those interested in such work.

Mr. Abraham Valentine, under date of July 17th, makes the following estimate for a ton of pig metal from a good

coke furnace producing 75 tons per day, and supposing railroad connection to ore banks—the latter, together with the plant, owned by the operating company:

Coke, (Connellsville) 1¼ tons @ $2.25,	$2.81
Ore, (Nittany valley hematites) 2⅛ tons @ $1.25,	2.66
Limestone,	.50
Labor,	1.50
Expenses (wear and tear),	.75
Interest on investment,	.59
	$8.72

"We are now making charcoal metal with 2¼ tons ore cold blast, and about ¼ ton of limestone. We can now get coke delivered at $2.00, and when the Clearfield region is opened up through B. C. C. & S. W. R. R, we should certainly get it as cheap, if not cheaper, so that the figures given are not too low. You can throw in $1.25 per ton for extras and still make iron for $10 per ton."

In further illustration of this interesting subject I present a further estimate, made on Sept. 22d, 1883, under similar circumstances and compiled by Messrs. Coxe and Howe, of the Montour Steel and Iron Co., Robert and Abraham Valentine, and Gen'l James D. Beaver, of Bellefonte. The figures for ore *only* were furnished by the Messrs. Valentine.

Ore (Nittany valley hematite 45–50 per cent iron), 2¼ tons @ $1.50,	$3.38
Coke, 1¼ tons @ $2.25,	2.81
Limestone, ½ ton @ .50,	.25
Labor at furnace,	1.50
Miscellaneous, general repairs, etc.,	1.50
Sinking fund, for chilled furnace, breakage, etc.,	.50
Interest at 6 per cent,	.35
	$10.29

For comparison the following estimates at various places in Virginia and Pennsylvania are taken from Mr. McCreath's report on the "Mineral Wealth of Virginia." Estimates made in 1882.

Milnes,	Virginia,	$12 55
Buchanan,		12 94
Roanoke,		12 58
Central,		11 89
New River,		11 03

Middle Pennsylvania,*	Pennsylvania,	$18 22
Harrisburg,		18 35
Lehigh Valley,		20 38
Pittsburgh,		17 97
Philipsburg, N. J.,		17 87

The present product of the furnaces—charcoal pig—is estimated as follows:

Logan furnace,† Messrs. Valentine & Co., March 21, 1884.

2¼ tons of ore, @ $2,	$4 50
150 bushels of 2150 inches charcoal, @ 6½ cents,	9 75
¼ ton of limestone, @ $1,	25
Labor at furnace on above,	1 90
Other expenses: smith, carpenter, management, interest, etc.,	1 60
	$18 00

"These other expenses will vary, of course, with amount of iron made, and with railroads to mines and larger furnace would be materially reduced, as also labor on each ton of iron made."

Mr. A. G. Curtin, Jr., under date of March 29, 1884, sends the following estimate of cost of producing a ton of pig metal at the Pleasant furnace of the Eagle Iron Works:†

4750 lbs., one half Fishing Creek bank and one half Red bank ore, @ $2 50,	$5 30
109 bushels charcoal, @ 6½ cents,	7 08
500 lbs. limestone per ton of iron, @ 50 cents,	15
Labor at furnace,	2 07
Contingent expenses, management, interest, etc.,	3 00
Bad weather, wet days, etc.,	1 00
	$18 60

It is the practice of this firm to charge their forge with metal at $19, though they have equal facilities with other parties in manufacturing cheap iron.

These are both fairly representative estimates of the average cost of production of charcoal iron, both companies at present being obliged to transport their ores by teams 3 miles to their furnaces, and bring their charcoal from the Allegheny mountains, 23 miles distant.

The Howard iron works,† less advantageously situated in

* Broad Top region. † Published by permission.

the Bald Eagle valley, 10 or 12 miles from Bellefonte, estimate under date of March 29, 1884, at $25 00 per ton, as follows :

2¼ tons of ore @ $4 00,	$9 00
160 bushels of charcoal @ 7 cents,	11 20
⅕ tons of limestone @ 90 cents,	18
Labor at furnace on above,	2 00
Other expenses, management, repairs, etc.,	2 62
Total,	$25 00

The large increase in the first two items of ore and coal at this point will account for the increased cost of manufacture here.

Mr. Frank McCoy, of the Milesburg Iron Works, located near Bellefonte, states their quantities of raw material used in the conversion into a ton of charcoal metal at 2¼–2½ tons of ore ; 600 to 900 bushels of limestone and 120 to 140 bushels of charcoal.

With the early completion of numerous graded and prospective railroad lines ; with an abundance of 45–50 per cent hematite ores readily and cheaply mined and limestone and coke very accessible, Centre county certainly seems a favorable locality for the manufacture of cheap iron, and the re-establishment of her position in the front rank of iron-producing counties of Pennsylvania.

Chapter XIV.

Township Geology.

In the preceding chapters, on the Coal Measures, the Ore Mines, &c., many geological features have been already sufficiently described which otherwise would find place in this chapter.

Thus the detailed description of the coal measure rocks in chapter V practically includes everything of interest in the geology of Rush, Snow Shoe, Burnside and northern Curtin townships.

1. Rush township.

Almost the entire area of the township outside of the coal measure rocks, is occupied by the conglomerate of XII or the coarse white sand resulting from its disintegration.

The Tyrone and Clearfield pike shows some few exposures of the underlying rocks XI and X, the latter well seen at the Big Fill at Mt. Pleasant station.

At the Taylor line, No. X shows a dip of about N. 45°, W. 3°, in buff and white sandstone in beds 15′ thick with intercalated shaly SS. Various outcrops of the same occur on both sides of the curve with gentle north-west dips, forming the terrace of the Allegheny mountains, and crowning the various knobs on either side of Ameigh run.

Probably 100′ ± of X show at the station, made up of massive white sandstone beds sometimes tinged with red, with shaly bands and all dipping about 3° N. W. The outcropping edges are a yellowish brown as if stained by iron.

No. X extends along the tangent east of Mt. Pleasant station to point of curve, where it is succeeded by some rusty brown and red shales very much disintegrated and intermittent and probably representing No. XI.

This is succeeded by fine grained sandstone and conglomerate of No. XII to Sandy ridge, 250′± thick and carrying on top at the latter place the fire clay already described.

2. Snow Shoe township.

This township has likewise been pretty thoroughly described in chapter V. For 1 mile south of Snow Shoe city bowlders of a fine grained coal measure sandstone occupy the railroad, the southern limit of the coal field being probably somewhere near the forks of the road.

The railroad passes for 100 feet through this rock and again cuts similar sandstone dipping about 3° N. W. about ¼ mile north of Fountain station.

A rather more fine grained sandstone shows just north of the long trestle, about 10′ thick, and a probable representative of the Homewood sandstone or upper member of XII.

The first side cut south of the trestle over Beech creek is in XII also, exposing a massive but fine grained sandstone for 200′ along the track, dipping N. 40°, W. 2°–3°, and about 25′ thick. It consists of beds of sandstone intercalated with shaly measures 6 inches to 1 foot thick.

The sandstone is generally a gray banded rock, but slightly conglomeritic, carrying masses of red chert and sandstone in a central bed 6′ thick. The shale is ochre to olive color and decomposes readily.

From here to the Boggs township line similar exposures of XII occur, differing but slightly from those already mentioned. The underlying measures XI and X are only exposed in this township along Beech creek east of Cato, and they have been described in chapter V.

3. Burnside township.

The eastern division of this township is occupied by the coal measures of the first and second basins on either side

of the Pine Glen-Hyner axis, which dies as a distinct topographical feature west of P. Etter's house.

The central part of the township occupied by this anticlinal ridge is a high barren plateau of XII, dividing the drainage system of Beech creek and the West Branch Susquehanna. In the numerous affluents of the latter are exposed sections of the Mauch Chunk red shale XI, and Pocono sandstone X, the former nowhere measurable, but the latter showing a thickness in the north-eastern portion of the township of 300′±.

No. XI goes under water level at Salt Lick and carries between it and Buttermilk Falls, carbonate ore decomposed on its outcrop to a slimy hematite.

South of the anticlinal in this township the conglomerate of XII shows in the ravines of the various branches of Beech creek, dipping south-east and carrying on top near the Snow Shoe line, the north edges of the little detached Beech creek coal basins.

4. Curtin township.

Nothing lower in the series of the Palæozoic rocks than No. VIII occurs in this township, and of this formation only the Upper Chemung member.

The high ridge known as the *Marsh Creek Divide*, between Curtin and Howard townships, is made up along its north flank of these Chemung slates and sandstones up to the lowest red band in the overlying Catskill No. IX formation.

In this township exposures of VIII are scarce owing to the mountain drift; but one outcrop of flaggy sandstone dips N. W. about 80° on the Howard road south of Brickley's.

Marsh creek forms the divide between VIII and IX from the Liberty line as far west as the saw-mill at the second road over the hill, though towards Liberty, the red sandstone hills of IX have receded from the creek to make the meadow-land of the Marsh creek flat.

At Brickley's the creek flat is narrowed, and bluffs of

red sandstone (Catskill No. IX) skirt the north side of road with dips of 16°, 14°, and 15° to the north-west.

From J. V. Knoll's west, No. IX occupies the creek bed exclusively to the Boggs township line.

The north boundary of No. IX (including in this division the transition layers between the Catskill and Pocono formations) lies about 400 yards north of the north branch of Marsh creek. The junction with the white sandstone of X is tolerably well marked below Mrs. Hawk's house on the Cato road, though the red and olive sandstones and shales of the Catskill-Pocono group extend still further north in a narrow strip along Weasels run.

Pocono sandstone No. X is only partially exposed in place along the Cato road, 200 yards north of Mrs. Hawk's, where it shows a thin-bedded fine-grained gray sandstone, 30 feet thick, dipping 10° to the north-west. This is succeeded in 100 yards along the road by buff and red shaly sandstone, dipping about 8°, and finally a pebbly hard white sandrock forms the bluff and terrace of the mountain.

No. XI Mauch Chunk red shale is difficult to recognize here as elsewhere through the county, but is somewhere near the junction of the Cato and Hays Run roads.

The conglomerate of XII marks the summit, dipping with gentle angles to the north-west and carrying the lowest coal measure beds in Coal hill and in the high knob south of Beech creek.

The tier of townships making up the Bald Eagle valley and Allegheny mountain foot hills from Blair county to Clinton county everywhere present very similar features.

They all present a sequence of the Middle Silurian, Devonian, and Sub-Carboniferous rocks from the Medina sandstone of IV to the Pocono sandstone of No. X, and in Boggs and Union townships even the succeeding formations Nos. XI and XII.

They include all the rocks of the Bald Eagle-Allegheny mountain monoclinal, exposing highly inclined strata in the first named ridge, with gradually decreasing dips up to the Allegheny summits, but always dipping northwards.

They comprise a rock mass nearly 12,000′ thick, the relative position of whose members and their general thicknesses are shown in the vertical section on the map.

5. Taylor township.

The Bald Eagle valley has widened considerably here, though the creek flow is feeble and the summit is reached just outside the township at Fowler's, in Blair county.

The creek here, and indeed as far east as Milesburg, has been arbitrarily fixed upon as the division line between the lower Helderberg limestone No. VI and the Marcellus slates of No. VII1, the intermediate formation, Oriskany sandstone No. VII, dying away as a distinct rock mass between Snow Shoe intersection and Milesburg, in Boggs township.

The valley bottom lands are usually made up of a mixture of shales and limestone, forming a clay deposit and making it impossible to sharply define the contact lines of Nos. VI and VIII.

The upper white Medina sandstone No. IV everywhere marks the crest of the Bald Eagle mountain and the southern border line of the township.

The débris from this compact, gritty sandstone has profusely covered the north flank of the mountain and in many places effectually conceals the overlying formations. Consequently nothing of V and VI is seen in this township. The valley being very high here, makes the mountain to the south seem low by comparison and creates a marked contrast to the broken and knobby range of hills presented in Boggs and Howard townships on the east, where erosion in the valley and on the hills in front of the Bellefonte and Howard gaps has produced very different topographical features.

The gray shales and black fissile slates of the Marcellus and Hamilton groups are well exposed along the various roads and streams north of the Bald Eagle creek, and are essentially the *valley-makers* of the county, since they disintegrate readily and break down into a thick and good farming soil. The upper members of this formation—Por-

tage and Chemung—are not cultivated to half the same extent.

West of the old Hannah furnace, in the road leading up Sharrow's run, 40′ of reddish and black Hamilton slates, dipping 60° N. W., are exposed, succeeded further east along the valley road by a dip of 55° in the same in a bluff 40 feet high. The rounded slate hills which everywhere mark the horizon of these measures through the valley, have receded considerably northwards in this township, leaving a wide flat of white clay and broken slate.

All the mountain streams here have made wide valleys at their mouths, unlike the narrow ravines further east, and the exposures are few.

Vaughan's run shows none at all up to the red layers of No. IX, and the lines of contact of the different members of VIII are obscured. Sharrow's run is equally unproductive of exposures, though the hill road to the east shows a good face of Hamilton slate above S. Hoover's place, dipping N. W. 40°. One mile north the brown shales and slates (Genesee?) dip 35°, succeeded in another half mile well up the hill by flags and thin sandstone and shale beds of the Portage group, dipping north-west towards the mountain about 30°, and forming a series of low terrace hills.

The stream north of J. Peters' house marks the junction of IX, throwing the Catskill-Chemung transition layers into No. VIII.

The valley road 100 yards east of Hannah furnace shows a mass of rocks 30′ thick, exposing bands of sandstone 1′ thick, and massive blue-black slates mixed with softer gray slate measures. Several similar exposures occur east to the Worth line, and correspond to the Hamilton type of rocks, though devoid of any fossils.

West of Henderson's place, the divide between VIII and IX keeps in a cove north of the road heading up Laurel run, passing which the red Catskill layers occupy the hill road all the way to the old pike. A patch of the upper Chemung rocks shows at intersection, dipping 12° N. W.

The transition beds of the Catskill-Pocono division show along Tyrone and Clearfield R. R. tangent, succeeded at

the curve beyond Gardner's station by gray shaly sandstone of X, dipping almost due north 6°, but soon showing beds of hard white sandstone 2–6 feet thick further north interbedded with shaly measures and dipping N. 20°, W. 5°.

The junction of IX and X is well marked on the old pike, and from there east to Sharrow's run the hill road runs along a terrace of red Catskill rocks. This terrace is generally broad and flat, sloping gently to the cove south of the road south of which the bold Black Oak range of hills is formed by hard red sandstone layers of IX, heavily wooded along the north flank, but considerably cultivated on their southern exposures.

As a rule, this whole belt of country is wild and rugged and deficient in outcrops.

The Catskill rocks are well exposed on the Little run road dipping 15° N. W., and on the mountain road in an excellent series of sandstones and shales dipping 10°–12° N. W.

Pocono sandstone No. X everywhere occupies the north portion of the township, entering it on the east from Worth in a bold, prominent, straight ridge, heavily timbered and covered with white SS. bowlders, and keeping an average height of about 2200′ A. T. as far as Sharrow's run.

North of Sharrow's house the prominence of this ridge dies away, becoming notched and finally gapped by the stream. West of the run the ridge is still a marked feature of the topography, but its crest line is more uneven and broken up. A ledge of slightly north-dipping (18°) sandstone shows above Miller's house.

The Philipsburg-Tyrone pike likewise shows excellent exposures of X on both sides of the deep and narrow ravine of Little run, dipping north-west 5°–7°. The hills are precipitous and bowlders profuse.

6. Worth township.

The Half Moon-Worth township line forms the crest of the Bald Eagle mountain, and is here, as in Taylor, the upper white Medina member. Erosion has thrown down a vast amount of bowlders of all sizes, so that the character and position of both V and VI are as completely hidden

here as in Taylor township. The contact lines on the map, therefore, are only approximate.

No exposures are presented in the numerous ravines descending from the unusually straight summit line of the Bald Eagle mountain.

The shales and black slates of the lowest member of VIII are well exposed along the valley road, the foot hills coming right down to the road in this township, so that the Bald Eagle valley is not over ¼ mile wide.

About 200′ west of Port Matilda cross roads the Marcellus black slates show 40′ thick in bluffs extending almost continuously for ¼ mile, with the same general characteristics and occasionally quarried for road ballast. Some of the layers are quite calcareous.

The slates are both massive and fissile, generally a bluish black to gray in color, and dip 50°, 52°, 48°, and 45° to the north-west.

They are considerably jointed with cleavage planes, and in the upper part show red bands and sandstone layers.

The south and east slopes of these hills have been largely cultivated, and carry a good though rather cold and harsh soil. The ravines coming down from the north show comparatively few outcrops. The road along the Taylor line is devoid of exposures in place, though just near the horizon of the lowest Catskill red bands the road leading into Taylor at J. Peters' house shows a profusion of Chemung fossils in a dull brown and gray sandstone.

The Port Matilda–Philipsburg road shows (Genesee?) black slate above Weston's place dipping 40° N. W. and opposite S. Turner's the same, dipping 38°.

About 150 yards above where the creek crosses the road at old saw mill, boulders of massive coarse grained white sandstone are profusely spread over the ground and are probably representative of the lower Chemung rocks.

Few if any flags are seen in the formation here.

The red soil and sandstones of IX come in about J. Hunter's, about 100 yards south of the Black Oak church, the olive slates and gray sandstones of the upper Chemung swinging up the various ravines whose hillsides are capped

with Catskill rocks. These latter occupy the crest of the hill above the M. E. church, crossing summit above Gingry's house at the bend of the road 625′ above Martha and bearing up the creek bed. Just south of this, Chemung rocks filled with fossils, dip 20° N. W. in the cove west of S. Gingry's and again at J. Wiser's on the creek dipping 28° N. W.

Finally, above the crossing at J Ardley's, Hamilton red and brown slate and gray sandstone 100′+ thick dips about N. 28° W. 45°.

Catskill rocks show in the road on the summit above W. Gingry's, sandstone dipping 15° N. W., and again on private lane along the terrace, dipping 10°. These rocks make a gentle terrace slope to the overlying mountain of X, north of Williams', Spotts', Laird's, and Richards' places, swinging up the Port Matilda road and the creek nearly to the Rush township line at Richards' saw-mill.

No. X Pocono forms the crest of this hill and the north part of the township, gapped at the Huston line, and covering the terrace of IX with white sandstone boulders, often conglomeritic, for half a mile from summit.

7. *Huston township.*

Upper Medina IV sandstone again forms the southern boundary line along Bald Eagle mountain and are the lowest rocks in the township.

A glance at the map, however, will show the curved contour of the mountain. The thrust northwards, south of Martha furnace, due to the vertical rise of the Nittany valley anticlinal to the south in Chestnut ridge, has brought about this waved line in the mountain. On the road between Martha furnace and Matternville, the upper Medina white sandstone is exposed on road, dipping N. 18°, W. 70°—a vitreous hard white sandrock accompanied with a profusion of sharp while boulders.

The Clinton No. V and Lower Helderberg No. VI formations are both concealed here, the mountain being nowhere gapped west of Bellefonte so as to expose sections of those rocks. Prof. Rogers, page 552, vol. I, says that "fragments of the Surgent (Clinton) calcareous layers, full of fossils

and of buff shales, were thrown out of diggings at Juliana furnace;" but this is the only mention made of these rocks now so completely covered up.

North of Bald Eagle creek, VIII extends for 2½ miles, with several excellent exposures in the ravines and road cuts.

Just east of the Worth line, opposite S. Gingry's place, some little (75 tons) lean hematite is reported to have been raised; but all traces of the excavation are now covered up, and it is exceedingly doubtful if the locality was ever productive. The Bald Eagle ridge is regular and even here; the valley narrow. Williams' run shows Chemung sandstone and olive slates at the saw-mill above the forks of the road dipping 25° N. W., succeeded by the Chemung-Catskill transition beds of gray and red sandstone to F. Williams' place at the junction of IX.

The road up branch creek to the Hill school house runs around the north base of a Chemung and Portage flag hill, meeting the Catskill rocks at the second creek crossing.

The intersection above Cronister's house is about 1487 A. T. in IX., south from which the junction of IX and VIII is well marked on the hill road by a dip near the summit in Chemung sandstone of 12° N. W. south of J. Skirts' house. Genesee black slates show in cross road over to Mud Lick run, dipping 28° N. W.

East from the intersection of Mud Lick and the valley road to Julian, the road shows frequent exposures of Marcellus slates and shales, especially at railroad crossing in bluffs 20′ high with dips to the north-west of 50° and 46°.

Similar exposures occur east of Laurel run to the Union line, all in Marcellus slates, slightly calcareous, dipping north-west 32° at Julian S. H., 25° at cemetery, and 28° at Parsons, all showing massive slates and thin sandstone flags slightly quarried.

Laurel run shows Hamilton measures just north of the branch stream at Turner's house, dipping 35° N. W.

No. IX Catskill shows a beautiful terrace in this township, Pocono SS. X making the crest and highest rocks, exposed beautifully above W. Steel's place in a prominent

ledge, dipping about 10° N. W. This formation is everywhere the mountain-maker, all the bolder and more rugged from the contrast with the long, sloping terrace spurs of IX. It is, moreover, frequently as coarse and conglomeritic as XII.

At the Rush township line at the head of Laurel run X dips 4° N. W. in white and gray-banded sandstone, and again about 150 yards from cross-roads 8° N. W.

The Catskill rocks head well up the ravine along the creek bottom, but X keeps the road to the intersection, succeeded by transition beds dipping 11° N. W. Finally, about 500 yards south of the intersection, the Catskill rocks are displayed in a splendid sequence of sandstone and shale, red and olive-colored with dips of 17°, 10°, and 12°.

Further south there is another excellent exposure, massive red sandstone (IX) keeping the road for 125 yards, and giving a section here 200′ thick.

The dip at Rowan's is about 12°, soon followed by Catskill-Chemung transition beds.

8. Union township.

The divide between this and Benner township is accented the reverse to Huston. The township line, however, leaves the summit of white Medina sandstone about 2½ miles from the Huston line, and is then confined to the Clinton No. V, which here rides high up the mountain crest.

It nowhere shows in place, being only indicated by its red soil north of the mountain rib.

The position of the Lower Helderberg or Lewistown limestone No. VI is somewhat better defined, for it has been opened and somewhat quarried in Alexander's quarries, south of Bald Eagle creek, and about 1 mile east of the Huston line. It shows a shaly, impure limestone, somewhat fossiliferous, and but sparingly exposed, dipping N. W. 50°.

About 2 miles further east, and south of Unionville, this limestone has been also opened in Fisher's two quarries, showing dips of about 52°, impure and shaly.

Splendid exposures of Marcellus black slate No. VIII oc-

cur in the bluffs along the Tyrone road between the Huston line and Dick's run, beginning on the west with 48° N.W., and showing dips of 40° at Edmonston's and 35° north of Peters'.

East of Unionville, the exposures are continued in a dip of 40° N. W. beyond Fisher's; 38° at small run at J. Idding's; 40° at Free Run crossing, and 50° at Hoover's.

Everywhere across the township this formation shows little variation from a massive black and gray slate, sometimes carrying thin gray sandstone beds and brownish slate, referable to Hamilton age, the whole mass cut by cleavage planes and decomposing readily. The north side of these hills is made up of Genesee black slates and shales, succeeded by Portage and Chemung rocks, not separable.

Unionville (782′ A. T.) shows loose black slate everywhere through the town. Dick's run to the west shows several good outcrops. It crosses railroad at an elevation of about 800′ A. T. and heads up towards Rattlesnake summit in X. Its east branch heads up towards the terrace at Hall's and with the main stream makes the largest water course in the township.

The road up this ravine shows Genesee black slate at G. L. Peters' dipping 38° N. W. Opposite Hoover's saw mill and for 150′ along the road there is an excellent exposure of rusty flags and shales—the first good outcrop of the Portage rocks—succeeded north by buff-colored Chemung sandstone and olive shales, all dipping N. 22° W. 30°. The latter frequently shows large masses of a refractory gray building stone, easily dressed and durable and used for road ballast.

At the cross roads, the Chemung–Catskill transition beds come in with the same dip, confined westward to the south side of Dick's run, while the north side is more distinctively red Catskill No. IX. At Iddings' all is IX, the road ascending to the summit of Black Oak ridge terrace, with an exposure of red shale and sandstone at G. R. Hall's dipping 12° N. W. There is a cove north of here which probably marks the junction with X. At A. R. Hall's No. IX dips

10° N. W. on the road, the hills through here being still heavily timbered.

For a quarter mile above Hall's No. IX is exposed, succeeded by Catskill–Pocono beds and finally by white Pocono sandstone flags, forming the outer ridge or terrace of the mountain.

Several exposures of X, 5–10 feet thick, show along the road with dips of 5°–9°, with some red beds just south of Rattlesnake hotel, with IX in the ravine of Dick's run below.

A jog in the township line between Union and Rush townships extends the former up to the southern border of Snow Shoe, and the highest hills on each side of Glen Harris carry the conglomerate of XII on their summits as shown on the map, flanked with Pocono sandstone X and finally with the red measures of IX swinging up Glen Harris.

Dewitt's run road for ¼ mile north of Unionville shows black slates and brown fissile sandstone dipping 40° N. W. in a first exposure 60′ thick, and succeeded by massive (Portage ?) sandstone flags at W. P. Fisher's, considerably quarried. Red soil is met with first at Campbell's, though VIII extends still further up the creek bed. West 100 yards of the forks at Shipley's No. IX dips 15°, followed by a dip of 20° ¼ mile further west. This makes a distinct terrace from which Rattlesnake knob can well be seen.

McCormick's run road shows no exposures, with a probable junction of IX at the school house above the Messiah church, the latter being in VIII.

Gray and olive slates mark Free run road to Brower's place, showing *in sitû* there and dipping N. 30° W. 35°, with 20′ of mixed shale and slate, colored red where decomposed.

About 50 yards north, ferriferous slates show loose in the road, succeeded in 150 yards by black Genessee slates dipping N. 36° W. 30°, followed by gray and brown Portage flags and slates, and finally Chemung rocks slightly conglomeritic.

The road, after turning at J. Lannen's place, shows a profusion of loose Chemung sandstone bowlders filled with

characteristic fossils. South of W. Brower's place, buff-colored sandstone and olive shale dip N. W. 25°.

This makes quite a bold hill, but not so strikingly so as those immediately north of the road formed by IX. These hills are deeply grooved by branches of Free and Wallis runs. Catskill measures show close to the Boggs' line at frame church below Reese's, dipping 18° to the north-west.

9. Boggs township.

This, the next township adjoining Union on the east, presents the same character and number of formations, with the addition of the Oriskany sandstone formation No. VII, which makes quite a distinct ridge in this township through the Bald Eagle valley, seen for the last time westward in the small knoll on the railroad between Snow Shoe intersection and Milesburg, though extending eastward into Clinton county.

The south border of the township is an irregular line passing through Point McCoy in the Clinton red shales of V, dipping N. 40° W. 70° at the observatory, bearing thence nearly east and west across the white Medina ridge of IV to Spring creek. On the east side of the gap the line passes a little north of east along the upper Medina ridge, the lower Medina red shale and sandstone valley, and meets the road through the Curtin gap in Oneida sandstone, keeping on the latter terrace mountain to the junction of Howard and Marion townships.

The Bald Eagle mountain is twice gapped, and good sections of the formations IV, V, and VI are exposed in the openings.

A sketch map of the Bellefonte gap, reduced from a partially completed contour survey of Mr. R. H. Sanders, is shown upon page 280, which sufficiently shows the topography of the mountain and the approximate elevations of the district.

The following list of barometrical elevations between Bellefonte and Point McCoy may be of some interest:

Bellefonte R. R. station,	744′	above tide.
R. R. crossing at Milesburg Rolling Mill,	724′	
Spring on mountain road,	1442′	
Farm gate to Poorman's house,	1540′	
Fence corner on south hill, Oneida No. IV,	1612′	
At well below echo shed,	1617′	
Spring at echo shed,	1636′	
Summit at Point McCoy (Clinton No V),	1814′	
Top of observatory,	1834′	

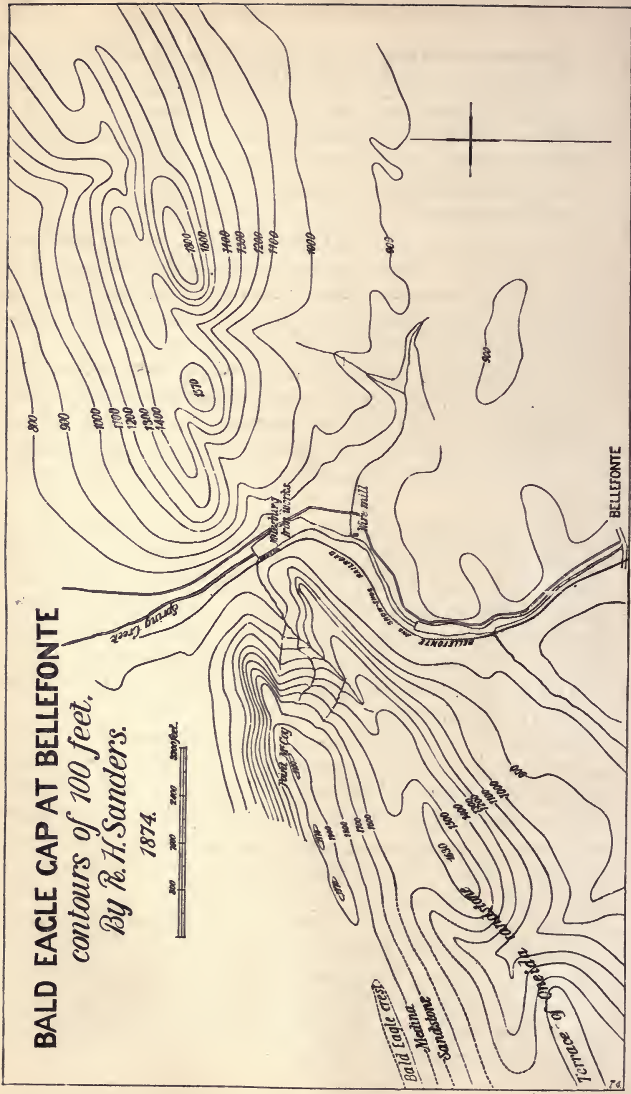
This latter station showed an elevation of nearly 1100 feet above Bellefonte and commands a most magnificent view of the rolling Allegheny foot hill country to the north as well as the great plain of the Nittany valley south to the region of the Seven mountains.

It affords a most advantageous place for the study of the topography and structure of the entire Palæozoic series, comprising as it does a connected view of all the formations from No. II Lower Silurian limestones in the valley to the Conglomerate of XII crowning the Allegheny mountain plateau.

From this elevated position, also, almost the entire range of the Bald Eagle ridge is visible from Blair to Clinton county and beyond, and the varied contour of that mountain is nowhere more plainly depicted. The action of the erosive power of Spring creek in past ages is here forcibly illustrated in the rough and knobby character of the mountain on both sides of the gap, a feature that is also brought out in the contour map.

Prof. H. D. Rogers in Vol. I, page 547, gives the following section of the triple formation No. IV in the gap which my measurements in the vertical section on colored map have somewhat amplified. The cross section of the county was made through this gap, and its measurements will tend to verify those of the vertical column which are more or less general for the county.

Prof. Rogers says: * "The Pre-meridian (Lower Helderburg or Lewistown limestone No. VI) is quarried back of Milesburg, dipping 30° in a slight elevation at the foot of the mountain. At another exposure on the W. side of the creek, the layers stand almost vertical; and it is seen again a quarter of a mile to the north.


BALD EAGLE GAP AT BELLEFONTE
contours of 100 feet.
By R. H. Sanders.
1874.
Spring Creek
Milesburg iron works
Wire mill
BELLEFONTE
Bellefonte and Snow Shoe Railroad
Point McCoy
Bald Eagle crest
Medina Sandstone
Terrace of Oneida sandstone

In the Milesburg gap, the Surgent (Clinton No. V) olive slates appear in a nearly vertical position. On the S. W. side of the gap, the red and buff shales are exposed, but no limestone is visible. A section through the mountain which here as elsewhere is double, gives the following characters for the Levant (No. IV) series :—

1. Levant (upper Medina) white sandstones 450 feet.

2. Levant (lower Medina) red sandstones, argillaceous, thin-bedded, gray and red sandstones, alternating with quartzose, red, gray and greenish shales and without conglomerate. In the upper part a vertical stem-like form, like an irregular Scolithus. Thickness 500 feet.

3. Levant (Oneida) gray sandstone, consisting of (*a*) greenish-gray slightly micaceous sandstone, with ochreous specks; thin layers of fissile green slate, perhaps belonging properly to the red sandstone, 380 feet; (*b*) hard gray sandstone, forming a terrace on the mountain to the S. W. Not conglomeritic, full of yellow specks, 170 feet."

Bald Eagle mountain west of Milesburg shows quite a decided terrace about half way up its north flank.

It must be made by the limestone of VI as the Clinton No. V rides high up the mountain even forming its crest for a short distance west of Spring creek.

In the gap the dip of the measures varies from 50°–80° to the north-west, and averages about 70°.

The opening in the Lower Helderberg limestone referred to by Prof. Rogers is evidently at Swoyer's quarry.

The limestone dips from 30°–40° N. W., showing a slip or crimple on the north side with the edges turned up and dipping S. E. 10°. The limestone is sparingly burned, and occurs in thin layers 2–3 feet thick, intercalated with bands of gray argillaceous shale, and under a cover of 8' of sandy soil derived from the mountain.

This rock makes quite a decided ridge and is again opened on west side of Spring creek.

Eastward it flattens into a mere bench on the mountain flank until south of Curtin's rolling-mill, where it again becomes prominent. In the opening the rock seems devoid

of fossils, is thin and siliceous, and beds for burning must be selected with care.

The whole formation, measured by outcrop, is something like 1000′ thick, though generally so covered as to make careful measurements impossible.

Bald Eagle creek at Milesburg shows Oriskany S. S. No. VII outcropping in plates on south side beneath the Bellefonte R. R. bridge. It is quite fossiliferous, and dips N. 38° W. 42°. West it makes quite a distinct though low hill, and is exposed for the last time in the railroad cut on the north side of the creek ½ mile east of Snow Shoe intersection, dipping 35° N. W. A mixture of soil from this rock and the Marcellus argillaceous slate of VIII is worked into brick in the flat about ½ mile west of Milesburg.

East from this place, along the road to Curtin Station, No. VII shows in a knob north of the road beyond the site of old mill, from which sand was considerably quarried for glass-works. East from here a cove extends south into Curtin's gap, and opposite the site of the old furnace, No. VI limestone is again opened, dipping N. 32° W. 78° on the Curtin estate. The stone is blue and firmer than at Swoyer's, and shows seams of calcite. The sxposure is 60′ thick and quite siliceous.

About 200′ south from this there is a drift crossing the *old* Milesburg road and entering the hill, Helderberg ore—the "Baker ore" of the Juniata—was mined here formerly to some slight extent, and used at the Curtin furnace. An old pile of dirt and ore taken out 30 years ago marks the place of operation.

The ore is a lean, argillaceous hematite, carrying 25–30 per cent of iron. The course of drift was about N. 10°, E. and S. 10° W., continuing along which course a hole dug 15′ to the south threw out red shale.

In 150 yards from the road, a shaft 25′ deep was put down in VI, and drifted slightly in two levels 5′ vertically apart at the bottom of the shaft.

About 100 tons are said to have been taken out here, but in the presence of an abundance of 45–50 per cent ores in the Nittany valley this ore has received but slight attention.

Upon examination the bed appeared to be about 5′ thick and dips steeply N. W. Both drifts show decomposed slate carrying hematite ore. Another open shaft 15′ deep, further south-west 50′, shows about 3′ of ore slate under 10′–12′ cover of dirt and clay.

Immediately south 100 yards, a pile of open cellular hematite lies on the ground, claimed to have been raised here. No opening was seen, however. The ore is said to have analysed 35 per cent iron. It is largely mixed with red slate.

It is possible that this ore was taken from an opening 200′ south in No. V, where a calcareous bed 15′ thick between red and olive slates is exposed in the woods.

The bed dips steeply N. W., and the limestone is apparently quite pure, though siliceous. Seams of quartz intercept the bed but are not a prominent feature.

Another appearance of ore occurs in the creek 250 yards south of last locality, and apparently corresponds in position to the block ore near the base of V.

Here it seems more like a thickly-stained ferruginous sandstone greatly disintegrated. It shows on the west side of the creek, close to the base of the hill, though the slope is so covered with bowlders of Medina sandstone that it is but poorly defined. It trends about S. 50° W. This ore is claimed to have been mined high in the mountain, where it showed in better shape, no doubt due to the greater decomposition at the outcrop.

This same bed has been mined south of Howard.

On the east side of the creek here, on road leading through Curtin's gap, there is a bed of clay which has furnished the neighboring furnaces for years with clay for patching tuyeres, etc. It is plastic, while quite firm, and shows but little gritty material.

The Milesburg road south of Curtin Station shows some little indications of VI at the cross-roads south of the water-station. On road summit, limestone of VI shows in a broken outcrop, better exposed south in the quarries already mentioned and dipping 80° N. W.

Another small quarry shows VI just south of Curtin's

foundry, turned over at outcrop but really dipping N. W. 70°–80°.

From the rolling mill east to the Howard line exposures of the Lower Helderberg limestone, in addition to those already mentioned, occur along the line of the old B. E. canal, showing a blue gray limestone, often slaty and crushed at the outcrop, with dips of about N. 35° W. 50°–60°.

East, beyond cemetery on the hill, and south of the road in a small ravine, there is another exposure of generally slaty stone, with some good pure limestone layers, formerly quarried for the Pleasant furnace. The dip is about N. 28° W. 20°. The exposure is small, but serves to locate the crop line of No. VI, which all through here seems to occur at the foot of the Bald Eagle mountain in low knobs, often broken through in the line of their outcrop and superficially covered with drift and sand from the mountain.

Oriskany sandstone No. VII is generally well marked in this township, having been opened in two quarries for hearth-stones for the Pleasant furnace.

The first of these, on the west along B. E. creek, was advantageously worked before the abandonment of the canal, and shows an exposure of excellent white sandstone but little stained or rusty, dipping N. 32° W. 44°.

The exposure is 75′± thick, and is probably on the same out-crop as that opened 200 rods east in a quarry on the road already mentioned, which shows dips of 50°–60° N. W.

The various ravines leading up to the Allegheny mountain plateau show good exposures of the overlying Devonian and sub-carboniferous measures.

Thus, beginning on the west, a section up the Wallis run road and Snow Shoe railroad, shows the Marcellus black slate in place about 100′ north of the school house, dipping N. 20°, W. 45°, disintegrating rapidly and creating a good rich soil all through the flat north of the valley road.

The road up to Crider's shows loose pieces of slate and a slaty soil varying from a black through green to gray cast, getting more firm and massive northwards, and finally ex-

posed in a 20′ bluff just above Crider's, dipping N. 18° W. 15°. They are next well exposed 100 yards north, where they dip about 22°, and have become again fissile and black with a reddish cast at outcrop (Genesee).

No. VIII continues north to the ravine coming down from the east to the church at C. Lucas Sr.'s, red bands of the Catskill rocks there coming in and creating a marked change in the color of the soil and the character of the topography.

Taking the railroad from here, frequent exposures of red sandstone and shale show around curve to Crider's mill, all with a north-west dip. At 10-mile post to the north, 6 feet of sandstone shows, holding in center a layer of blue conglomeritic quartz flags 2′ thick. Switch Back No. 1 is laid right in the bed of the stream, and considerable stone was filled in here for making grade.

The bulk of this shows green and bluish and olive-colored flags, unlike the gritty red sandstone and fissile red shale of the rest of the formation of IX.

Between Switch Backs Nos. 3 and 4 a 20′ bed of red sandstone, massive and capped with shale, dipping 15° N. W., is exposed at several points.

North of and above this, divided by shaly bands, a 25′ bed of sandstone shows in railroad cut, dipping N. W. 10°–14°. At the next curve north the following section of still higher measures shows:

Surface soil,	4′		
Brown and red broken shaly sandstone,	2′		
Red shale,	2′		
Impure red sandstone,	1′	6″	
Iron-stained shales with olive bands,	5′	0″	31
Massive gray and red flags,	3′	6″	
Shales, mostly of a reddish cast,	1′	6″	
Massive block sandstone and flags,	15′	6″	

The north end of exposure shows:

Top soil,	10′	
Red sandstone bands,	2′	
Shaly sandstone,	1′	6″
Broken red shale,	4′	
Flaggy red sandstone,	2′	
Massive brown stone,	4′+	

This is part of the McCafferty Bros.' quarry, who have

supplied the town of Bellefonte with some excellent paving flags, and I believe also the brown stone of the Presbyterian church. If so, the decaying condition of this edifice demonstrates a lack of first-class weathering capacity in this stone. The exposure is about 500 yards long and presents the best section of these Catskill rocks seen in the county.

North of the 14 M. P. shaly red sandstone outcrops for 100′, dipping gently N. W. North of this the railroad curves through 12′ of No. IX flaggy red sandstone, beautifully ripple marked, and showing several reed-like impressions of calamites, some of them a foot long.

From here to Walker's cross-roads the transition beds of Catskill-Pocono occur, consisting of more or less shaly green and gray beds, mixed with thin red beds, and capped with a fine-grained white conglomerate sandstone of Pocono type.

This whole mass of Catskill beds approximates 2600′ in thickness, inclusive of the 400′–500′ of Pocono-Catskill beds near the top of the formation, here rather more suggestive of Catskill than Pocono age and so considered in the vertical section on the map.

The Catskill rocks extend far up the west branch of Wallis run through Glen Harris, where the stream has cut a deep gorge in the hill, through which a tramroad 3 miles long is laid to the site of the present logging operations of the Messrs. Crider.

No. IX occurs high in the hill sides, capped with Pocono sandstone X at first, and farther north along the Snow Shoe line by the conglomerate measures of the Allegheny mountain crest.

There are no exposures of X in place along the railroad, but its terrace flanks on the south the Indian Grave hill of XII at the summit, the latter conglomerate making the real crest of the mountain all along the north border of the township. No. XI Mauch Chunk red shale was nowhere identified here.

Wallis run proper, from where it leaves the railroad to Walker's summit, has deeply grooved the country, so that on the summit of the mountain road, near the junction of X, the creek flows in a gorge 300′ lower down.

At A. and J. Ackley's red shale and sandstone (IX) shows a dip of N. 22° W. 10°. Two hundred yards north at the bend of the road, massive red sandstone dips N. 20° W. 10°, extending for 50′ along the road and showing a bed 12′ thick. Some few exposures are shaly. A distinction between the red Catskill and red Pocono beds is hardly discernible along this road, but the pebbly white rock of X is well seen on both roads leading south-east from Walker's on either side of Wallis run.

At the intersection of the farm road to J. Williams', red sandstone shows coated with a slight film of greenish material not unlike malachite.

Red, green, and olive colored shales and sandstones, north of second large bend in the road, dip 10°–15° N. W.

The true Pocono beds come in near the summit of the road, replacing the red soil with dry white sand and boulders, and showing in place just around the last bend of the road, dipping N. W. 12°.

The back road from Walker's over the "Ridges" shows boulders up as far as the second branch to Wallis run, derived from the formation in place on the hill top to the north.

Beyond and going down hill-side the road shows many excellent exposures of Pocono-Catskill and Catskill rocks, which the absence of any dwellings or land-marks renders it difficult to describe. Many of them show massive red sandstone beds, outcropping in road and impeding travel, but all dipping gently north-west into the mountain.

Moose run, north from Milesburg, shows further sections of these rocks. The lower Marcellus slates show in and just north of the village in an extensive road cut, dipping 40° N. W. Another exposure in the same rocks 70′ thick shows on both sides of road at B. S S., comprising in all a mass of these lowest black slates several hundred feet thick.

The upper Genesee black slates show south from the intersection of small lane to the east, iron-stained and fissile, dipping 35 N. W. and 200′ thick.

North of this exposure the lowest Portage flags and sand-

stones,—green and yellow, iron-stained,—crop near D. Watson's, dipping N. W. 30° for 25 yards along the road. Flags and brittle Chemung sandstone and olive shales show at Reside's intersection and at Hollowbaugh's, dipping 20°–15° N. W., succeeded by transition Chemung-Catskill rocks, and finally by the red beds of No. IX in the bolder hills north of the ridge roads. The road through Holt's hollow shows No. VIII shales and flags at forks, dipping N. 30° W. 10°, and again 1 mile south at small run entering from east, dipping N. 32° W. 15°.

Numerous additional exposures may be seen in any of the several ravines and hollows cutting down these slate hills; but the character of the rock mass and dip of the measures vary but slightly.

Between D. C. Poorman's and the Bald Eagle valley road, black and gray Marcellus slate of VIII dips in an excellent exposure N. 28° W. 30°. The same rocks show along the valley road to Curtin's furnace, confined to a low ridge just north of the road, and especially well displayed for about 100 yards on each side of the school-house, dipping N. 18°–25° W. 15°–22°. This dark, blue-black fissile slate usually weathers to a light clay, no doubt due to some extent to the intermittent lime layers frequently occurring as balls at the base of this formation. Slate 15′ thick occurs at the junction of Antis run road, dipping about N. 16° W. 25°, and the brownish shales and sandstones of the Hamilton group at L. Dixon's further north, dipping N. 14° W. 20°.

At the next stream, a firm and compact sandstone mixed with slate layers of a rather reddish cast dips N. 20° W. 18°, succeeded further north by a series of good dips in the creek bed, all averaging about 18° from R. Nyman's north.

Above the next lane entering from the east a good 40′ exposure of mixed shales and flags dips N. W. 20°, rusty and iron-stained. An exposure 500 yards north shows reddish olive-colored and white flaggy sandstones and slates dipping 15° N. W., followed above next run by dips of 12° and 15° in green and gray shales up to the junction of the red Catskill rocks.

From here north these red rocks occupy a distinct and

higher range of parallel hills, allowing the shales of VIII to swing up the various coves, but carrying themselves the massive red sandstone beds which make up the dividing ridge to the Marsh creek country.

Between Curtin's works and the Howard line an almost continuous exposure of the Marcellus slates and shales shows along valley road north of Beech creek.

North of the quarry in No. VII, at the eastern end of the township, No. VIII crops, dipping N. 40° W. 40°, and exposed at intervals for the next 600 yards, though with no good dips.

Various exposures to the railroad show dips of from N. 40° W. 35° in fine dark gray slate, to N. 45° W. 32° and N. 48° W. 30° in a railroad cut about 50′ east of E. end of bridge over Bald Eagle creek. The slates occur in a bluff 40′ high, covered by about 20′ of alluvial drift and bowlders of the mountain formations.

The exposures along the north valley road above mentioned show some reddish and blue bands, but mostly a dark gray slate, compact and massive on the west, and grading eastward into a more shaly and fissile black slate, in bluffs 30′ high and with dips of N. 25°–30° W. 20°–25°.

A thin bed of argillaceous limestone occurs in the road the base of the slate just west of Dowdy's run.

The Catskill red rocks show little variation in the eastern part of the township from that given in the Wallis run section. Any one of the numerous roads leading north or south from the valley of Marsh creek (which takes its rise in the rocks of this formation in this township) will expose the same sequence of red shale and sandstone measures, and a reference to the colored geological county map will show the direction and amount of dip in these strata.

Along Marsh creek these rarely exceed 15° and decline northwards towards the Pocono ridges to 8° and 10°.

The whole formation through Centre county seems to be devoid of economical value, and is only sparsely cultivated. Various reports of copper finds and indeed even *gold*, *silver* and *tin!* reached my ears during the progress of my survey, but it seems hardly necessary to tell the inhabitants of

these districts that it would be simply sending money to the bad to devote it to exploring the territory for any of these metals.

Even the small and worthless coal and iron ore beds mentioned as occurring in this formation in Report F, in Huntingdon county, were nowhere detected here, so that, in a commercial sense, the various efforts to prove these rocks productive will undoubtedly prove failures.

10. Howard township.

The Bald Eagle mountain is again gapped in this township south of Howard and a fairly representative section of the rocks of IV are exposed.

The dividing line between Howard and Marion townships is not straight, as an inspection of the map will show, but bent in the middle with the angle turned towards the south. It generally marks the trend of the middle or red Medina member of IV.

The rocks of this member are extensively exposed on both sides of the gorge, everywhere a red sandstone and shale without the conglomerate base that characterizes it further south in the Kishacoquillas and other valleys of the Seven mountains. These rocks in the Howard gap decompose readily, but do not show any of the green and olive slates seen in the Bellefonte gap. Some 400′ north of the toll gate compact and shaly sandstone dips to the north-west from 75°–80°, having had a nearly vertical dip further south.

The upper white Medina sandstone shows here as elsewhere an unusually persistent and well characterized rock consisting of hard white and greenish-gray siliceous beds. It contains few or no pebbles, and is more compact and finer grained than the underlying gray Oneida member of the series.

Its great hardness has preserved it everywhere through this monoclinal ridge as the distinct crest, the lower member occasionally attaining an equal elevation, but usually forming an outer terrace to the south.

All the dips in this gap are steeply north-west.

The white Medina sandstone is succeeded by the Clinton

No. V red shale and sandstone, exposed back of the saw mill or tannery on the east side of the creek where some old ore drifts on the lower or block ore bed are exposed.

In past times some considerable ore digging was carried on in this formation, high up on the mountain crest; but as they have long since been abandoned I quote the following remarks from Prof. Rogers' Final Report, Vol. I, page 547, on the occurrence of these ores of V. "Near Howard furnace the 'block ore' has been successfully reached and mined on the N. W. slopes of the Bald Eagle mountain by the proprietors of the Howard iron works. Its outcrop is more than half way towards the summit of the ridge.

The strata inclosing it dip 70° to N. 30° W., and the ore bed lies about 60 yards S. E., or further in the mountain than the fossiliferous ore, which has likewise been discovered here, and regularly mined to a small extent.

The block ore when seen in 1852, was 22 inches thick, and the ore was moderately rich, appearing to contain about 28 per cent of iron. The iron-sandstone, the usual accompaniment of the block ore, outcrops in some places in this vicinity high in the mountain. The ore-sandstone is apparently altogether wanting here, unless a few thin bands of gray sandstone in the overlying slates may represent it.

The total thickness of the whole slate group, with the included iron-sandstone, is at this place probably 600 feet. Both the Surgent upper and lower slates decline in thickness as they range S. W. while the included iron-sandstone augments."

The Howard gap is a very beautiful and wild one, and looking south from McDowell & Rogers' mill on the furnace road, shows the upper Medina forming the outer ridge, presenting on the east side of the creek a very irregular contour and ending at the gap in a rounded knob or sugar-loaf mountain.

In the background the lower Oneida mountain is seen closing up the gap and here attaining almost as great an elevation as the main crest.

The red Medina occupies the intervening cove between the two mountain ribs.

A peculiar feature of all these gaps is the easterly cutting action of the eroding streams, owing to the north-west dip of the measures, always issuing from the outer mountain *east* of the point of attack in the terrace crest.

The crest of the Bald Eagle mountain from here west to the Bellefonte gap is singularly uneven and curved in a succession of summits and its slope covered with bowlders.

From the Boggs to the Liberty line the B. E. V. R. R. is entirely in the Lower Helderberg limestones of VI, but the formation itself is considerably hidden by a mass of drift and bowlders from the mountain to the south.

No. VI makes essentially the valley bottom in this township, nowhere rising to the prominence of a ridge as it does further west at the Boggs line, where a single exposure shows high up against the mountain in a knoll on J. Glenn's place, dipping 45° N. W.

On the north side of Bald Eagle creek, on the small road crossing the railroad track at the water-station, No. VI is exposed in a low hill, just beside the abandoned canal, dipping N. 25° W. 38°, 25′ thick, and carrying No. VII Oriskany sandstone on top.

The limestone area broadens going east, and the dip flattens. No. VII occurs north of the creek as far as Mount Eagle station, and from there to within ¼ mile of Howard the creek forms a natural boundary between VI and VII.

The north line can be continued straight out to Liberty township line, which it crosses about 200 yards north of Pletcher's work-shop on the valley road.

Bowlders everywhere show a rather siliceous and fossiliferous limestone, which adds considerably to the fertility of the valley.

Oriskany sandstone No. VII occupies the high ground immediately north of the creek, making a narrow but prominent ridge 300 yards wide.

Where eroded, in the flat north of Howard, this formation can be distinctly traced by a heavy deposit of white and buff-colored sand.

As far east as Bullet's run the ridge is flat, and shows no

outcrops in place; but crossing the stream, the road passes along a hill of VII, which has been trenched along its summit for about 700 yards in various places. All these trenches show from 10–30 feet of good, pure, vitreous white sandstone, dipping N. 40° W. 20°–30°, and furnishing excellent sand for glass-making.

The largest opening is probably on J. B. Leather's property, where a considerable amount of quarrying had been done formerly for the Bellefonte glass works.

The crest of the hill is generally south of the road with No. VIII Marcellus black slate on its north flank, showing on the road about 200 yards west of Green run in a patch on top of the hill. East of Canœ run No. VII dips N. 36° W. 28°.

All through this hill the sandstone is made up of a mass of characteristic fossil shells.

The rock decomposes readily into a thick sand deposit. High ground is again seen close to the Liberty line, where on the township road some tests for the Oriskany iron ore have been made on top of the hill by shafts 70′+ deep to VI. In this county this formation can hardly be said to be ferriferous, though thin seams of siliceous hematite often occur in the rock, discoloring the sand.

This is well seen in Leather's quarries, and the presence of this iron no doubt led to its abandonment for glass-making. There is no difficulty in recognizing this rock wherever exposed in the county, being marked by an abundance of cavities marking the place of former fossils, which being generally of a large size, attract the attention of even careless observers.

This rock has been successfully used for hearthstones in the charcoal furnaces of the valley, and while not being as refractory as the conglomerate of XII, it furnishes a readily quarried and useful substitute. The extreme thickness of this formation in the county does not exceed 130′.

The only other rocks occurring in this township are those of the next higher formation No. VIII, if I except the small patch of red Catskill No. IX occupying the extreme N. W. corner.

The lines of contact as between Marcellus, Hamilton, Genesee, etc., cannot be located with any more precision than has been elsewhere possible in the Allegheny foothills.

In general, however, topography assists us materially. Thus the lowest Marcellus black slates everywhere make up the low, rounded, flat hill north of the sharp Oriskany SS. ridge, showing, where weathered, a tendency to split up into fissile layers of reddish-brown slates and carrying lenticular flattened masses of dark, carbonaceous limestone in the lower measures, which adds considerably to the fertility of the soil.

This will account for the cultivation of this entire range of conical hills in this township.

Any of the numerous streams rising higher to the north in Portage and Chemung ground show outcrops of this black slate, weathering finally to a gray, argillaceous clay. So on the road up Bullet run, a good exposure of this slate shows just south of the intersection at Riddle's house, dipping N. 35° W. 30°. Again opposite Riddle's house 30 feet of massive black slate with limestone masses dips N. 32° W. 30°. At Hughes' place, further north, Hamilton rocks are exposed, dipping 30° N. W. in a sequence of variegated shale, slate and sandstone of a blue-gray color when fresh, and weathering brown at the edges.

No regularity of deposit is noticeable in the various layers, as they apparently blend into one another within short distances. These rocks, however, mark a line of long, smooth and partially cultivated hills, cut through by various streams, but of slightly bolder outline than those first mentioned.

North of these a higher and wilder range of hills supports the Portage and Chemung group of flags, sandstones, and olive slates, the intermediate cove holding the softer Genesee black slates, and making the Hamilton group form really a terrace on the Portage hills to the north.

The forks of the road at McQuillan's old house show a fine outcrop of Portage flags of a light green-gray color, accompanied with dark slate.

The road leading from Howard north over the hill to S. Brickley's on Marsh creek, in Curtin township, shows black slates to the forks at Mrs. Packer's, succeeded by gray and olive-green shales, brown slates, and finally flagstones and shales, making a steep hill up to the summit, 360′ above Howard.

Some little tendency to a conglomerate is seen in the Chemung sandstones on the north slope of the Marsh creek divide, accompanied with brown and olive shales and sandstone to the creek bed, 310′ below, though nowhere outcropping.

Bald Eagle creek swings north into VIII north of Howard as far as N. Askey's, showing a dip of 30° N. W. at the school-house. North of the Oriskany ridge, on the road leading out from the cemetery, VIII black slate shows just at the bend of the road 20′ thick in a quarry, dipping 32° N. N. W., and succeeded in 100 yards by a dip in brown and olive slates of 28°, and these by Hamilton massive brown slate and shale at R. Pletcher's, dipping N. W. 20°.

11. Liberty township.

From Beech creek station to Eagleville the railroad shows no outcrops in place, but everywhere a heterogeneous soil mixture of sand and bowlders of IV, V, and VI.

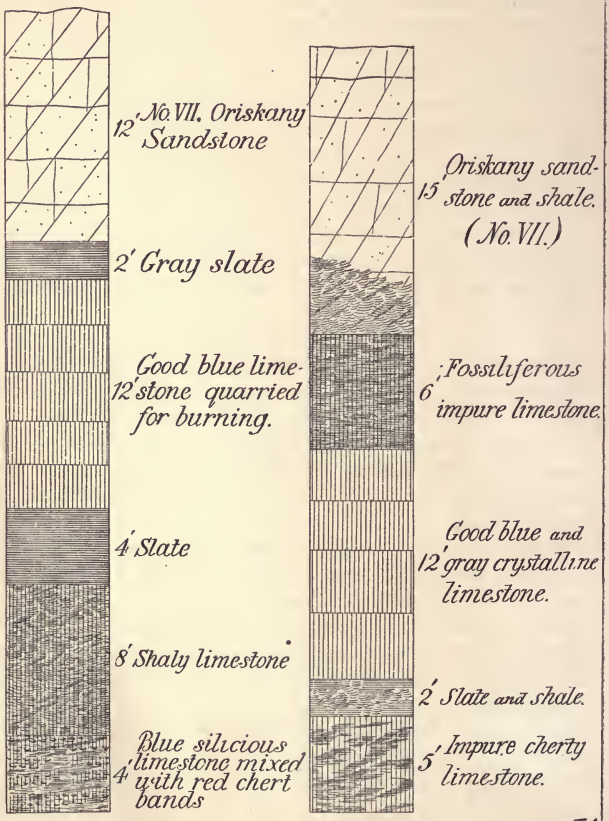
Midway between the stations the mountain to the south shows a considerable gap in the Medina crest; but the terrace mountain of Oneida is not cut through anywhere in this township.

The Bald Eagle valley is considerably spread out here owing to the wide breach in the first range of slate hills made by Beech and Marsh creeks.

The valley narrows and deepens considerably going west, with a low flat Oriskany sandstone to the north supporting the Marcellus slates on its north flank and washed by Bald Eagle creek on the south.

The mountain is again partially gapped south of the Mountain house at Eagleville station, carrying a terrace of V halfway up its north flank and showing a superior elevation of its white Medina member over the Oneida ridge to

Limestone quarries in Liberty tp. Centre Co., Pa.



the south, both of which, however, have very uneven crest lines.

Marsh creek shows some red soil of V along its banks south of Eagleville, though this is only a derived deposit, probably brought down from the Catskill ridge to the north. West from Eagleville the valley road ascends a hill of VII everywhere marked with a thick deposit of sand, a profusion of whose bowlders filled with unusually large and beautiful fossil casts, cover the Marsh creek flat to the east.

The crest of the ridge is but little north of the valley road to the Howard line. West from Leggett's the soil along the road loses much of its arenaceous character, admitting in turn No. VI limestone, which 500 yards west is opened and well exposed in Crider's and Shank's quarries.

The first of these shows the junction of VI and VII plainly. It is located just north of the public road and exposes a face of rock 45′ thick dipping N. 28° W. 26°, the upper 12 feet of which is No VII.

No. VI rides well up the south flank and is quarried for burning in Crider's kiln. The quarry was idle but shows an excellent seam of blue limestone 12′ thick in the centre of the opening. Some few argillaceous layers occur beneath this productive layer as well as small beds of red chert and bastard limestone.

One hundred yards west, close to school house, the same outcrop is opened in Shank's quarry showing 40′ of a face with the 12′ bed of good limestone in the same relative position.

Two sections of these quarries are presented in Fig. —, page 296, for comparison. The dip is about the same in Shank's quarry, which was in operation and furnishing about 5000 bushels of burnt lime a year for fertilizing and plaster purposes. The stone quarried here seems rather more gray in color and crystalline.

Crider.

No. VII Oriskany SS.,	12′	
Gray slate,	2′	
Good blue limestone, quarried for burning,	12′	42
Slate,	4′	
Shaly limestone,	8′	
Blue siliceous limestone mixed with red chert bands,	4′	

Shank.

No. VII Oriskany SS. and shales,	15′	
Fossiliferous impure limestone,	6′	
Good blue and gray crystalline limestone,	12′	40′
Slate and shale,	2′	
Impure cherty limestone,	5′	

Neither quarry shows any good fossil casts.

Lower Helderberg limestone, filled with fossils, dips N. 25° W. 22° on the road ascending hill from the creek at about 100 yards west of the school house.

From here to the Howard line the road is all in VI, which extends south to the creek, where it is several times exposed dipping N. W. 50°–60°.

Mr. Schenck in sinking for ore in the Oriskany ridge north of the road, reports going through from 80′–100′ of sand and sandstone to a limestone floor.

The various roads and ravines running north from the main valley road show the usual sections of the different members of VIII.

Probably the best is afforded by Marsh creek, which at the Curtin line carries the transition Catskill-Chemung beds on both sides, the true red rocks of IX having receded to the north. Chemung gray and brown sandstone shows on the hill to the south, and passing over the road summit 475′ above Howard, an excellent exposure of Portage flags is seen at Thompson's, dipping N. 22° W. 20°.

At J. C. Beachdale's quite a mass of mixed red sand and white clay fills the valley flat, south-east of which, further down creek, Chemung rocks show a dip of 22° N. W., succeeded in half a mile by Portage flags and sandstone with a dip of 19°.

These are followed south by an excellent exposure of Hamilton slate, shales and brown sandstones opposite Clark's on the north bank of the creek.

About one hundred feet of these measures are exposed here on D. Hendricks' property, showing a very small *fault* of about 22 feet, inclined at an angle of 50° S. 30° E.

A sketch of this exposure is given in Plate X, on page 300.

The dip at both ends of the exposure is about 30° N. 35° W., with an anticlinal roll and a crushed synclinal west

of the line of *fault*. There are also two gentle rolls on the east side of the fault in sandstone and shales.

Some little prospecting for ore has been done in the heavy blue sandstones and shales, exposing a ferriferous, argillaceous, soapy slate with small threads of hematite.

The ore as such, is generally worthless.

The creek from here south flows over a clay soil of No. VIII Marcellus slate to the junction of the Oriskany sandstone at Eagleville. On the road leading north out of Eagleville and just south of J. Gunsallis place, the lower black slates show in a road cut 60′ thick, some gray and red where decomposed, and dipping N. W. 30°. Several outcrops of Hamilton rocks occur west from the school-house on the road to Hendricks', with north-west dips of 25°–28°, exposing similar measures to those along Marsh creek. Olive, gray and green slates, argillaceous, occur in road bed close to Marsh creek intersection, with a dip of 25° N. W.

Beech creek shows black slates about 1 mile above its mouth, dipping 30° N. 15° W., succeeded in 500 yards by calcareous beds dipping 25° N. 15° W. Still further north, blue and brown slates and olive shales show, overlaid by alternations of shaly, olive-colored rocks and argillaceous sandstones with same dip. Two miles above its mouth the stream has become confined to a rather narrow gap in hills of Portage and Chemung rocks, capped with Catskill red layers.

Higher and higher rocks successively come down to the creek bed, proceeding northwards along the grade of the new railroad, until the transition micaceous beds of Catskill-Chemung rocks appear with dips of 20° N. 18° W.

About 5 miles above Beech Creek town the Pocono beds come down to water-level, dipping N. 10° W. 15°, to be succeeded in turn by Mauch Chunk red shale of XI, which, however, nowhere gets down to creek level before entering Snow Shoe township.

A small patch of XII conglomerate probably crowns the hill top in the extreme north-west end of the township, forming the base rock of the Curtin township coal measures.

This completes the detailed geology of the Devonian and sub-carboniferous measures of the county.

Downthrow fault in Hamilton rocks, No. VIII. shown in Quarry 1½ miles W.N.W. of Eagleville, Centre Co., Pa.

sketched by E. V. D'Invilliers. (Looking S. 70° E.)

T4.

Townships S. E. of Bald Eagle mountain.

To *the south of the Bald Eagle mountain*, the highest rocks exposed are the bottom layers of the Clinton red shale and sandstone formation No. V, which is only retained in the deep synclinal trough of Pheasant valley in the Nittany mountains and in one or two small patches in the Seven mountains.

A study of the cross-section of the county will show how the lower Silurian measures have been repeatedly brough to the surface in successive folds, from off the surface of which all the overlying upper Silurian, Devonian, subcarboniferous, and coal measure rocks have been long since been eroded.

Pursuing the same plan in describing the country south of the dividing Bald Eagle ridge, the following townships, comprising Nittany valley proper, merit attention in the order named: *Half Moon, Patton, Benner, Spring, Marion, and Walker.*

In illustrating the sections of Nittany valley, in chapter IV, on the structural features of the county, much was necessarily said concerning the character of the various outcrops, while the detailed description of the Lower Silurian brown hematite ores will relieve the description of these valley townships of those particulars.

The *Lower Silurian* or *Siluro-Cambrian limestones No. II* are essentially the valley makers of this region, for their rocks have everywhere more readily yielded to ærial and subterranean erosion than the more resisting sand rocks now left standing as mountains.

These limestone rocks (the lowest exposed in the county, and therefore the lowest shown in the vertical column of Palæozoic measures on the colored county map) are of great thickness (6000′+) and may consequently be expected to show many forms of type.

But these changes are not sudden, as is natural since they are oceanic precipitates, and the lines of demarcation

on the ground are almost everywhere concealed by reason of the gradual and often imperceptible change in the constitution of the several rock masses making up the formation.

Even the aid of palæontology would assist but little in determining these transition lines, for with the exception of the upper Trenton group, 400± thick, the whole system is generally deficient in fossil remains in this county. No attempt, therefore, has been made to depict these divisions on the map, the whole formation being given a cobalt blue color.

However, the lowest division (Prof. Rogers' *Auroral Magnesian limestone*) the non-fossiliferous portion, shows usually two varieties of magnesian limestone. Of these two forms Prof. Rogers says in the Final Report, Vol. I, p. 470:

"One of these is a rock of rather dark, dull-gray aspect, and a crystalline or granular internal structure.

"Its weathered surface is peculiarily harsh and sandy to the touch, not so much from the presence of siliceous sand as from the disintegration of the minute crystals which compose it. This variety is decidedly ferruginous.

"The other portion of the formation is a remarkably smooth and fine-grained rock of a very pale blue color, or rather of the tint called French gray. It is very uniform in its texture, and consists apparently of excessively comminuted particles that have cohered into rock from the condition of an impalpably fine pulp. It is highly magnesian, the weathered surface being coated with a white crust, composed of carbonate of magnesia and lime.

"Besides these two varieties there alternate with them in the upper part of the formation, some thinner masses of non-magnesian limestone of a clear and rather dull blue color. Of the two chief rocks described, the darker and more crystalline sort constitutes much the larger portion of the whole formation, predominating greatly in the middle and lower strata." And this fact will explain the occurrence of the better class of ore mines along the central part of the valley where these lower rocks are brought up by the anticlinal axis. To this (auroral) magnesian group—corresponding to the Calciferous and Black River groups of New

York—he assigns a thickness of 5400′ in the vicinity of Bellefonte, the detailed measurements of which will be given in the description of Spring township.

Above this Mr. Rogers describes his *Matinal limestone*—corresponding to the Trenton beds of New York—as not sharply distinguishable from his magnesian limestones underneath, either lithologically or palæontologically. A dark-blue somewhat carbonaceous limestone characterizes the formation, alternating throughout with light-blue and gray thin-bedded fossiliferous layers, and in the middle or higher portions contains some thin seams of dark blue shale. It is the dark red soil which the decomposition of this division affords that often forms the only guide to its identification through these limestone valleys. This rock Mr. Rogers gives a thickness of 300–400 feet in Nittany valley, so that the combined thickness of all divisions will yield 5800 feet.

Mr. Sanders' instrumental measurements in Blair county, Report T, page 52, sub-divide the group into three members, as follows:

Upper limestone series,	5400′
Middle white sandstone beds,	40′
Lower limestone series, (with the Potsdam),	1160′
Total, including some Potsdam layers,	6600′

It must be remembered in comparing these sections that the underlying Potsdam sandstone formation No. 1 is nowhere exposed in this county, and the 40 feet of "middle white sandstone beds" in his section may well correspond to similar measures exposed on the Centre Hall pike just at the anticlinal arch.

Above this limestone formation No. II, comes the Hudson river slates No. III, which everywhere intervene between the limestone of the valley and the sandrocks of the various mountain ranges through this southern division of the county. Prof. Rogers also sub-divides them into:

(a.) *Matinal black slate* (Utica slate of New York), a dark-blue carbonaceous slate and shale, fissile in its lower beds, containing, though nowhere in profusion, characteristic fossils. Thickness, 300.

(b.) *Matinal shales* (Hudson river slate), consisting of blue and greenish-gray shale, alternating with gray, calcareous, and argillaceous sandstone in thin beds. Thickness, 700′.

My own measurements on the vertical section through the Bellefonte gap gave 1011′ for the combined thickness of these two members. With this general summary of the character of these valley formations, I will proceed to point out some few of the detailed geological features in the various townships.

12. Half Moon township.

The main anticlinal of the Nittany valley is represented in this township in Buck or Chestnut ridge, the most northern hill of the "barrens," and exposing the lowest rocks.

These rocks make quite a prominent ridge here, dying gradually eastward. Very few exposures of these arenaceous rocks are seen, for they disintegrate rapidly and fall into sand, creating a dry and barren soil and sustain but little vegetation.

Chestnut and oak timber and stunted pine, however, take foot-hold well.

Occasionally an impure siliceous blue limestone crops on the flanks of these ridges, making ribs which in the eastern end of the county form a distinct ridge or terrace on the main crest.

The Loveville ore bank lies just north of Chestnut ridge, in limestone, hard and siliceous, dipping 45° S. E. This rock supports a northern low but prominent limestone ridge between Chestnut hill and the Bald Eagle mountain, whose dips are nearly all overturned.

Still higher limestones crop along the valley road, dipping 80° S. E., *overturned* on J. Gray's farm, but N. 40° W. 80° on the road to Scotia, south from Stormstown, and carrying a slight ore crop about 500 yards further south towards the crest.

This ridge carries the Desert, Gray and other banks in Patton township.

The Juniata Mining Co.'s operations are carried on at "Tow Hill," south from Stormstown, a full description of which will be found in chapter X.

East of Stormstown the hard, siliceous, magnesian limestone with quartz veins stands vertically in the road near the school.

Between the valley road and the Bald Eagle mountain the Trenton upper limestones occur, and their steep dip has lead to their rapid erosion through the valley of Half Moon run.

But one exposure of the slates of III was obtained in this township on the west road over the mountain to Port Matilda, dipping apparently 62° S. 22° E., no doubt *overturned* to that amount. About 45′ of slate is exposed here, somewhat quarried for road ballast.

The Oneida and red Medina SS. of No. IV lie further north, with the upper or white Medina forming the Worth township line and divide between Half Moon and Taylor and Worth townships.

None of these rocks show any special features here.

Fully one half of the area of this township is occupied by the sandy measures of the "Barrens."

13. Patton township.

The same class and number of formations occur in this township as already described in Half Moon adjoining it on the west.

The Chestnut Hill "Barrens" are still continued in this township, though sinking rapidly with the anticlinal which exposed them, until between the Pond and Markle banks, the higher magnesian limestone beds completely encircle its eastern end, whence eastward they no more appear until again brought up in Sand ridge 3 miles east of Bellefonte.

The township is rich in iron ore, the Scotia, Ackley, Lytle, Scott, Pond, Newell, Tar Hollow banks in the barrens, with the Desert, Lambourn, Markle, Crust and smaller openings in the higher measures, all tending to characterize this township as one of great economical importance. These openings have all been described in their proper place.

The "Barrens" are, as usual, unproductive of outcrops, and present the same heavy deposit of sand and cherty limestone bowlders before mentioned.

The upper magnesian limestone, forming the gentle ridge between the main hill and valley road, is again exposed in several places in this township.

North of the Desert bank it dips 60° N. W., but further east at the gap of a branch to Buffalo run, it is probably overturned, dipping S. 48° E. 65°, beautifully exposed in Jacob and Miles Mattern's quarry.

Selected beds make a very good quality of lime. Wash ore shows in the road between here and Gray's house. Limestone again crops in the lane opposite P. A. Sellers' house, apparently dipping N. 30° W. 50°, though further east a hard, blue limestone shows in the Lambourn bank dipping 42° into the hill south-east.

Along the valley road dips of 70° to north-west and south-east, the latter overturned, show just east of the Half Moon line, and at Gray's, just south of Matternville, good blue Trenton layers are standing vertical.

Further outcrops in No. II show further down Buffalo run at Mrs. Green's dipping 75° N. W. and along the railroad on the Brockerhoff farm with the same dip, between which outcrops some considerable ore wash occurs.

South of Fillmore, limestone with pipe ore shows on the township road dipping 20° N. W., succeeded by dips of 15° and finally 10° N. W. in the Crust bank, south of which the Nittany anticlinal passes.

The Trenton beds, with characteristic reddish brown soil, occur mostly north of the Buffalo run and form the best farming land in the township.

The gray and black slates of III occupy their usual place, outcropping along the south flank of the Bald Eagle mountain and riding well up the slope. They are also extensively cultivated, though considerably covered with drift of IV. On the road from Matternville to Martha furnace, in the Bald Eagle valley, these slates show back of the B. S. S. dipping 85° N. W. and extending to the foundry.

To the north, the terrace mountain of Oneida sandstone is

gapped by a small branch of Buffalo run, behind which an extensively cultivated cove of red Medina sandstone occurs, showing dips in red sandstone at the forks of the road of N. W. 70°, and reaching nearly to the hill summit, about 1500′ A. T., in white Medina, making the north township boundary line.

These same rocks are again exposed along the Patton-Benner township road, where another branch stream cuts into the middle member of IV, exposing III along the road, with dips of 70° N. W., and in the red Medina 60°.

The Oneida mountain shows no outcrop, but a profusion of hard, angular, gray sandstone bowlders covering the south flank of the mountain and the valley below.

The middle member of IV forms a marked cove between the two mountain ribs, and is highly cultivated through here by numerous farmers, and its soil is well spoken of.

14. Benner township.

This township joins Patton on the west, with Spring east and College south.

Its contour is beautifully varied by the waters of Buffalo run and Spring creek, especially the latter, which courses through the township from south to north, and presents in its sinuous course an excellent section of the lower Silurian limestone rocks.

From Roopsburg south a wagon road leads along this romantic stream, which is a favorite ride for the pleasure-seekers of Bellefonte.

At the grist-mill cross-roads No. II blue and white magnesian limestone dipping 70° N. W. marks the north leg of the Nittany valley axis. This dip subsides rapidly going south, inclining 65°, 60°, 40°, and 35° along the road to the south end of the dam.

At the first sharp bend in the road, No. II cherty and sandy magnesian limestone dips only 20° N. W., and the last north dip of 12° is exposed in the same at W. Smith's private lane.

About 500 yards south, close to the intersection of the road south to Lemont pike, marks the position of the Nittany

valley axis approximately, showing the same sandy, crystalline limestone as exposed in the arch on the Centre Hall pike.

Just south of G. Pratt's the dip is 10° S. E.

Two hundred yards further south at the next bend to the west, a splendid bluff of blue and white "ribbon-stone" shows a dip of 12° south-east at the Eagle's Nest.

Dips of 10° and 15° still south-east, succeed in the same bluff west around the bend of the road opposite the axe factory. On the north side of the factory dam, the hill is deeply grooved, rising in a perpendicular bluff 80′ above the stream and presenting a very wild and picturesque scene.

On the south side of the road two dips of 15° and 12° mark the beginning of the upper division of the magnesian limestones, displaying a soft French gray stone, devoid of the sandy, gritty characteristics of the lower beds. No good exposures occur for ¼ mile until the cross roads at Ballatt's 140′ above Bellefonte is reached where the dip is S. 40°, E. 15° in thin bedded limestone.

Between here and the bridge crossing the creek, an almost continuous exposure of limestone shows along the south side of the road in a bluff 40′ high and 200 yards long. The hill rises probably 100′ feet back to the Lemont pike, studded with interrupted limestone beds high up, considerably crushed and broken.

To the north of the creek the ground rises gradually to the axis which forms through here a broad plateau between Spring creek and Buffalo run.

Some iron ore was reported at Lutz's place near here. An old furnace stood many years ago at Rock, from the bridge crossing at which around the point to Reynold's mill, the soil is very red and probably marks the base of the Trenton limestone. No fossils were noticed in the rocks through here, but good blue carbonaceous limestone shows at the mill dipping S. 35°, E. 12°. At the next creek crossing at Waddell's, the dip is 18° in a 40′ bluff of blue limestone on the south side of the road.

The valley becomes more open west and the hills less pre-

cipitous. But few good exposures are seen until at the bend east of the school-house, there showing dips of 15° and 18° south-east.

Some little show of pipe ore occurs on Gordon's place to the south, but bearing off up the hill to the north-west, some more fine exposures occur near the line of College township close to the lime kiln, all dipping to the south east at angles of 15°–10°.

Following the Patton township line road north, some little pipe ore crops in J. T. Hale's heirs farms.

The country south of Spring creek rises to the Nittany mountain and exposures of No. II are more rare.

The Lemont pike rises from Logan's branch in Spring township on to quite a high ridge, the summit on the road being about 350′ above Bellefonte.

Cherty and thin bedded limestone dipping 70° S. E. shows in the pike, and after passing the second toll gate at A. Schwartz's, a dip of 10° accompanied east by some fair surface show of ore was seen.

The erection of College township cut off the south portion of Benner, but a narrow strip extends south-east to the crest of Nittany mountain.

The road at the base of the mountain shows Trenton limestone dipping 36°–20° into the synclinal, showing near the lime kiln an exposure 150′ long, good burning limestone bands mixed with siliceous and argillaceous layers, greatly broken and succeeded south by the slates of III.

The dips grow very gentle towards the mountain, so that the division of the formations Nos. II and III is not well marked, except by the sinking of the mountain stream issuing from McBride's gap as soon as it strikes the limestone.

The mountain is double at this gap, but contains no central keel of white Medina, the double crest being formed by north and south-dipping Oneida sandstone, with a red shale and sandstone valley of the lower Medina between the two arms.

Just at the stream crossing the road in this gap this latter

rock dips N. W. 18°, and marks about the center of the synclinal.

The Buffalo Run road shows but few good exposures in this township, and all of these in the upper magnesian limestones, dipping north-west 70° at the school-house and 46° at Hunter's hematite mine and in the bluffs between it and the road.

One apparently overturned dip of 80° S. E. shows in the road cut just west of the Roopsburg grist-mill.

North of the creek the Trenton beds occur, to be followed by the slates of III and the sand rocks of the Bald Eagle mountain.

East from the Patton line through the mountain the road swings northwards around the Oneida terrace, with red Medina in the cove between it and the main crest of white Medina.

On the summit above J. Moran's, 1450′ A. T. (bar.), everything is lower Medina, really making the ridge, while the upper member of IV has flattened considerably.

The Union township line is on the upper Medina for 400 rods, after which the mountain makes quite a jog to the south and admits of a small area of Clinton No. V shale along the north portion of Benner.

Some tests for ore were made on Mike Meyers' farm just north of the road, a shaft 12′ deep in the lower measures having turned out some gray ferruginous sand rock carrying a very lean and impure hematite.

To the north 60′ another shaft was put down and some little dark red ore removed; but neither of these operations furnish any additional light on the character of the fossil ore beds of V in this part of the region.

From here the road practically marks the divide between upper IV and V to Pardoe's, where a summit about 1700′ A. T. is reached and admits of fine views of the Bald Eagle valley.

South of Pardoe's a dip of 60° N. W. shows in white Medina, and east of this a flat summit marks the junction of the Oneida and upper Medina crests, cutting off the coves of the middle red member, which deepen east and west as

the mountain again separates. This feature is shown on the colored county map.

The road descends along the Oneida mountain as far as creek crossing, (branch to Buffalo run), after which the red Medina crops with dips of 70°, 65°, and 68° N. W. to the Spring township line.

15. Spring township.

This, the keystone township of the county, merits special mention not only from the fact of its containing the beautiful county seat of Bellefonte, with its varied industries, but by reason of its great mineral wealth and the great beauty and charm of its varied scenery.

Bounded north and south by prominent and lofty mountain ranges, whose rugged walls are gapped in three places, two thirds of its area is made up of the lower Silurian limestones, forming an abundance of most excellent farming land and containing several of the oldest and most productive pipe and hematite ore banks in the county.

The Gatesburg, Taylor, and Nigh banks of the Messrs. Valentines & Co., have turned out a large quantity of 50 per cent pipe ores; so likewise with the old Logan bank of Curtin & Co., and their present Fishing creek and Red bank operations, all of which have received such description at my hands as was possible with the limited time at my disposal during the field season of 1883.

The beauty of the Bellefonte gap in the Bald Eagle mountain, and the Pleasant gap in Nittany, are too well known to need special description here. Suffice it to say that in the repeated trips I made through them on my various excursions in the county, they never lost any of their grandeur or interest on close and intimate acquaintance, and the well-kept pike from Milesburg to Centre Hall makes a study of the lower Palæozoic rocks one of ease and pleasure.

The Nittany valley anticlinal axis is well marked on the pike just south of the toll-gate and 1 mile from the town, throwing off dips of 9° to N. W. and S. E., though immediately increasing these dips northwards to N. 30°–40°, W. 40°–50° through the town of Bellefonte in a series of excel-

lent exposures continued north to the junction of No. III Hudson river slates.

It was through the gap of Logan's branch and along Spring creek that Prof. H. D. Rogers made his typical section of the limestone series.

Logan's branch section.

Black river group of N. Y., 600 —.	k. Thin-bedded *encrinal* and *coralline* limestone,	30′
	j. Massive, fine blue limestone, weathering in holes from an obscure *coral*,	20
	i. Lighter blue, fine limestone, resembling the "Birds'-eye," limestone of New York; *Cytheria*, and other fossils,	150′
	h. Blue massive, and also thin limestone layers, some speckled with spar, and full of holes left by the removal of a *coral*. Many fossils,	400′
Calciferous sandstone, N. Y., 4800 +.	g. Alternations of blue clay—limestone with gray *coralline* magnesian l. s.,	200′
	f. Light-blue, massive magnesian limestone, (*no fossils*),	500′
	e. Alternations of light-blue, fine, with dark-gray crystalline *coralline* limestones,	1000′
	d. Light-blue limestones, (*fossils very rare*),	300′
	c. Gray crystalline magnesian limestones, (*no fossils*),	1500
	b. Light-blue magnesian limestone, (*no fossils*),	700′
	a. Gray crystalline magnesian limestone, (*no fossils*),	600′
	Total,	[more than 5400′

"The transition from the almost non-fossiliferous portion of the magnesian limestone to the overlying fossiliferous rock is well seen in the bank of the old Bald Eagle canal, about half a mile above the town of Bellefonte."

Above the uppermost layer of this section (K) comes 300-400 feet of the fossil-bearing Trenton beds to the Utica and Hudson river slates, dipping 50° north.

Thin bedded blue limestone intercalated with slates shows just south of the private lane crossing the canal and Spring creek to the nail works. About 200 yards east of this, within the limits of Bellefonte, is the extensive lime quarry of A. G. Morris, Tyrone. It is worked on the same outcrop as Alexander & Co.'s "Sunnyside Quarries" on the west side of the creek.

The quarry is about 150′ long N. E. and S. W., 100′ wide and 60′ deep. It is opened along the crop, the beds dipping apparently N. 35° W. 66°.

This is evidently the "Shortlidge quarry" referred to in Mr. McCreath's Report M², of which he gives the following analyses, made by J. Hartshorne in the laboratory of the Survey:

Shortlidge Quarry.

	Upper (*1012 a.*)	*Middle* (*1012 b.*)	*Lower* (*1012 c.*)
Carbonate of lime,	97.890	98.322	97.532
Carbonate of magnesia,	1.285	1.170	1.210
Carbonate of iron, . . } Alumina, ... }	2.03	.320	.377
Insoluble residue, . . .	.540	.390	.815

(*1012a*) *Upper Bed.* Hard and compact, seamed with calcite; pearl gray, with conchoidal fracture.

(*1012b*) *Middle Bed.* Very hard and compact, fine grained, seamed with calcite; pearl gray with conchoidal fracture.

(*1012c*) *Lower Bed.* Hard and compact; mottled with calcite; pearl gray, with conchoidal fracture.

The quarry is worked the year round, averaging 3000 bushels per week in summer, though not so much in the winter months. Four wood kilns, with a daily capacity of 180 bushels, comprise the plant.

South to High street in the town a series of excellent exposures averaging 50°–70° in dip and rising in bluffs 100′ high, occur

The *Sunnyside quarries* of J. R. and C. T. Alexander are opened on the west side of the creek about ¼ mile north of Bellefonte depot. The quarry shows a face 80′ high and exposures 70′ thick, about 50 feet of the latter being fit for burning.

As many as 8 distinct beds make up the mass in the quarry. The top covering, not quarried, is a shelly white limestone not fit for burning and the bottom a white magnesian limestone said to contain about 2 per cent iron.

The rocks dip regularly and steeply 60° north-west. The quarry has been worked for 18 years and produces yearly,

according to Mr. C. T. Alexander, 100,000 bushels of burned lime in addition to the shipment of about 10,000 tons of raw stone.

There are three kilns here, two of them having a combined capacity of 300 bushels, and the new one, slightly larger, 200 bushels per day of 24 hours.

They are lined inside with fire brick, then red brick and stone outside, strong and durable.

In none of them does the fire come in contact with the stone.

The following is an analysis made by H. Pemberton, of the Pennsylvania Salt Manufacturing Co. :

Iron, alumina, silica and sand,	.65
Carbonate of magnesia,	2.00
Carbonate of lime,	97.35

Logan's branch south of Bellefonte flows through a narrow gorge, created by the erosion of the stream, the hills rising on either side of it 100'+ to the plateau of the real Nittany valley.

South of the anticlinal as seen on the pike through this gorge, the same sequence of rocks already described in the section appear with south-east dips to the Nittany mountain synclinal.

South of the lime kiln, broken and somewhat shaly layers of magnesian limestone dip S. 32°, E. 20°.

Exposures of these lower rocks continue at intervals along the road to the store with about the same dip, in generally light blue broken stone with occasional massive beds. At Hume's grist mill, limestone is exposed 200' from intersection on the west bank of the creek in the hill, dipping S. 40°, E. 15°.

Close to the Benner township line a small quarry in cement stone has been opened on Robert Valentine's farm. The rock is a dolomite and dips about S. 38°, E. 15°. It is prepared for market at Hicks' kiln near the site of the old Valentine furnace.

The plant consists of 2 double kilns, each holding about 200 bushels and with a yearly capacity of 1600 bushels.

The eastern part of the township is a high table-land, and

the trend of the anticlinal axis has already been described in chapter IV, on Structural Geology. But few exposures occur here, though sufficient to show the steep inclination of the north leg of the anticlinal as compared with the south limb, which in the adjoining township east amounts to perpendicularity and even *overturned* structure.

Thus near the intersection of the north or Jacksonville road and the Curtin gap road, No. II dips 88° north-west, while south of the limestone ridge marked on the map the outcrops never show dips of over 30° S. E., and generally only 20°.

So likewise south of the Nittany mountain road from Pleasant gap to Zion, the upper beds of Trenton age make a low ridge with gentle dips south-east, with slightly lower magnesian limestones of a French gray tint cropping continually along the road with dips of 20°, 14°, 15°, and 12°, to the Walker line.

This whole section of country is a beautiful and highly cultivated farming region.

Some few sink-holes show in No. II limestone, especially on J. Kaufman's farm along the back road where the Trenton ridge has died away.

But the most remarkable of these is at the large pool known as Blue Spring, north of Pleasant gap.

Nittany mountain to the south shows but few irregularities of crest line, the north ridge of Oneida sandstone being generally of almost uniform height and nowhere breached between Pleasant gap and Hecla.

Pleasant gap is a remarkably beautiful one. The mountain stream which forms it sinks in the limestone at the north base of the mountain.

The slates of III ride well up the north flank, and limit the cultivation of the slope, meeting No. IV Oneida in the gap road at the stream crossing.

No exposures of the lower member of IV occur in the gap in this township, but everywhere a profusion of immense gray sandstone bowlders, creating a wild and rugged contour, and adding considerably to the picturesque features of the breach.

To the south, the overlying red Medina sandstone crops in several fine exposures of red sandstone and shale and flagstones, with dips of 20°, 25°, and 30° S. 30° E., making the north limb of the mountain synclinal or basin.

The township line to Potter is practically the axis, for the same red rocks appear just south of this line, with several dips, (70° N. W.,) which illustrate the form of the synclinal.

About 1½ miles east of the road, the upper or white Medina member of IV first shows, forming a central synclinal ridge, which in turn splits further east to admit of the red shale and sandstone valley of Clinton No. V.

The monoclinal north-dipping Bald Eagle mountain, forming, the north boundary of the township, presents a very broken contour, the main features of which are brought out in the sketch map of the Bellefonte gap, page 280.

A good exposure of white Medina 80′ thick shows close to the Boggs' line in the gap, dipping N. 30° W. 85° along the railroad, and an excellent exposure of the middle red member along the pike, dipping N. 26° W. 74°.

16. Marion and 17. Walker townships.

These two townships can be better described as one, for they practically include the Nittany valley eastward between the Bald Eagle and Nittany mountains.

They are divided from each other by a central low hill of the "Barrens," known as Sand ridge, which, passing into Clinton county, dies south-west of Mill Hall, with the anticlinal which elevated it, under a plain of higher limestone measures.

This ridge in all respects resembles the Barren ridge of the western part of the county, and in discussing the structural geology of the region in chapter IV I have supposed it to represent a part of the same main axis of Nittany valley contained in the Buck or Chestnut ridge.

This central divide is everywhere "a deeply-grooved, high ground plateau rather than a definite ridge.

Hard ribs of impure limestone make its contour uneven."*

It is evidently highest near its western extremity, where

*Final Report, Vol. 1, p. 495.

a barometrical elevation of about 1300′ A. T. was obtained, the ridge declining gradually eastward.

Right on the summit here outcrops of the hard, blue, impure limestone above referred to dipped south-east 20°–25°, almost virtually a sand-rock.

Some exploration for the heavy hematites of the western "Barrens" have been made here on tracts of Messrs. Valentine, but no very great success was attained.

This part of the valley is very dry and sandy.

On the summit at the road crossing from the Hecla bank to the Jacksonville road, about 1000′ A. T. (bar.), further outcrops of this siliceous blue limestone dip S. 15° E. 20°–26°, accompanied with sandy soil and bowlders and some little hard ore to the south.

A marked cove extends from the summit through Marion township to the Jacksonville road, which well shows the different topographical character of the two valleys on either side of this dividing ridge.

South, in Walker township, everything was smooth or gently undulating, owing to the slight dips of the measures.

In Marion township, however, the rocks are all turned upon edge, and even overturned all through the Jacksonville valley to within 3 miles of Bellefonte, where, opposite Curtin's gap in Bald Eagle mountain, the limestones, though steeply inclined, dip north at angles of 70°–80°.

Several dips to the south-east of 80°–87° *overturned*, were obtained at the cross-roads, and west along the Jacksonville road, a splendid exposure of soft blue limestone near J. Hoy's, dips S. 22° E. 70°. This deeply-marked groove extends west as far as Weaver's, where steep northerly dips occur.

In this distance, frequent short coves shoot south into the Sand ridge, producing detached hills of limestone along its north base and throwing the ridge itself into a series of knobs and spurs.

The records of the wells at the Scotia mines in the west, 400′ deep through these sand measures and underlying limestones, and the same at Beck's bank here, 600′+, first through sandy measures and then limestone along the north flank of the hill, in addition to the fine exposures of massive

blue and gray limestone in the Darrah & Zimmerman banks dipping south-east *into* hill, all tend to prove the propriety of calling this sandy rock a member of II low down in the series, but *not* the lowest.

I can see no reason for introducing a fault structure through this valley, as suggested in Prof. Rogers' Final Report. The Trenton limestones are in place north of the road at Jacksonville, where the "fault" is located, succeeded south by the dolomites or magnesian limestones to the Sand ridge, and by placing the anticlinal axis in the rounded knobs of cherty siliceous limestones S. W. of Jacksonville, with *overturned* structure, there is ample room to get nearly 6000′ of No. II up to the slates of III at the base of the Bald Eagle mountain.

One mile west of Jacksonville and close to Condo's B S S. there is an extensive exposure of broken "ribbon stone," dark blue siliceous limestone dipping 85° S. E.

On the Howard pike, north of Jacksonville, the Trenton beds, apparently devoid of distinct fossils here, are opened on the same outcrop on each side of the road.

The east quarry is Ertley's, where 7000 bushels a year are burned, in addition to supplying Howard furnace with limestone. The exposure is 60′ thick in beds from 6 inches to 1½ feet thick in light blue limestone, dipping S. 45° E. 80°.

On the west side it is quarried for farm use by Yearick and Long.

No. II extends as far north as the cove in the hill, where it is overlaid by the slates of III exposed in a road cut, crumpled and twisted by the overthrow of the anticlinal, here beginning to right itself. At the cross roads 250′ north, the dip is N. 40°, W. 82°, in a fair exposure of gray slate 50′ thick, extending to within 100′ of the flour mill.

Here the lower Oneida member of IV is exposed, dipping 78° N. W., 30′ thick, of coarse gray sandstone.

This extends to within 200 feet of the Howard township line, in the beautiful gap of that name, where the red Medina sandstone comes in and continues for some distance through the gap.

The junction of II and III is well marked again at J. Holmes' farm, about 1 mile west of the Clinton county line, where, in a gully washed down by spring water, about ¼ mile north from valley road, Trenton limestones dip 80° S., 38° E., *overturned*, almost imperceptibly grading into slate with same dip. The slates are highly polished and jet black, not unlike those quarried at Brown's "coal mine" at the north base of Nittany mountain.

South of Sand ridge, from Spring township line to Clinton county, No. II limestone shows in the various ore banks already described, dipping uniformly south-east at angles of from 40°–15°, in gradually higher measures ascending the slope of Nittany mountain.

These limestones are nowhere quarried in Walker township, and need no special description.

The mountain, however, is twice beautifully gapped by Little Fishing creek at Hecla furnace and by affluents of the same stream further east near the Clinton county line at the Madisonburg or Washington furnace gap. Another gap, sometimes confounded with the latter, is made by Big Fishing creek in Clinton county, which, after draining the anticlinal Sugar valley, issues through the magnificent gorge south of the old Washington furnace.

The Hecla gap is still a very wild and picturesque one, though not now the thoroughfare to Brush valley that it formerly was before the abandonment of the Hecla furnace. The site of the old furnace was on the slates of III.

No. IV white Medina is well developed here, forming a double central hill, which, widening eastward, takes in the red slates and sandstone of No. V in Pheasant valley. No. IV Oneida sandstone forms the terrace mountain on either side in Walker and Gregg townships, with an elevated vale of the middle red Medina sandstone between.

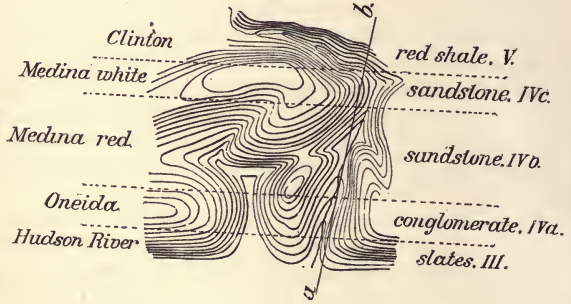
The slates of III are not well exposed in place, owing to a heavy covering of sand drift, but cover an extensive area south to the breast of the old dam, where they crop, dipping 32° S. E.

South 50 yards No. IV Oneida shows well in an outcrop extending 125 yards along the road, dipping S. 37° E. 40°–

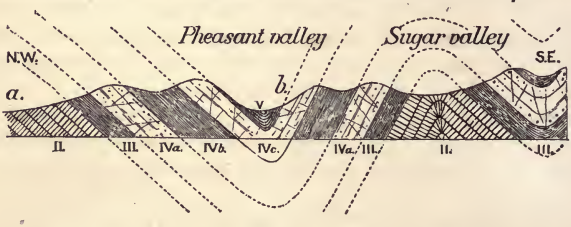
View of Conical hill in Big Fishing Creek Gap, Centre county.

Looking south-east from Washington Furnace.

Sketch map of Big Fishing Creek Gap.



Section through Fishing Creek Gap.



T4.

42°, in gray compact massive sandstone, weathering to a rusty brown, but with few signs of conglomerate.

No. IV red Medina forms *Rag valley* to the south, riding high up the central white Medina slope and really forming a terrace on it, though not seen from the valley to the north.

The white Medina synclinal forms the township line. Dividing east to receive No. V, the north rib of this inner mountain is twice notched in Markle's gap and in Lee's gap by tributaries of Bear run.

The slight south-east dips in Walker township throw both the main crest and its north terrace well out towards the Nittany valley road.

The Madisonburg gap—called Johnson's gap in the Final Report—forms at present the great highway of travel between Brush and lower Nittany valleys. It is only excelled in grandeur and importance by the Big Fishing creek gap in Clinton county.

A reference to the structure of this part of the mountain in chapter IV will assist an understanding of the outline sketch on page 320 from Geol. Pa., 1858, Vol. I, page 487.

The road from Nittany P. O. to Madisonburg) formerly a pike) passes through the gap in question.

For wildness of scenery and magnificent rock exposures, it is remarkable, as well as for its deep breach in the inner white Medina mountain, whose two prongs are nearly a mile apart here and admit between them in Pheasant valley, or "Little Sugar valley," quite an area of No. V.

Three mountain streams combine to make up a considerable volume of water. Two of these, Dry run and Mosquito run, drain respectively the red Medina country in upper Sugar valley and the Clinton shales and sandstone of Pheasant valley east of the old pike.

The third and longest, Bear run, rises west in Markle's and Lee's gaps and drains all western Sugar valley. No. II limestone occurs up the gentle slope south of Nittany P. O. to within 250 yards of forks to Washington furnace, succeeded there by III dipping just north of old dam S. E. 40°.

This is within a short distance of the Oneida terrace ridge,

where IV gray is splendidly exposed in a ledge 20′ thick and rising 80′ high just north of the new toll house and dipping about the same (40° S. E.)

The road and creek make a sharp bend westward south of this point, strikingly similar to Millheim gap in Brush mountain. Oneida sandstone continues to a point about 250 yards south of next bend, dipping 30° S. E. near the junction of IV red Medina, which in turn dips 25°.

After passing the forks of Bear run, the north prong of IV white Medina shows a good exposure of white sandstone dipping 25° S. E. on the east side of the road.

Just on the opposite side of the creek there is a curious, cone-shaped knob or spur contained between the waters of Bear and Dry run, which Prof. Rogers supposes "to be the result of denudation upon a small local flexure."

It has all the appearance of the eddy-formed moraine spoken of by him as occurring in Antis gap in Nippenose valley, and as seen by me in Big Fishing creek gap east from here back of the Oneida terrace, presented an appearance somewhat as shown in Figure, page 320.

It leaves the main ridge of the "Big mountain" (white Medina) about half way up its slope, admitting of a cove on each side between its knob and the mountain, and sloping gently on its north side to the creek forks.

This part of the Big mountain ends with an extensive exposure of white sandstone, dipping S. E. 28°–30°, succeeded by dips of 35° in the ferruginous slate and sandstone of the Clinton formation No. V in Pheasant valley.

The crop is 30′–40′ thick. The slate is of a dull blue gray color, and was formerly tried for ore at Washington furnace.

The south prong of Medina sandstone dips steeply 70° N. W., thrown up by the Sugar valley anticlinal, which in this township has also lifted the middle and lower members of IV in western Sugar valley, all dipping steeply N. W.

The connection and manner of occurrence of these various rock measures will be readily made out by referring to the colored map and key-section.

17. Ferguson township.

This township practically comprises lower Nittany valley, or that portion of this great limestone area which, with College township on the east, is not affected by any of the anticlinal flexures of Penn's valley proper.

Two subordinate anticlinals south of Buck or Chestnut ridge have been already referred to as Gatesburg and Tadpole or Sand ridge. West in Huntingdon county these flexures attain more prominence, but neither of them are traceable east beyond the Ferguson-College line.

These two ridges form a portion of the "Barrens," and with the main ridge on the north present the lowest rocks in the county on their arches.

South of the most southern or Sand ridge, about 2500′ of No. II magnesian and Trenton limestones are exposed to the base of III along the north flank of the Tussey mountain monoclinal.

Still lower rocks are brought up in Gatesburg ridge, and the lowest of these sandy measures finally appear in the main Nittany valley axis in Chestnut ridge.

This will be made plain by referring to the cross section of this part of the valley, page 38.

On the road between the Bryson ore bank and Pennsylvania furnace, splendid exposures of the lower magnesian limestones, trending parallel from the dam at the water pump along the south side of the road, show in an almost continuous outcrop.

The dip varies from about S. 30°–40° E. 25°–40°.

A fine face (30′) of blue and white stone is seen at the dam.

The road from here through Marengo City shows a dip of 30° N. W. in a dark blue, sandy limestone at the county line, marking the north leg of the anticlinal of Sand ridge.

At J. Eyre's house, bluffs of similar gritty limestone 20′ thick dip S. 25° E. 35°, and just beyond this in field near the old lime kiln, there is a small show of pipe ore dug from old pits. The specimens were of good quality, but scarce. The soil is sandy. Limestone crops in the woods 50 yards beyond, dipping south-east.

In the gap of Half Moon run through the Gatesburg ridge,

the anticlinal is well seen, throwing off dips of 6° south-east and 12°–15° N. W. in sandy layers.

There are frequent wash ore deposits along the road here, possibly derived from the Whorell's bank horizon, which is visible in many places to Gatesburg village.

An unreliable dip of 65° N. 70° W. was obtained on this road, which is probably not in place.

Regular dips of 20°, 15° and 10° show on the township line along the south flank of Buck or Chestnut ridge.

Further east along this ridge, impure limestone crops south of J. Booth's, dipping S. 35° E. 22°, succeeded in 200 yards S. E. by a good crop of wash ore, extending east in good shape on the Snyder, Roop, and Grenoble farms, and west along the road as far as the pond near Garner's house.

Gatesburg and Sand ridge have both died away considerably, so that along this road to the White Hall road, only rolling and barren sandy flats are visible.

Near D. Fye's place and John Weaver's, good soft blue and white limestone dips S. 45° E. 18°.

Crossing the White Hall road a small crop of pipe ore occurs at J. Weaver's.

South, over hill to Pine Grove mills, in the valley of Slab Cabin run, frequent exposures of cherty blue limestone show, dipping south 30°–25° into Tussey.

Pine Grove village stands on II, a good exposure of which is seen in the stream N. W. of the grist-mill, dipping 38° S. 30° E. At the school-house, the run disappears in a sink hole.

All the exposures along this back road are near the top of II.

N. E. towards Harris township, No. II crops at several places, notably at D. Ross and T. Yarnell, dipping about S. 35° E. 35°-40°.

At T. Patton's there is another sink hole, and two beautiful springs here considerably increase the flow of Slab Cabin run.

In a low ridge south of road, there is a lean show of ore on P. Botorff's farm—flinty and local.

N. E. up the hill from Yarnell's, several crops of limestone in good exposures dip S. 35° E. 15°–35°.

From Pine Grove S. W. along the back road, several exposures of the upper members of II dip about S. 40° E. 40°, especially well exposed in the neighborhood of Rock Spring village.

Here a fine example of the underground drainage so common to these limestone valleys can be seen in the spring on J. J. Goheen's farm, which has given the name to the village.

The spring issues from a 50′ bluff of good pure gray and blue massive limestone, dipping S. 40° E. 10°, about ½ mile from the base of Tussey mountain.

It issues with considerable force from a cave in the rock mass, after having sunk a mile to the east in the limestone north of Erb's gap.

It is virtually the source of Spruce creek and flows from here 12 miles to Spruce creek station, P. R. R. on the Little Juniata.

The main white Medina crest of Tussey to the south is unbroken, and dips south-east into Huntingdon county.

Its summit is about 750′ above Pine Grove hotel. The terrace mountain of Oneida is twice breached, however, at Pine Grove and Erb's gaps.

The slates of III ride well up on this terrace, dipping on the Pine Grove road through the gap, south-east 30°.

The iron ore banks of this township are described in chapter XI.

19. Harris and 20. College townships.

These townships lie next of Ferguson, the latter, College township, having been created recently out of Harris and Benner.

They contain portions of the lower Silurian limestone rocks of II and the slates and sandstones III and IV of Nittany mountain and the Seven mountains.

Both townships are extensively drained northwards by Spring creek and its tributaries, Slab Cabin and Cedar runs.

The Nittany mountain synclinal shows on the pike south of

Dale's mills, with dips in No. III Hudson river slate of 12° N. W. and S. E.; along Slab Cabin run road in Trenton limestone with 8° dips; and south of the State College with south-east dips of 18°, 12°, and 15°, and north-west ones of 20° in upper magnesian limestones and carrying in this narrow trough the Blair and Cooper banks.

To the north in College township several outcrops of lower limestones occur.

Thus at the bridge over Spring creek on the Lemont and Centre furnace road, massive blue limestone dips S. 35°. E. 15°, and again 100 yards west, somewhat quartzose and broken.

To the north 300 yards, a prominent but low ridge of II *probably* marks the extension eastward of the Sand ridge axis of Ferguson township, but everywhere here southerly dips prevail. No. II of good quality crops in an old quarry west of the furnace dipping about S. 60°, E 12°, and considerably used by the State Agricultural College.

From Lemont north to Haldeman's, Trenton limestones dip 10°–18° south-east in small exposures. At Botorff's the dip is S. 18°, E. 20°.

A short distance south of the school-house in Wm. Thompson's meadows, Slab Cabin run joins Spring creek, further increased by two beautiful springs from Mayes' place.

At Osman's cross roads, dolomitic limestone dips S. 22°, E. 28°, and ½ mile further towards Big Hollow bank 20° S. E. In a bluff on the south side of Big hollow No. II is well exposed, dipping S. 22°, E. 14°.

South, in the hill summit north of Centre furnace, sandy magnesian limestone dips S. 33°, E. 14°, and again in Thompson's quarry at roadside, in a face 20′ thick of rather siliceous blue and white banded limestone dipping S. 40°, E. 20°.

The great drawback to most of the quarries here and in Penn's valley generally, is the difficulty in finding any thickness of good burning stone, always occurring in small beds of 12 to 18 inches between beds of a more sandy and siliceous character.

South of the pike in D. Kinport's quarry, excellent Tren-

ton limestone shows which is claimed to have made good cement.

It is very much fractured and occurs in cubes 3″ on each side, of dark blue color and dipping in a 15′ exposure S. 30°, E. 30°.

From Dale's mills S. W. to Stover's bank, limestone dips everywhere about 50° to N. W., marking the north limb of the Brush Valley axis.

Near the Harris line, on the Boalsburg pike, gently dipping S. 18°, E. 12° limestone marks its south limb.

About 200 yards N. W. limestone at Irwin's dips N. W. 48°, and 46° in a knoll at Foster's place, and 50° at B. Peters' farm in an excellent 30′ exposure of soft blue stone.

At the lime-kiln quarry, the dip is still about 50° N., 28° W.; an historical locality, once "salted" with gold and placed in the Centre county market as an offset to the claims of California.

Two hundred feet further north the slates of III stand on an edge, and dip 50° N. N. W., but gradually subside to 12° at the synclinal axis, and indeed beautifully basined, with dips of only 2° each way.

These slates have a dark-brown and chocolate color.

The same axis is well exposed about 250 yards north of the barn on the road from Lemont up Slab Cabin run, occupying high ground and curving in a gentle basin, with dips of 6°.

Passing E. C. Humes' farm-house, the dip increases to 30°, and 100 yards further, beyond brown school-house, to N. 20°, W. 40, in blue limestone with mixed seams of calcite.

There is some little show of ore at Musser's house, ¼ mile further S. E.

In Harris township, in the Pine Grove-Boalsburg road east of Dr. A. A. Henderson's, No. II outcrops almost continuously to Ishler's house, trending along road and dipping S. 20°, E. 25°–28°.

West of Boalsburg, the dip is only 12°, while east it is 20°.

South of Linden Hall several good exposures of magnesian limestone occur on the south side of the Brush Valley axis.

They show mostly a siliceous blue stone, greatly broken, and dipping about S. 30°, E. 25°–30°.

Between the mill and the village the dip is only about 12°.

Passing the axis at Ross' place, and ascending to McBride's gap, the measures dip north-west, followed by slates of III.

No. IV Oneida makes the crest here, dipping N. 28°, W. 40°, about 50 yards from summit. The stream between the two mountain ribs has cut down into the Medina red shale and sandstone 185′ below the crest, at the road crossing close to the Spring-Potter line.

Tussey mountain, in Harris, has its terrace member gapped at Thomas and Hasson's gaps by branches of Slab Cabin run. Between them the terrace is greatly subordinate to the main Medina crest; but from Hasson's gap eastward the terrace is higher, steadily rising with an irregular crest line until it ends in the bold Tussey knob.

In the gap leading into the Bear Meadows, both this sandstone and the slates of III show dips of 40° S. E.

The inner mountain ends in a high spur west of this gap road, swings south-east around the meadows near the Huntingdon county line, and passes east along the south side of Sinking creek, in a compressed synclinal ridge to Thick Head in Potter. Returning around the dying Confer and Decker Valley axis, it forms a kettle in the south-east corner of Harris.

It again swings east along the south side of this hollow to make the county line, and the prominent Bald mountain spur in Potter, seen from the Lewistown pike.

It forms another loop south in Huntingdon county, and returns to form Paddy mountain and the county line to the Union corner.

The Bare or Bear meadows is a high, flat marsh consisting of several hundred acres of ground 2000′ A. T., and supporting a great variety of botanical curiosities.

The marsh is made by the Sinking creek which, rising in

a spring on the north side of the Oneida ridge, swings around its dying anticlinal, where its flow is somewhat arrested in the kettle of the encircling Medina mountain, and thence north-eastward into Potter township. The creek gaps the Oneida mountain close to the Potter line before issuing in the slates of the "Loop."

Two small patches of Clinton No. V are embraced in the wide basin of white Medina south of Hasson's gap and close to the Huntingdon county line.

The area of these rocks is small in this county, but widens considerably south-west in Huntingdon.

They are also drained in that direction, as will be apparent by inspecting the colored map.

This whole southern part of Harris is a wild and uncultivated region, and totally uninhabited.

21. Potter township.

This township adjoins College and Harris on the east, and together with this whole tier of southern townships it presents a great variety of scenery and fine exposures of the Lower Silurian rocks.

Its structure will be readily made out from the general section across the county, as the section line from Nittany mountain on the north to the Mifflin county line passes through Centre Hall, Centre Hill, and Potter's Mills.

Its northern barrier, Nittany mountain, is a synclinal double mountain, until 1 mile east of the pike it becomes triple by the rise of the inner main crest of white Medina.

The northern township line is the approximate axis, so that the rocks of this mountain in Potter show always northerly dips.

In the Watson bank road, excellent exposures of the middle red Medina sandstone and shale dip N. 30° W. 50°.

Further south 100 yards outcrops of the same rocks dip 60°, immediately south of which No. IV gray Oneida is well exposed, dipping 70° N. W.

The slates of III, supporting this mountain ridge, show first at the private lane at the base of the hill, exposed in a quarry, but so crushed as to conceal the dip.

They continue south to Gregg's house, there succeeded by the limestones of No. II.

The pike leading over the mountain to Centre Hall shows exposures of these same rocks, the red Medina in the elevated shale and sandstone valley between the two opposing ribs dipping 70° N. W., succeeded south by Oneida sandstone, dipping 50° in the same direction.

Centre Hall to the south, is in the limestones of II, the Brush Valley axis passing through here and well marked east along the road, with dips of 70° and 65° N. W., and 40° and 48° south-east, close to the Gregg line.

This axis attains its greatest elevation and northern deflection about Centre Hall, where the upper magnesian limestones are exposed. West of Centre Hall it swings south, passing through the first low ridge south of the Watson bank, and throws off dips of 30° to south-east.

The Watson bank occurs in north-dipping limestones and near the base of the Trenton division.

The L. & T R. R. grade shows some wash ore in the cut south of Lingle Bros., and the Brush mountain synclinal practically keeps the grade line here, with dips in No. II of 30° S. E. and 50° N. W.

Rising on the flat limestone ridge to the south, marking the Penn's Valley axis, these dips subside to 25°, 15°, and 10°, the arch being broad and flat here, and dying west in the offset of Tussey.

The country is high and rolling in this township, marking the water shed of this section, and largely farmed.

Along the Gregg line, the Penn's Valley axis shows dips in magnesian limestone of 20°–50° south-east.

East of Centre Hill, in the neighborhood of the Sinking Creek mine, there is some appearance of a steep compressed anticlinal roll along the road, with dips of 50°–80° N. W. and 65°–70° south-east at the mine into Egg hill.

The junction of II and III along the Gregg line at the base of this hill is at the Sinking creek crossing, extending west to the church and cemetery at Royer's, and thence to the Lewistown pike, about 500 yards south of Centre Hill, and finally to Churchville or Tusseyville cross roads, and

along the cove south of the Boalsburg road to the Harris line.

Dips on the east are about 40° S. E. into Egg hill, 65°–70° at Penn's Valley mine, and 50° on the road west of Centre Hill in an almost continuous exposure to the forks at the large mill-dam. There are probably 500′ of the upper limestones exposed south along this road, with a dip of S. 38°, E. 45°–50°, from Runkle's to the flour mill, mainly blue and cherty. This outcrop of II extends east along the ridge to Centre Hill, excellently exposed and quarried in the pike south of that village for farm use.

At Churchville, the limestone crops from the school house north to the quarry, dipping at the latter place S. 39°, E 60°, with N. W. cleavage planes of 80°. It is about 300′ thick here. Some little fine ore and sand occur north on Krummerine's farm.

South of this limestone anticlinal is the synclinal of Tussey knob and Egg hill, from which the Oneida rocks of IV have been washed away between these two spurs, but have left a long belt of slates intact. This slate belt averages about 1 mile in width.

Egg Hill shows only a small remnant of IV gray Oneida about 2 miles long and mainly in Gregg township.

It is of simple synclinal structure, and its axis may lap past that of Tussey mountain.

The south dips in the slates are about 40°, but the north dips much steeper, owing to the presence of the compressed *George's Valley* anticlinal on the south.

Along the Sinking creek road, these gray and brown slates dip 50° N. W., and at J. Wolf's 55°. Another dip of 70° N. W. was obtained about 200 yards S. W. of the M. E. Church on the road to Potter's Mills, succeeded at pike intersection by No. II limestones.

North, the slate synclinal shows well at the Sinking creek crossing in dips of 10°–20° each way, continuing on the latter dip north to the limestone.

No. III slate is well seen north at J. McCoy's, where in a hollow ½ mile north of the "Loop" road, the dip is nearly vertical 85° N. W.

Tussey Knob synclinal carries Medina red and Oneida gray sandstone in this township. The axis passes north of Rev. D. Kerr's house, exhibiting along road dips of 6° N. W. and S. E., rising to 20° south-east on the hill at the Evangelical Church, and 45° at the junction of the limestone. South of the axis the N. W. dips are steep, 50° at Sinking creek crossing and 60° further south towards the George's Valley anticlinal.

George's Valley anticlinal is very much contracted in this township. No limestone is seen further west than P. Kerlin's, where it is only about 250 yards wide. It spreads but little eastward until nearing the Gregg line it is about 500 yards wide.

It is a regular but steeply compressed anticlinal. On the pike north of Potter's Mills at the creek crossing, it is slightly quarried from an exposure 60′ thick of blue Trenton limestone dipping S. 25° E. 70°–80°.

North of J. W. McCoy's, the dip is 74° S. E., and along the "Loop" road west from here limestone shows again at the cemetery dipping S. E. 70° close to the junction of III. At the school house the dip is 50° S. E. The axis passes near Jno. Moyer's at the road forks, showing a north dip of 78°.

Potter's Mills is situated on the slates of III, which are quarried for road ballast back of the ruined mill, dipping 40°–50° south-east into the mountain.

Seven mountains. The best section in this township is developed along the Lewistown pike. The first ridge south of Potter's Mills exposes Oneida sandstone of IV high on the east side of the road, dipping 48° S. E. and succeeded at the bend of the road by red Medina, with about the same dip. All these valleys through the mountains in the middle members of IV are distinctly made up of red shale and sandstone to the exclusion of olive and green slates and lower conglomerate. No middle hill of white Medina is seen in Triester valley, so that the red Medina makes up both sides of this synclinal, well marked where the pike turns west at the small stream crossing, by dips of 0°–10° each way.

North, at the wood road to the east, 15′ of red shale and

sandstone dips S. E. 35°, again exposed inclining the same way 30° at the toll gate. South of the axis, the same rocks dip 20° northward, succeeded by Oneida sandstone, fine-grained, dipping 40°.

This ridge forms the north barrier of the little Decker slate valley, which is a tight anticlinal only bringing up the No. III slates to daylight. Crossing this valley, *Sand Ridge* is made up of IV Oneida dipping south-east under Foust's or Underwood's red Medina valley, a broad synclinal basin extending to the Mifflin county line. The spur of Bald mountain in IV white Medina dies west of the pike, but is continued further east near the Gregg line in Paddy's mountain.

The mountain at Potter's Mills extends east and west into adjoining townships, only once gapped by Laurel run at W. Boal's saw mill.

Triester Valley extends unbroken into Gregg, but divides west near the Harris line to receive "Thick Head Knob" of white Medina encircling the Bare Meadows to the west.

Decker Valley in No. III contracts west to Underwood's saw mill, where the retaining wall of Oneida sandstone circles around it, the latter being in turn surrounded by IV red Medina near the head waters of Laurel run.

East, the valley spreads somewhat into Confer valley, but is never over a half or three quarters miles wide.

The *Foust Valley* synclinal forks westward to admit of the central keel of Bald mountain, but is unbroken north of Paddy or Long mountain into Gregg township.

22. Gregg township.

This township is but a continuation eastward of the topographical features of Potter.

Nittany mountain is partially gapped by a small branch of Penn's creek, though its central rib of white Medina remains intact. The road crossing to Hecla shows this central ridge as a broad synclinal double mountain, receiving east the Clinton shales and sandstones of No. V.

South along the road, the red rocks of IV dip 60° N. W. succeeded by those of the Oneida member with a dip of 58°.

No. III is not well exposed, but continues south of the terrace to where a sink-hole marks the junction of No. II.

Brush Valley anticlinal, continued west from the Miles line, is steadily rising and bringing up lower measures. It is very straight in this township and practically trends along valley road. Numerous sink-holes cause a very uneven contour. At S. Yearick's the dip is 65° N. W., and at the M. E. church, two good exposures of siliceous limestone dip 70°. Along road through Brush mountain, No. II dips 15° S. E., close to the edge of the slates.

The axis is south of the valley road here and the arch shows much steeper north dips than south ones.

Long's Cave is one of the best known examples of the sink-holes that may occur anywhere in these valleys. It is about 4 miles east of Centre Hall and 3 miles north-west of Spring Mills. Many people visit this underground opening.

The stream issuing from Hecla gap north of it, sinks in No. II at J. White's house north of the Brush Valley road.

It courses thence underground to Long's place, where an entrance by steps about 25′ high leads to the surface of the water in the cave. An excellent exposure, about 30′ thick of fine French gray limestone, fills in the face of the opening, dipping S. 30° E. 45° and creating a picturesque entrance.

The cave is simply a fissure in this limestone rock. It is about 1260′ long and is arched from 6 to 40 feet above the surface of the water. Its width varies greatly, in some places being scarcely wide enough to admit of the passage of a 5′ scow, used to navigate this underground stream, and again widening through a dry chamber 200′ northwards.

The depth of the water is from 12 to 17 feet, with a considerable fall. At its exit, the water is dammed for a saw-mill, and there would seem to be quite sufficient power to furnish an electric light for the cave.

From the inclined roof of the cave the stalactites are suspended, comparatively few in number and of no great beauty of form and color, the smoke of candles and lamps having done much to soot their surfaces.

The stalactites and stalagmites are usually short, the best

forms showing in the dry chamber, though a very beautiful cluster is seen about 500′ from the entrance, where some pillars 6′ to 8′ long occur, with fine combs of a moss-like character.

Quite a canopy of stalactites form a quadrant arch here, taking very attractive forms.

The cave has been opened for about twenty-six years and yet very little has been done to enhance the natural beauty of the spot.

West of White's, the dip along the road is 70° N. W., succeeded shortly along the cross-road to the south of J. Weaver's by dips of 42° S. E. At Long's house, in private lane, some good exposures of gray and slaty blue limestone occur with dips of 45°, 48°, and 50°, all to south-east into the synclinal of *Brush mountain*, whose sand-rock members have disappeared at this point, but whose supporting slates of No. III stretch in a narrow basin nearly to Centre Hall in Potter township.

Brush valley is a scant mile in width, and as its rocks are steeply upturned, erosion is marked.

Brush mountain ends in a knob, south-east of the cave, formed of Oneida gray sandstone, separating 2 miles further east at the road-crossing, but retaining no red Medina until at the Penn township corner. See map.

Several small streams gap the north ridge, only to sink on striking the margin of the valley limestones. The latter dip 15° S. E. at the road crossing the mountain, succeeded south by slate, and eventually IV Oneida, dipping 20°.

At the bend of the road south at the springs in the gap, the same rock dips N. W. 40°, so that the synclinal passes closer to the north ridge.

The slates of III cover nearly a mile of territory south along this road to Penn Hall, and apparently contain a small and local anticlinal flexure to give them that expanse.

The dips near the mountain are about 30° N. W., but near the junction of II they are thrown up to 60°. A combination of these dips, with one of 50° further west along the mountain road, would produce an enormous thickness,—

at least 2500′.—for No. III, which is hardly possible in the face of so many proofs elsewhere to the contrary.

The *Penn's Valley anticlinal* to the south, entering from Penn township north of the pike, is well marked on the road north from Penn Hall at A. Bartges, with dips of 60 N. W. and 20° S. E.

This steep north-west dip must have been caused by the presumed roll in No. III to the north, for in continuing along the axis west, it shows one mile north of Spring Mills in a broad arch with north-west dips of only 10°, succeeded north by 16° and 15° to the slates of Brush mountain, and with dips of 35°–40° south-east on the south side of the anticlinal.

Moreover, from the Penn's line west to Spring Mills, the limestone area is just as much contracted as the slate belt has spread, being only about ¾ miles here as against 2 miles at the Potter line.

The pike ¼ mile east of Penn Hall, shows a quarry in II, displaying 15′ of limestone overlaid with 2′ slate, dipping S. 36° E. 30°.

North of the forks at the B. S. S. there is quite a stretch of blue limestone exposed, dipping S. 27° E. 22°.

West from Penn Hall, the pike runs along the south base of a high, dolomitic limestone ridge, all cultivated and clear, and showing dips of S. 33° E. 30°–35°.

Penn's creek north of Spring Mills, shows a fine exposure of II, the side hills being stripped for 75 yards along the road, with dips of about S. 35° E. 35°–40° in blue and gray cherty limestone, also cropping on the west side of the creek.

North of the anticlinal, crossing this road near a private lane, almost continuous exposures of broken limestone extend from G. Kornman's to the edge of III, split up with cleavage joints dipping steeply 80° S. E., but the beds themselves dipping apparently from 6°–15° N. W.

The limestones extend south to Sinking creek, dipping at angles of about 30° south-east under the slates of the *Egg Hill synclinal.* This hill of Oneida is but a remnant 2 miles

long, supported on No. III slates, and dividing Penn's valley proper from George's valley and the Loop.

It is, of course, of synclinal structure, its south ridge dipping more steeply (N. W. 60°–70°) than its north and more gently (40° S. E.) inclined member.

It is flanked by Hudson River slates, which extend from its eastern flank clear across the township and into Penn.

It shows dips of 12° south-east on the road south from Spring Mills, in a splendid exposure of firm, gray and brown slates in a cut below the new hotel, and 30° S. E. below Penn Hall.

On the same road near J. Oswald's place, the dip is 60° N. W., and at the church it rises to 70°, showing the character of this synclinal trough.

On the road south of Egg hill near T. Decker's house, the lower fissile Utica black slates of III dip 74° N. W. into the hill.

They are very much broken and weather red.

The *George's Valley anticlinal* succeeds this synclinal on the south, between Egg hill and the Seven mountains. In this township it shows everywhere a regular and a gentle arch, with dips of 10° N. W. and 15°–20° S. E, contracting however, towards Potter where steeper dips prevail.

No. II shows in R. R. bank above red brick school-house dipping S. E. 15°. The road leading east from the school to Heckman's, passes over a considerable area of dark red soil and shale due to the decomposition of an argillaceous limestone cropping in several places with a south-east dip of about 20°.

While regularly arched, the floor of George's valley is by no means smooth, being made up of detached hills, whose soft Trenton limestones have been readily eroded through numerous small streams and branches of Penn's creek.

Seven Mountains. The southern portion of this township is beautifully diversified by the intrusion of small portions of the Confer and Poe slate valley anticlinals into the wide sand flat of Oneida No. IV.

The slates supporting the seventh mountain along Penn's creek dip everywhere at slight angles (20°) into the ridge.

The road leading south from the M. E. Church in George's valley into Confer valley, presents a wide section of III occupying the flat ground to the south of the new saw mill, where it meets No. IV Oneida in a perfect exposure 170′ thick, almost without a break, in massive gray, fine grained sandstone, dipping S. 28° E. 30°. At the creek crossing heading up towards P. Auman's, No. IV middle or red Medina sandstone shows 25′ thick in massive sandstone and flags, and again exposed at the next creek crossing south with the same dip.

South of this the creek winds eastward in the basin of the synclinal. It makes a breach in the opposing ridge of Oneida sandstone ¼ mile further south, where 25′ of gray sandstone dips about 60° N. W. about 50 yards north of Brillinger's old mill.

This breach leads into Confer valley—a slate anticlinal of III—which narrows and heads up eastward near the M. E. Church, around which the two mountains of IV circle and form a high knob.

Confer valley is about 250 rods wide at the Potter line, and shows a regular arch with the axis along the north side of the valley. It is not yet the garden spot it is capable of being made by a liberal use of fertilizers or even burnt lime from the valley; but even now it is tolerably well cleared and cultivated.

From its east head a wide sand plateau of IV Oneida extends to the Penn line, holding this anticlinal and the synclinal of Foust valley and spreading south to the Poe valley anticline. This slate valley heads westward from Penn township and is similarly encircled with No. IV Oneida ridges to Confer valley.

The synclinal of Foust's valley, between Poe and Confer, shoals eastward before reaching the Penn line, while to the south, the Mifflin county line is marked by the high straight ridge of white Medina known as Long or Paddy mountain. This portion of Gregg township is wild and still heavily timbered.

23. Penn township.

Penn township is nearly a parallelogram, bounded on the north by Brush mountain, and on the south by the white Medina ridge of Paddy's mountain.

Brush Mountain synclinal consists here of the two lower members of IV, the middle red Medina member contracting rapidly from its splendid outcrop in the Millheim gap to the narrow elevated vale at the Gregg line, with the bounding mountain ridges of the Oneida sandstone forming the two sides of the synclinal.

There is only one breach in this mountain in the township—that made by Elk creek through the Millheim gap—but it is not surpassed for beauty or exposures by any of the mountain gaps in this part of the county.

Leaving the Miles line in the synclinal of red Medina, where an abnormal dip of 80° N. W. is seen, the pike runs south along the west side of Elk creek, and, after one or two apparent rolls in the rocks, the dips settle down to an average north-west inclination of 25°–30° to the bend at the saw-mill.

About 50 yards N. of the mill, 30′ of massive red sandstone shows, though almost continuously exposed north to the Miles line.

South from the mill, an exposure of sandstone and shale continues for 500 yards, showing massive beds 20′ thick with shaly partings, aggregating on a 30° dip nearly 900 feet of red rocks.

At next bend, just north of the toll-house, the gray Oneida is magnificently exposed in a bed 35′ thick on both sides of the creek, dipping conformably with the overlying red sandstone, and making almost a solid rock exposure from the saw-mill to the toll-house. At the Clover Mill dam, another excellent exposure in this member dips N. 28°–30°, W. 35–40°, continued on the opposite side of the creek in a series of bold out-crops for 100′ further south, the ledges rising 60′ above the creek and consisting of massive gray sandstone in beds 40′ thick on dips of about N. 30°, W. 40°–50°.

The hill is profusely covered with timber, and its wild

and rugged scenery forms a striking contrast to the beautiful rolling limestone country to the south.

The slates of III come in just south of the mill and show well along the east bank of the creek, where they have been drifted upon for some distance in the hopes of finding coal.

They dip 50° N., 27° W., and extend a short distance south of the dam before meeting the Trenton beds of the lower Silurian limestones of II in Penn's valley.

Penn's Valley anticlinal is steadily rising and trending northwards from the Haines line. It passes 500 yards south of Millheim, crosses to the north side of the pike somewhere near the school-house 2 miles west of the village, and thence to Gregg township. Along its arch south of Millheim, it brings up some of the upper magnesian layers below the Trenton beds, corresponding to those just north of Bellefonte, and which, being slightly ferriferous, show some little traces of ore here on the Stover farm and further west.

The pike from Millheim to Aaronsburg rises over a large hill of No. II, dipping 60 N. W. towards Brush mountain, and on the Millheim Gap road, ¼ mile north of the cross roads, it is quarried and burned.

It shows Trenton limestone in the north quarry 60′ thick, dipping N. 30° W. 80°. The south quarry shows two massive beds of good stone, each 4′ thick.

West of the Millheim church at the U. B. church the dip is 64° and east of the school-house 60°–62° north-west.

The *Egg Hill synclinal* has lost its force in this township, only showing a patch of III on the Gregg line, and having but little effect on the limestone, unless it be to lessen the dip of the south leg of the Penn's Valley axis.

In consequence of this dying away, there is practically one broad limestone valley, 2½ miles wide, from Brush mountain to Penn's creek at the north base of the Seven mountains, with two anticlinal rolls, and a sharp basin between them.

On the road south from the school, No. II, at A. Hosterman's, dips S. E. 28°, outcropping in ledges with the same dip to the cross-roads.

At S. Krape's there is another outcrop greatly cut up with cleavage planes, which I have interpreted as N. 29° W. 45°, placing the Egg Hill synclinal north of his house and the Pine Creek or south anticlinal near B S. S.

South from Millheim, the pike shows excellent exposures in II. The first, at the mill, dips N. W. 70° with cleavage, and the same at the second bend further south.

The Penn's Valley axis passes somewhere near here, for at G. Schwartz's private lane the dip is 12° S. E., and below J. Dame's 20° S. E. The dip stiffens to 30° opposite D. Kreamer's, and to 40° below J. Dinge's estate, south of which the synclinal is developed in a gentle basin, with dips of 4° each way. The basin is shallow and narrow and quickly rises to the *Pine Creek-George's Valley anticlinal.*

This axis is much straighter than the northern arch, and can be traced in this township in an almost direct line from just north of the toll-gate at the intersection of Elk and Pine creeks, a little south of west to the Gregg line on the road from Coburn to Spring Mills.

North of the toll-house, the N. W. dip is about 40°; south of it No. II shows in the creek, dipping S. E. 42°. Again, 100 yards further south, a good quality of blue and white stone massive, 50′ thick, dips 45°. Fifty yards further a magnificent exposure occurs, dipping 40°–60° for 300 yards to the bend of the road west to Coburn, showing fine-grained smooth blue and white limestone 500′+ thick, and one of the best outcrops in the township.

Hick's cement works is supplied from near the junction of the magnesian and Trenton limestones and in the road, east into Haines township, 150′ of excellent limestone shows below the works, dipping south-east 40°–50°.

Further west in this township, this anticlinal is seen north of the Evangelical church, south of which No. II dips S. 28° E. 62°, and again at the intersection of Pine Creek road in a reef of rock dipping S. 25° E. 22°.

On the private road north from the saw-mill near the Gregg line, No. II dips 50° south-east, and at Nee's house 70° N. W., with the Pine Creek anticlinal between the outcrops.

The little village of Coburn, situated close to the junction of Penn's, Pine, and Elk creek, in front of the great gap in the Seven mountains, and the L. & T. R. R. station for Millheim, bids fair to assume importance in the near future. Its principal shipping interest now is lumber, though its valley, being made up of the Trenton argillaceous limestones, will soon assume agricultural prestige. Its scenery is beautiful.

Seven Mountains. Properly these mountains, with their included slate valleys, take up about one half of the township.

Penn's creek, entering from Gregg township, practically divides II and III as far as Coburn station, where it changes its course to south-east, and, with the assistance of Pine and Elk creek waters, plunges through a splendid gap in the mountain and establishes the course of the railroad line to Lewisburg.

South of Coburn, No. III dips S. 26° E. 60° in a cut below the station.

Entering the first or outer mountain of IV Oneida, cut down to its base, there is nearly 200′ of massive gray sandstone exposed on both sides of the creek, dipping S. 30° E. 42°.

This is followed by red Medina at a small stream heading west from R. R., which occupies the railroad for half a mile in a shallow synclinal, with an initial dip of S. 24° E. 25°, and one of N. 28° W. 30° higher on the hill above the Beaver dam tunnel.

At the tunnel, the hill is only about 60′ above the track, rising east and west on both sides of the creek.

East of the tunnel, there is a magnificent exposure of IV gray Oneida, forming the north barrier to the little slate valley to the south. The rock rises in ledges 80′ high, and dips about N. 28° W. 48°.

Oneida sandstone shows about 225′ thick in the tunnel, mixed with some yellow slate with a wavy structure.

At the north entrance the dip is about N. 26° W. 47°, while at the south end it is much steeper.

Emerging from the tunnel, the railroad passes through a small slate valley (anticlinal) to Fowler's station in Haines.

The slate reaches north to the face of the tunnel, and its junction with IV is plainly marked about 8′ from the south tunnel head.

The upper part of III shows about 15′ black and brown slate, alternating with gray sandstone, gradually passing into IV.

The dip here is about N. 20° W. 64°, and is about 60° half way down the track to the Haines line.

This little valley, called "Lechathal" or Lick valley by the Dutch residents, is only about half a mile wide, and heads up west in this township into an elevated sand flat of IV Oneida, before mentioned in Gregg township.

On the road leading south from the saw mill on the Penn's creek road in George's valley, near the Gregg line a section of these same rocks is exposed, showing first II south of the track, overlaid with Hudson river slates of III, dipping S. E. 35°.

This is followed by Oneida south of the first dwelling, with same dip, continuing to the bend of the road at the small stream crossing, which marks the beginning of the red member, with a south-east dip of 20° in the north leg of the synclinal.

Half mile south of G. Confer's north dipping Oneida marks the south side of this red shale and sandstone valley, as well as the north barrier to the wide sand plateau, with an anticlinal and synclinal, and forming the mountain ridge encircling the Poe valley to the south.

This is another slate anticlinal of III, and stretches across the township from east to west from S. Lingle's saw mill to Mussert & Gepheart's old mill.

Two rough roads enter it from the north at either end, and a wood road traverses the creek. The valley is about ½ mile wide, and is a regular tight anticlinal of slate, supporting on its south leg the successive members of IV with the straight white Medina crest of Paddy's mountain marking the Mifflin county line.

24. Miles township.

This long and slender township lies north of Penn and Haines, with the Clinton county line for its north boundary along Nittany mountain.

The structure of this complex mountain divide has been elsewhere discussed; but, in general, along this border line, it presents a double or triple synclinal range of hills between the anticlinals of Sugar Valley, in Clinton, on the north, and Brush valley on the south, both of which lift the lower Silurian limestones to daylight.

The Madisonburg road continues south from the Walker line in the gap, passes over a wide and deep valley of red Medina IV, drained by the headwaters of Dry run north to Fishing creek. This is of *anticlinal* structure, owing to the insertion of the Sugar Valley axis from Clinton county, which flexure dies rapidly westward in white Medina.

The *south* mountain in this rock is a tightly-folded synclinal, but once exposed on the Madisonburg road close to the junction of the road to Rebersburg, with a N. W. dip of 50°, and continuing east a short distance beyond the Rebersburg-Tylerville crossing, where its south limb dips 70° N. W., east of which this middle keel is swept away.

To the south of this a narrow and elevated vale of IV red Medina occurs, dipping north-west; exposed on the road, dipping 55° N. W., and showing a dip of 70° further east.

Still further south, the terrace mountain of Oneida shows an outcrop of gray sandstone inclined 68° towards the north-west, supported on Hudson river slates from above the dam to the sink-hole at the roadside, and then No. II Trenton limestone to Madisonburg.

This village, like Aaronsburg, is supplied with water from a dam or reservoir by a system of wooden pipes through the streets, by natural pressure.

The Rebersburg road shows the *Brush Valley anticlinal* north of that village, with dips of 60° N. W. and only 10° S. E., and coursing thence S. W., but still north of Madisonburg.

The slates of III commence at the first intersection north of Rebersburg, and their steep N. W. dip carries them well

up the mountain flank. About 100 yards south of summit and 430′ above Rebersburg, No. IV gray Oneida sandstone shows 40′ thick, dipping 70° N. W., mixed north with shaly sandstone and slate. The white Medina crest shows a similar N. W. dip against one of only 40° S. E. in the other leg of the synclinal in Clinton county.

The middle (red) member of IV shoals in turn ½ mile east of the next road crossing beyond Wolf's store.

Oneida sandstone dips to the south of this 55° N. W., encircling the middle member eastward and forming a high knob of Oneida, with similar rocks meeting it here under similar circumstances from the White Deer synclinal.

Thus the road leading down to Stover's place shows the middle red member shoaling westward, exposed with a dip of 60° N. W. in the south leg of the White Deer synclinal, widening eastward into an elevated plateau of red Medina, in turn receiving the upper white Medina member in *White Deer knob.*

To the north of this synclinal, the White Deer creek courses in an anticlinal slate valley of III, heading west in Hall's hollow and overlaid north by the sand rocks of the successive members of IV to the county line synclinal of white Medina.

Oneida sandstone makes a low ridge *south* of the White Deer crest, exposed on the road north of Stover's place at the steam saw mill with dips of 50° N. W. and swinging east along the Brush Valley road, shutting up the "narrows" in Union county and circling back to form the north terrace of Brush mountain.

The "narrows" consist of the slate of III from the county line as far west as Rudy's saw mill; but the anticlinal, rising westward, brings up the Trenton limestone here which forms the valley of Elk creek and on to the Gregg township line.

As far as the first dam west of Wolf's store, the stream carries limestone on both sides; but from there west to Rockville, it forms the divide between II and III. The anticlinal keeps close to the north side of the road, showing there gentle S. E. dips of 10° and 12°.

South of Wolf's store, however, Trenton limestone dips S. 15° E. 50°, approaching Elk creek and Brush mountain.

South of Rockville the dip is 32°; south of Centre Mills 18° and 20°, which is about the normal dip west to the Gregg line. The whole surface of this narrow valley is very irregular and hilly owing to steep north dips and the erosion of Elk creek. Numerous sink holes occur also.

Brush Mountain Synclinal. From the Gregg line east to the Aaronsburg–Rebersburg crossing, this mountain shows only a double synclinal ridge of Oneida sandstone, with an elevated valley of red Medina enclosed between them. Immediately east of this road, however, the middle keel of IV white Medina rises in a bold knob to nearly twice the height of the terrace mountain and from here east to the Union line, a distance of 12 miles, this central ridge is nowhere gapped.

It everywhere presents a straight, unbroken crest of unvarying elevation, and receives now the local name of "Big Mountain." The north terrace then becomes "Brush Mountain" and the included red shale and sandstone valley "Brush Mountain hollow." So likewise the south terrace has received the local name of "Painter's Mountain" and its red shale valley "Painter's Valley."

The Millheim gap in this township shows the uppermost Trenton limestone layers in a series of fine exposures south of Centre Mills, dipping south-east.

To the south, just at the village of Spring Bank, No. III slates appear inclined S. 35° E. 25°–30°. A short distance south of the road forks, Oneida gray sandstone commences, with a profusion of gray boulders.

This outer mountain, on the east side of the creek, shows one of the best exposures of the Oneida rocks in the county, highly conglomeritic, and measurable 180 feet thick on a dip of S. 30° E. 45°–50°.

Elk creek here is a stream of considerable strength, and has created a wide breach in the mountain.

At the 2 mile post to Millheim IV red commences, dipping 50′ south of post S. 32° E. 45° in red shale and sandstone.

This is followed by successive outcrops of similar rocks, in the next 300 yards to the center of the synclinal by dips of 40°, 30°, and 20°, and finally rising in the south leg in an 80° N. W. dip.

The road out of Rockville across the mountain shows Oneida sandstone in the terrace, dipping S. E. 50°.

So the road south from Wolf's store shows III south of Elk creek riding well up the flank of the terrace mountain.

Big mountain makes the Haines township line. Its summit here is 875′ above Elk creek, and the mountain shows a compact synclinal form not bifurcated into two mountain ranges until it passes east into Union county.

It shows no rock exposures on the north flank.

25. Haines township.

This township is a trapezium-shaped area, bounded north by the Brush mountain and south by Paddy's mountain. Union county forms its eastern border line, with Penn township completing the figure on the west.

Brush Mountain Synclinal. The main central keel of Big mountain has just been described in Miles township to the north.

The south terrace of Painter mountain shows dips of 60°–70° N. W. on a broad plateau north of Aaronsburg, north of which the red Medina valley is somewhat cultivated, and shows sandstone close to the Penn line, dipping 75° N. W.

Immediately south of this point, No. IV Oneida, showing massive gray and yellowish sandstone 80′–100′ thick, dips about 66° N. W. 200 yards E. S. E., where some little conglomerate appears.

The lower member extends to H. Mowery's, where it is succeeded south by a mass of yellow and gray loose slate to within half a mile of Aaronsburg cross-roads.

The Woodward crossing, 5 miles east, shows an excellent exposure of the middle or red Medina shale and sandstone close to the springs, dipping N. W. 60°.

This stream is a feeder of Pine creek, and makes quite a ravine north of the terrace in Painter's hollow.

From the stream crossing to a point midway to G. Fox's

house, IV Oneida occurs, dipping 50°–60° N. W., and then slates of III to the private lane leading into Snyder's.

This geology is repeated along Penn Creek hollow, the terrace mountain gradually approaching the creek, and even flanking it on the north for a couple of miles east of Big Gap run, and finally returning around the head of the creek in Union county to flank Stone mountain.

Penn's Valley anticlinal issues from this narrow pass between Brush and Short mountains, carrying only the slates of III as far west as Hosterman's saw-mill, where the slate forks to swing north along the base of Painter mountain, and south to swing around the synclinal of "Round Head" and pass up Penn's Valley narrows.

This axis passes just south of Aaronsburg, and is marked by dips of 60° N. W. just north of the village and S. E. 35°–55° on the road leading south.

On the pike east of the village, No. II is well exposed along the road for 40 feet and about 15′ thick, slaty and thin-bedded, dipping 40° south-east at A. Weaver's house.

One mile east at the lime-kiln, the dip is 68° N. W.; but the axis crosses the pike just east of here, exhibiting its south limb one mile west of the church in a dip of 40° south-east.

The axis extends almost directly east from here to Hosterman's saw-mill and nowhere lifts 1000′ of measures to daylight.

Short Mountain synclinal, called sometimes *Stone mountain*, lies between Pine Creek Hollow and Penn's Valley narrows, and shows a triple mountain in this township.

Its upper white Medina mountain enters from Union county as a double synclinal, forked by a small stream; but the two ridges have not spread far enough apart to admit any Clinton No. V, as they do further east. The two opposing ribs approach each other rapidly westward and join about 2 miles west of the Union line in a high spur between branches of Whitmer's run, known as "Hind Knob."

The middle red Medina member occurs on either side of this central ridge in a regular synclinal valley, shoaling westward towards Round Head," formed by the junction

of the two terrace mountains about 2½ miles west of Hind knob.

The dips in this synclinal are about 40° S. E. and 60°–70° N. W., both in the Oneida member.

Extending well up the knob, and encircling it on all sides, are the No. III slates, which, west of the knob along Pine creek, cover a belt of country 1½ miles wide, but contract rapidly westward to a mere nose N. E. of the school-house on the pike.

At Rhinehart's, about 1 mile N. W. of Woodward, the dip is 70° N. W. The two limestone valleys on either side of it make a perfect W, with the slates filling in the central loop.

The *Pine Creek anticlinal* enters through the narrow valley south of Short mountain, passes through Woodward, and rising and bending northward passes into Penn about ½ mile north of the creek.

Pine creek carries only slate as far as Motz's saw-mill, but west to Stover's saw-mill it carries No. II, forming the divide between II and III as far as Reed's.

From here to the Penn line, limestone swings south of the stream and the Coburn road.

Above the mill in Woodward on the pike, No. II dips N. W. 35°–50°. Pine creek sinks ½ mile west in a cave or sink hole.

West of Hubler's run a Trenton limestone ridge flanks the creek on the north, frequently exposing wide plates on the south side, with dips of 45° south-east.

Just beyond Beaver's place, where the ridge begins to fall away, one of these exposures lays bare No. II for 100 feet along creek, dipping S. E. 50°, and, rising 30′ up flank. West of Reed's mill, the dip is S. 22°, E. 46°, where the limestone has been slightly quarried.

Just north of the bridge over Pine creek, Trenton limestone shows in many places in the road, dipping about 20° N. W., and making the north leg of the arch. The dip continues in a series of exposures for 100 yards along the road.

The synclinal between these two axes passes north of A.

Bartges' house, where No. II dips N. W. 70° in the north leg of the Pine creek anticlinal. South of his house 100 yards is the arch of this more compressed axis, showing south dips of 60°, and 50° at Behm's cross roads, and even 55° at the base of the mountains.

Seven Mountains. The only good sections of this region are by the road to Fowler's station and along the railroad.

The public road carries limestone on a south dip of 55° to a pond 50 yards south of the bend up into the mountain, meeting the slate of III at that point, and Oneida IV about half way up the flank. The latter extends to the crest at 550′ above creek, with dips of S. E. 54°, carrying some conglomerate of rounded gray quartz pebbles with a reddish tinge. The road descends south into a red shale valley of lower Medina. The synclinal of this valley lies north of S. Stover's, for there the dips are to the north-west 50°–58°. No. IV Oneida succeeds south at the stream crossing with the same characteristics, and breached by a branch of Swift run, through which the supporting slates of III are seen dipping N. W., but soon arching over the anticlinal of this valley to dip S. E along Swift run. This is in the "Lechathal" or Lick valley, 4 miles long, through which the L. & T. R. R. runs, carrying slate as far as Fowler's station, and succeeded by IV Oneida.

This south barrier is a tightly-compressed synclinal, between this valley and the eastern end of Poe Valley anticlinal to the south, which barely crosses Penn's creek. Oneida sandstone encircles it and forms the south-east-dipping terrace to Paddy's mountain, which latter makes the county line.

The L. & T. R. R. passes through a tunnel in this white Medina crest. Like the Beaver Dam hill to the north, this ridge is also pierced where it is only about 80′ above the stream, which has made a wide detour westward before cutting through the hill where re-inforced by Poe creek.

The synclinal is evidently just south of the tunnel, for 50′ from south face white Medina dips N. 8°, W. 54°, and S. 12°, E. 88°, in the tightly folded basin.

It shows about 25′ of sandstone and 2′ of slate in the north leg to the tunnel mouth. In the tunnel, there is about 170′ additional, and 100′ more of mixed red shale and sandstone brings us to the north end of the tunnel, where there is a dip of S. 30°, E. 75°.

Red rocks show for 120′ more to the end of the tunnel approach.

About 200 yards north of the bridge over Penn's creek, red Medina presents an excellent exposure of red shale and sandstone probably 250′ thick, dipping S. 28°, E. 60°, forming the south leg of the Poe Valley anticlinal.

Oneida sandstone comes in north at the new steam sawmill, dipping on the east side of the creek S. 30°, E. 62°, conglomeritic.

Near the 33d-mile, post slate shows a rather distorted anticlinal arch about 200 yards north, with dips of N. 28°, W. 60°, and S. 30°, E. 60°, though curved and cross-bedded by cleavage planes, rendering dips indistinct, in black slate.

The gap is an exceedingly beautiful one, and is still very wild and unbroken by cultivation.

APPENDIX A.

Extracts from J. P. Lesley's Report to Lyon, Shorb & Co. on the Iron Ores of Warrior's Mark and Spruce Creek Valley in 1873.

The following extracts relate only to mines situated in in Centre county, as follows:

No. 10. Lovetown.
No. 11. Lytle's.
No. 12. McKinney's.
No. 13. Hannah furnace, No. 2.
No. 14. Bull's.
No. 15. Pond, No. 4.
No. 16. Red.
No. 17. California.
No. 18. Reider's.
No. 19. Whorell's.
No. 29. Pennsylvania.

Except two situated just over the Huntingdon county line, viz:

No. 27. Kerr & Bredon.
No. 28. Hostler's.

The page plate map given on p. 355 is a reduction of the eastern end of the reduced topographical sketch map which accompanied the published report. The whole map will be given in a forthcoming report (T^3) on Huntingdon county to illustrate extracts respecting the mines of that county.

The numbers on the little map will be found in the key-

table at its lower margin, with the names of the ore banks which they designate.

References to my report made by Mr. D'Invilliers in his report can be found by consulting the index to this volume for the names of the ore banks to which my notes refer.

No 10. The Lovetown Banks consist of numerous open-cuts and shafts from which large quantities of ore have been extracted and extensive preparations are in progress for regular mining of this important part of the ore field. The principal outcrop occupies a vale watered by a small branch of Half-Moon. The old shafts of Abram Love were stopped by the influx of water. Pipe ore is visible near Love's barn. Half a mile west is an old "exhausted" Hannah Furnace bank. On the north slope of the ridge west of Love's, ponds and sink-holes abound. Hannah Furnace had a bank in David Berk's fields, and abandoned a good deposit of ore in its floor, merely on account of water. Surrounding shafts were also sunk, but no pumps were ever planted. A few hundred yards west of the open-cut some of these shafts went through a pretty good "top vein" into a regular deposit 20 feet beneath the surface. South-west of this, other shafts were sunk for the Milesburg Company, in Abed Stevens' fields, in good rich, sandy, black ore, close under the sod, the poorer clay ores lying down on the limestone foot of the hill. South of this, John Stine gathered much loose, heavy ore from his fields, and hauled it to Bald Eagle furnace, many years ago; but no sinkings were done. The outcrop is noticeable in Jos. Bronstetter's lane (leading to Wrye bank) and in his fields on Cronister's line.

The Lovetown banks are shown on Local Map, Fig. 20, occupying two vales, descending eastward to the Half Moon run, at the mill-dam.

A rib of solid blue limestone strata, dipping S. 38° E. >56° to 57°, forms a low hill, up the south slope of which the wash-ore rides on to the flat summit. Natural ponds occupy, at points, the beds of the two vales.

The north line of the Love property commences near the Beck banks, and runs down the northern vale to the corner of the mill-dam. The ore has been open-cut at Station


BALD EAGLE MTN.
TUSSEY MOUNTAIN
Key List
of the Iron Ore Mines
on this Map.
1. West Pennington.
2. East Pennington.
3. nameless
4. Beck's
5. Town.
6. Hamburger's
7. Hannah Furnace.
8. Waite's.
9. Braunstellers.
10. Love-town.
11. Lytle's
12. M°Kinney's
13. Hannah F. N°2.
14. Bell's
15. Pond. N°1
16. Red.
17. California.
18. Reider's
19. Whorell's
20. Pond. N°2
21. Wege's
22. Dixon's.
23. Little Dry Hollow.
24. Dry Hollow
25. Bean's
26. Bressler's
27. Kerr & Breden's
28. Hostler's
29. Pennsylvania.
30. Old Seat of H. Fun:
31. Huntingdon Fun:
32. Dorsey Ore Bank.
T4.

17, 165 yards west of where this line crosses the road. This once deeper old cut is now only ten feet deep, showing in its walls liver-colored, somewhat lean wash-ore. West, of it is a series of shafts for 450 yards, formerly sunk 60 or 80 feet (without timbering) until water was reached, and after a little side-drifting, abandoned. Hannah furnace ran for some time entirely on the ore got in this primitive fashion from these holes. In one of them (St. 39) pipe ore was found. Nothing more is known of them. They are evidently on a continuation of the Beck bank deposit, the result of decomposition of ore-bearing strata *underlying* the rib of blue limestone at Station 56.

The rest of the ore on the property belongs to the series of rocks *above* the blue limestone, and to the southern vale.

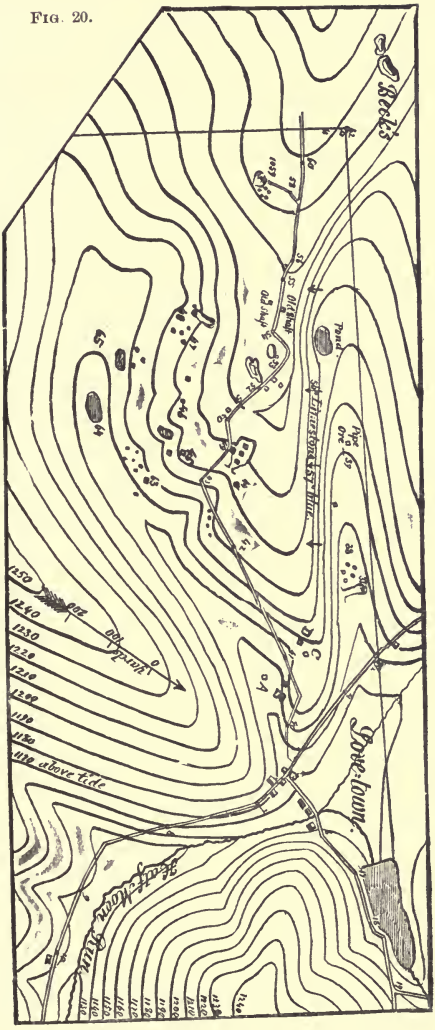
The first shafts are sunk near Love's house. Shaft A struck ore at 35 feet; B, pipe-ore at 35 feet. Ore has recently been found south-east of A, on the foot of the opposite hill.

From Station 44 there extends east and south-east down across the bottom of the vale, and west and south-west along the hill-slopes and hill-top, a universal surface deposit of wash-ore. In this area are numerous old shafts, pits, and open-cuts, and some new shafts sunk this summer and fall. The old works were always abandoned on striking water at various depths down to 80 feet, and are now filled up and no records preserved. Much ore was certainly mined from them.

The new shafts show that from 8 to 15 feet of wash-ore in clay underlies the surface at the depth of a few feet, and that under the yellow and white clays there lie separate deposits of ore-lumps, the geographical intervals being barren. There seems to be no regularity of the ore layers.

The old shaft at Station 48 is said to have passed through twelve feet of surface wash, then (ore-bearing?) clays to a depth of 80 feet, into lump-ore, which was mined for several feet, and left in the bottom when water stopped the works. The new shaft, only ten yards south-west of the old shaft, is down 80 feet, and found no ore in the clays. The ore got seems rich and rounded, as if water-worn.

FIG. 20.


Beck's
Lovetown
1250
1240
1230
1220
1210
1200
1190
1180
1170 above tide

It may be safe to give twelve feet of wash-ore to the whole area, under which are hard ores, yielding sometimes richly and sometimes nothing.

The surface ore extends 850 yards along the top of the hill. Most of the pits were shallow, but one at Station 59 is said to have been 115 feet deep through wash and lump-ore, with ore left in the bottom.

The general appearance of the deposit is the same as at the Dry Hollow and Wrye Banks. No regularly interstratified ore is noticeable. No estimate of quantity can be relied on. Taking only the area of heavy surface show, and calling it 850×300 yards, and the depth twelve feet, we have 1,020,000 cubic yards of seemingly good wash stuff, which, at 3 cubic yards to the ton, gives 340,000 tons.

To this must be added the very uncertain quantities here and there scattered through the under clays. As these have been sometimes locally considerable, it is possible that one or two or even three hundred thousand may thus be obtained. As the principal part of the lump-ore is evidently at the bottom of the clays, no knowledge of the quantity can be got until systematic mining reveals the truth.

Wash-ore ground here must be considered as the main reliance for the present. Washing here is easy; abundance of water is struck at 50 or 60 feet, and there is plenty of room for settling dams. The railroad line, adopted for a branch to the main railroad, rises one mile on a 92 feet gradient, and descends one mile on a 46 feet gradient.

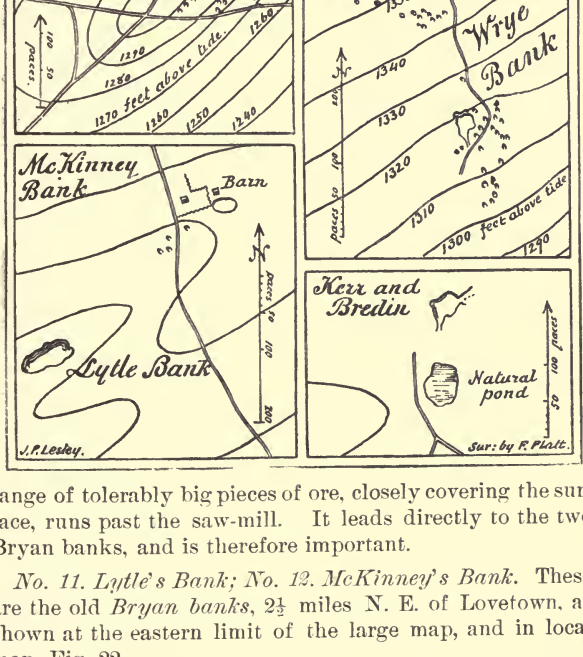
The ore has a much more extensive range than that above described, for Mr. Fisher has opened three small pits on ore just beyond the north-eastern property line; and the Beck Banks show that it passes south-westward into the adjoining properties in that direction also.

An analysis of Lovetown ore, from the large pit at Station 49, Fig. 20, made at my instance by Mr. Persifor Frazer, Jr., Professor of Chemistry in the University of Pennsylvania, shows a percentage of phosphorus low enough to bring this ore within the limits of safe use in the manufacture of iron for the Bessemer process. The specific gravity of the speci-

mens was 3.52. The calculated percentage of metallic iron was 45.36; alumina, 16.53; silica 6.63; lime, 0.58; sulphur, 0.04; and phosphoric acid, 0.05.

Between Lovetown and Stormstown (a distance of 3¼ miles) no ore is visible near Bald Eagle mountain, although considerable quantities of ore lie in the fields just northeast of Lovetown; but on a line parallel with the mountain, and about a mile from its base, in a hollow leading from one branch to the other of Half Moon run, a very fine outcrop

FIGS. 21, 22. FIGS. 23, 24.



range of tolerably big pieces of ore, closely covering the surface, runs past the saw-mill. It leads directly to the two Bryan banks, and is therefore important.

No. 11. Lytle's Bank; No. 12. McKinney's Bank. These are the old *Bryan banks*, 2½ miles N. E. of Lovetown, as shown at the eastern limit of the large map, and in local map, Fig. 22.

The Lytle bank was worked a long time ago for Hannah furnace, and measures about $70 \times 20 \times 10 = 14{,}000$ cubic yards. Very little lump ore is now visible, the walls showing about 25 feet thickness of wash ore.

McKinney's bank, worked for Pennsylvania furnace, is much smaller, say $25 \times 20 \times 10 = 5000$ cubic yards, and exhibits the same aspect.

Shafts sunk between the two excavations on both sides of the road, leading south from Stormstown to Gatesburg and Pennsylvania furnace, always struck good ore, dipping to the south-east; as do the limestone outcrops of the neighborhood. We have here a prism of ore deposit at least $350 \times 100 \times 10 = 350{,}000$ cubic yards in size; probably, after all due allowances, quite that many tons of ore.

The *Curtin bank*, a long, narrow open-cut on a prolongation of this outcrop, beyond the limits of the map, $2\frac{1}{4}$ miles N. E. of the McKinney and the *Lamborne* bank, $1\frac{3}{4}$ miles further in the same direction, have yielded cold-short ores, similar in appearance to the Pennington. These and other works of less importance show the persistent straightness of the outcrop of the ore-carrying strata, parallel with the Bald Eagle mountain, at the foot of which flows the east or main branch of Half Moon run, with a limestone ridge * between the valley of the run and the ore.

At McKinney bank we are 3 miles from the railway, where it strikes and begins to descend Half Moon run. The Lovetown banks require a railway 2 miles long, descending the west branch of Half Moon, with a grade of 40 feet to the mile, or else a railway across the ridge $1\frac{3}{4}$ miles long, with gradients 90 feet to the mile, as described. The line of the road was originally located to Lovetown, and thence down Half Moon; but it was considered more desirable to carry it across the dry hollow, among the ore banks to be hereafter mentioned.

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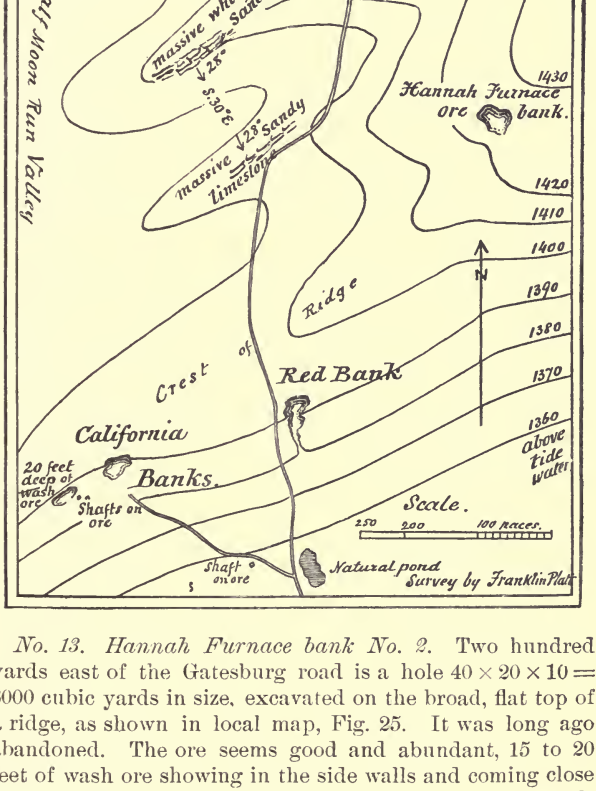
*This ridge, by an oversight, is not represented on the map, no surveying having been done north of the McKinney banks.

Before returning to these banks and the neighborhood of the railway I will describe a group of banks lying south of the Lytle and McKinney banks, at the east edge of the map, and on outcrops somewhat higher in the series.

FIG. 25.



No. 13. Hannah Furnace bank No. 2. Two hundred yards east of the Gatesburg road is a hole $40 \times 20 \times 10 =$ 8000 cubic yards in size, excavated on the broad, flat top of a ridge, as shown in local map, Fig. 25. It was long ago abandoned. The ore seems good and abundant, 15 to 20 feet of wash ore showing in the side walls and coming close to the surface. All the down-slid stuff may be washed.

Massive sandy limestones, 180 yards N. W. of it, dip S. 30° E. > 28; 150 yards further N. W. massive white sand rocks dip the same.

No. 14. Bull banks, half a mile east of the last, and in line with it, consist of two excavations on the south brow of the ridge; see A and B, local map, Fig. 27. Much sandy ore was formerly taken out before these banks were abandoned, twenty years ago. $A = 60 \times 50 \times 10 = 30{,}000$, and $B = 80 \times 40 \times 10 = 32{,}000$ cubic yards. A shows wash ore in the side, which is 30 feet high above the water in the bottom. B shows about 30 feet of reddish wash ore, with very little lump ore, from the water to the surface of the hill. A neighbor who had worked in the pits reports that several feet of deep brown richer ore was found lying everywhere in both banks beneath the mass of reddish leaner ore. All this awaits the time of improved mining with pumps and washers.

Fig. 27 shows other old workings in the same deposit from 600 to 800 yards to the south-west of A and B. From two of these there have been taken about 15,000 cubic yards of wash ore, which still exhibits itself 20 feet deep in the walls; the one furthest to the north-west, in Fig. 27, has been deep, say 40 feet, but now, like all the larger cuts, has standing water and mud in its bottom. Numerous shafts, all yielding ore, give us data for calculating an ore prism, in sight, of say $150 \times 200 \times 10? = 300{,}000$ cubic yards.

No. 15, Pond bank, No. 1, worked for Pennsylvania furnace, lies in the hollow at the foot of the ridge, $\frac{3}{4}$ mile south of the Bull bank, see local map, Fig. 20. Its honey-combed, rather light, easy-smelting ore, (mixing well with the more sandy ores of Bull Bank hill,) dips also south-east, and therefore belongs to a limestone outcrop still higher in the series, which is sufficient to account for its different quality. A great deal has been removed from this bank, but much still remains to be won, and water to wash it is abundant. This is included in the prism of ore calculated last above.

No. 16, *Red bank*, (Floyd's old bank,) at the roadside, half a mile south-west of the Pond bank, (see local map, Fig. 25,) is a cut in the same outcrop. The amount of ore is therefore very great, for the continuity of the deposits has been clearly proven. The red rock ore (35 or 40 per cent.) descends in a solid stratum from 8 to 10 feet thick, at a dip of about 25° to the S. E. Over this lies a stratum of white clay, 3 feet thick. Over this black ore in solid masses and great lumps scattered thickly or thinly through several yards of wash ore, to the surface. Some of these lumps are 2 feet long by 1¼ feet thick.

This *Old Gatesburg bank*, as it is sometimes called, was worked 40 years ago, and has been re-opened now to show its character.

The red ore was too siliceous and hard to work in the small cold-blast charcoal furnaces of the region ; but it will be eagerly sought by modern hot-blast coke or anthracite furnaces.

The black ore masses were selected for charcoal cold-blast use, having 50 to 55 per cent. of iron and being fusible ore.

It is impossible to say how deep these strata descend on their 25° dip in a peroxide condition. But allowing only 100 feet, we have in a mile of outcrop 150,000 cubic yards of red rock ore; and as the wash-ore ground holding the black lump ore descends with it, and spreads over a belt of surface more than 100 yards wide, there must be half a million cubic yards of it at the lowest computation.*

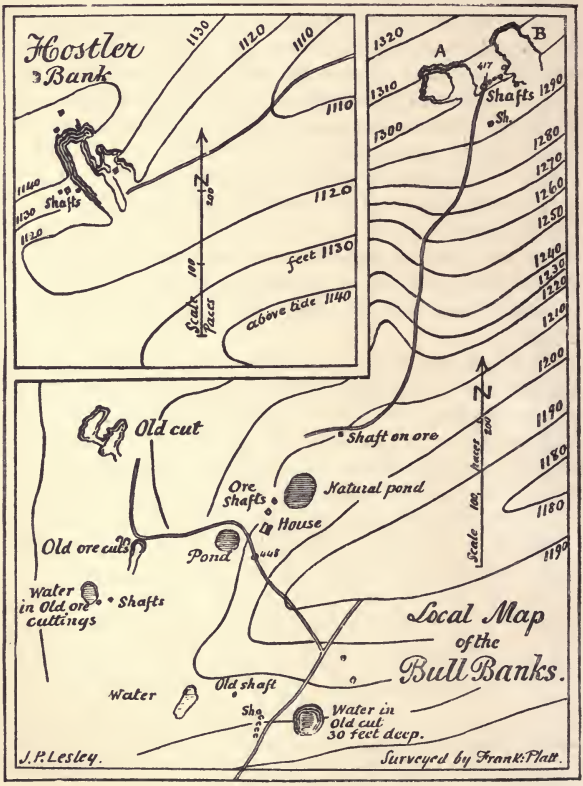
The old cuts at the elbow of the road west of the two ponds in Fig. 27 have had about 8000 cubic yards excavated, and are now filled with water to within 10 feet of the surface, showing that much wash ore without lumps. The

*I have described above only what I saw. Mr. Platt was informed that under 12 feet of clay holding black lump ore lay 4 feet of white clay without ore, under which lay 14 feet of red rock ore in red clay, and ore was still under foot. I give this report for what it is worth.

Mr. Böcking speaks of red rock ore only 6 feet thick, "and another fair layer in the clays above, all workable ; red ore not very rich; siliceous, but with visible sand; rich black ore in the top vein, [the word he always uses for a stratum of ore] on the whole proper for coke furnace use ; mining requiring pumps; deep workings at hand; an important locality."

two larger cuts (150 yards north-west of them) measure about 15,000 cubic yards, with 21 to 25 feet of wash and lump ore in the walls. Abandoned 20 years ago.

FIG. 26. FIG. 27.



No. 17. California bank, 200 yards west of the Red bank, and on the same slope and outcrop (see Local Map, Fig. 25,) received its name from the richness of its ore, before it was abandoned 20 or 25 years ago, on account of its dis-

tance from Pennsylvania furnace, the abundance of water and lack of pumping apparatus, the refractory quality of its mineral in the cold-blast charcoal stack, and especially the abundance of good ore at the furnace itself. Pits of standing water show 20 feet of wash ore in their walls.

This completes my sketch of this "dry hollow" outcrop east of Half Moon Run. It is a dry hollow because the whole limestone underground is cavernous, and water springs up abundantly in every excavation, but does not flow over the surface. This is a prime factor in the problem of the genesis of these ores, and must be taken into consideration in all speculations respecting the depths to which the brown hematite ores descend in a minable form.

The outcrop belt of surface wash ore and regular rock ores in which the Hannah Furnace, Bull, Pond, Red, and California Banks are excavated, passes on north-eastward into the untried wilderness of the Barrens, where we find upon it the *Floyd Bank*, an open cut on highland; ore very sandy for charcoal furnace use, but good and abundant for hot blast coke or anthracite; and good charcoal ore could be selected from it still.

No. 18. Reider's Bank, half mile east of Gatesburg, is a small surface opening of $30\times20\times5=3000$ cubic yards' extent. On trial at Centre and Hannah furnaces it was refused. The surface of the broad low hill north of the village is a sheet of wash ore. The roads north to Stormstown and west to Warrior's Mark expose ore ground at the surface, on the slopes of the dry hollow in which the village stands, and to the north and south of the village. The old opening on the roadside 250 yards south of the village is entirely filled up. Considerable quantities of very rich lump ore were taken out here many years ago, mostly from underground galleries. Much ore ground occupies the surface for more than 100 yards north-eastward. Limestone crops out 300 yards west of it dipping S. 30° E. $>20°$, and 300 yards north of it dipping S. 30° E. $>18°$.*

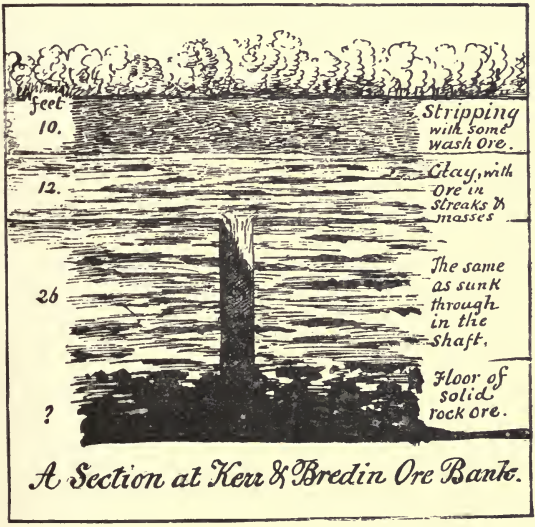
* The horizon of this and the Whorell bank is still higher in the series than the last, as section C D (Fig. 3) will make evident.

No. 19. Whorrel Bank, (see Local Map, Fig. 17,) is a continuation south-west across Half Moon run of the Gatesburg outcrop, which is here nearly 500 yards broad. The open cut on the north side of the Gatesburg road is about 40×13×5=2600 cubic yards; that on the south side 30×20 ×3=1800 cubic yards. Both have standing water in the bottom, and wash ore in the walls, while very heavy outcrops appear along the road, as well as along the cross road leading up the ridge north to Lovetown, beyond which an old shaft has struck the underlying sand rocks.

Fig. 34.

The double excavation in Fig. 10, 110×40×7=30,800 cubic yards large, is separated by a stratum of limestone dipping S. 30° E., >26°, (one exposure looking like >50°,) the ore underlying, overlying and surrounding one end of it. The wash ore in the sidewalls does not look rich. It is reported these holes were dry 40 feet deep and yielded good ore. The length of the surface show *i. e.*, S. W.—N. E. is only 50 yards, to be terminated by the erosion of Half Moon Creek Valley. The railroad is only 400 yards distant.

Fig. 35.



A Section at Kerr & Bredin Ore Bank.

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. Bocking was directed to sink south of the old cut, and to mount a pump. He reported a 12-inch

*This bank and the Hostler bank are across the line in Huntingdon county but I give my notes on them because they are instructive; and the wood-cuts, Figs. 34, 35, and 36, show the lay of these ores in the ground.

"vein of ore" at 40 feet, and water at 44 feet. A 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."

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).

This excavation 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 lime rock, varying in thickness from 10 inches to 2 feet. Below this 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 drilled through a continuous bed of pipe ore to an additional depth of 39 feet.

Fig. 36.

The percentage of iron in the pipe ore is uniform, or varied only by the chemist 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 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 ore below can be stoped and the top stuff thrown back into the abandoned ground as the ore face advances. As Mr. Brocking 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 require in future 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 $120 \times 50 \times 10 = 60,000$ 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 high north-west dip of the measures prevents this figure being used as a datum of calculation. It only shows, in a general way, the depth below the sod to which the weathering action had gone, *as exposed by the miners*. The late-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 one shaft 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 very 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 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 doubt that a continuous belt of mining ground runs the entire length of Cale hollow.

The *Red Bank*, 1¾ 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 north-east, (near the Warrior Mark-Pennsylvania furnace 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

*4½ miles from Hostler bank.

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 runs on in a straight line north-eastward, and is a geological prolongation of Cale hollow, shows plenty of outcroppings 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.

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 sandstones of the anticlinal, that is, ores belonging to the underlying limestones.

No. 29, Pennsylvania Furnace ore bank. For about fifty-eight (58) years Pennsylvania furnace has been supplied with its stock from the extensive excavations on the gently-sloping south side of the anticlinal ridge facing Tussey mountain; Spruce creek, above the furnace, flowing between the ridge and the mountain.

[See local map, Fig. 37, in lieu of further description;

and the landscape sketches of the excavations, to illustrate their extent and character: Figs. 39, 40,41, 42, 43.]

The geologist can here study the theory of the formation of the Lower Silurian brown hematite ores of Pennsylvania to great advantage. I know no better place, and few so good.

The ores are evidently not washings from a distance; neither from Tussey mountain, nor from the present surface of the anticlinal ridge; nor from any formerly existing surface in past geological ages, when the surface stood at a much higher elevation above sea level. They are evidently and visibly interstratified with the soft clay and solid limestone layers, and obey the strike and dip of the country; the strike being along the valley, and the dip about 40° towards the south-east.

Thousands of minor irregularities prevail; the streaks of ore and masses of clay are wrinkled and bunched, and thin out and thicken again in various directions. But all this irregularity is owing to the chemical changes of the strata, and to the changes in bulk of the different layers, during the protracted process of solution and dissolution, during which the looser calciferous and ferriferous sandstone layers have lost their lime constituent, packed their sand and clay more solidly, and perhydrated their iron. In this long process cleavage planes have been widened into crevices; caverns have been excavated; pools or vats have been created; precipitates of massive (rock and pipe) ore have been thrown down; and a general creeping and wrinkling of the country been effected. But the original general arrangement or stratification has been preserved; and those portions of the whole formation which had but little lime have been left standing as sandstone strata; while others having but little sand remain as solid and massive limestone strata; those which had an excess of alumina are now in the condition of streaks, masses, or layers of white or mottled clays; and only such as were properly constituted clay-sand-lime-iron deposits (originally) have been so completely dissolved as to permit the lime to flow off, and the iron to consolidate into ore.

Every stage of this interesting operation, and every phase which it presents in other parts of the Appalachian belt of the United States from Canada to Alabama may be seen and studied in these old and extensive ore banks of Pennsylvania Furnace.

At first sight of the bank the ore deposit looks as if it were a grand wash or swash of mingled clay and fine and coarse ore grains and balls, occupying hollows, caverns and crevices in the surface of the earth and between the solid limestone rocks; and some of it undoubtedly has been thus carried down into the enlarged cleavage partings of the limestones; and into sink-holes and caverns formed by water-courses; where it now lies (or lay when excavated) banked up against walls or faces of the undecomposed lime rocks. But as a whole the ore streaks and "main vein" of ore must occupy nearly the places originally occupied by the more ferruginous strata after they had got their dip and strike. See Fig. 40.

The ore is taken out with the clay, and hauled up an incline, by means of a stationary steam engine at its head, and dumped into a large washing machine, with revolving screens; whence after the flints and sandstones have been picked out, it is carried on an ironed tram-way to the bridge house of the furnace. See Fig. 42.

The ore forms from 10 to 50 per cent. of the mass excavated, and the small amount of handling makes the ore cheap.

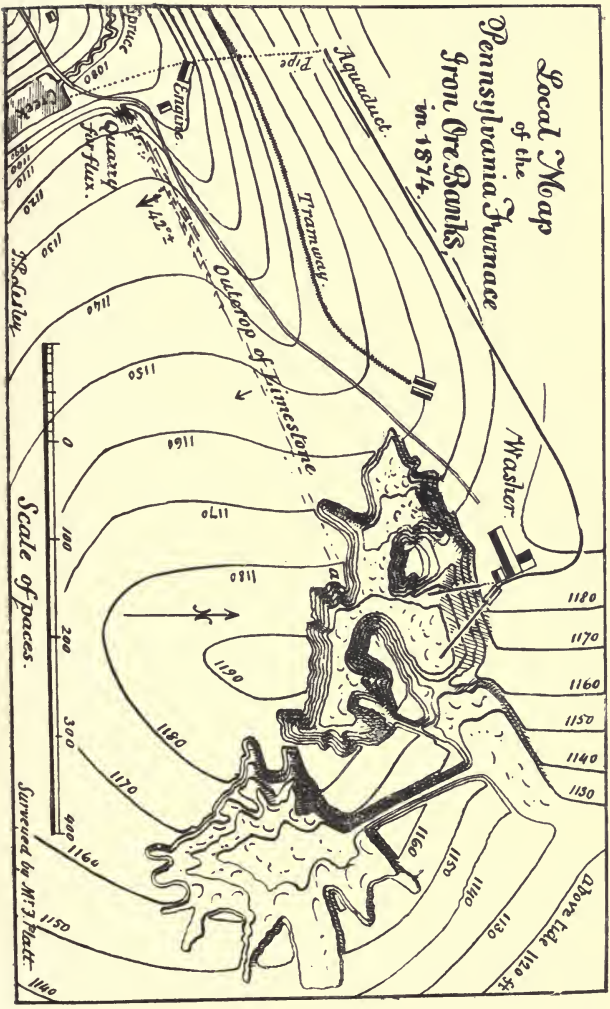
The floor of the excavation is about sixty (60) feet below the level of the wash machine.

Shafts sunk from 30 to 35 feet deeper in the floor to a permanent water level, have shown that other and even better ore deposits underlie the workings, covered by the slanting undecomposed lime rocks.

This is an additional demonstration of the correctness of the theory above stated.

The upper ores will furnish stock for yet many years. After that, or in case more furnaces are erected, or distant markets call for the shipment of ore by railway, deep shafts or bore holes must be sunk to drain the underground, and

FIG. 37.


Local Map
of the
Pennsylvania Furnace
Iron Ore Banks
in 1874.
Aquaduct
Pipe
Tramway
Engine
Quarry for flux.
Outcrop of Limestone
Washer
Scale of paces.
0
100
200
300
400
Surveyed by M.S. Platt
above lake 1130 ft.
1180
1170
1160
1150
1140
1130

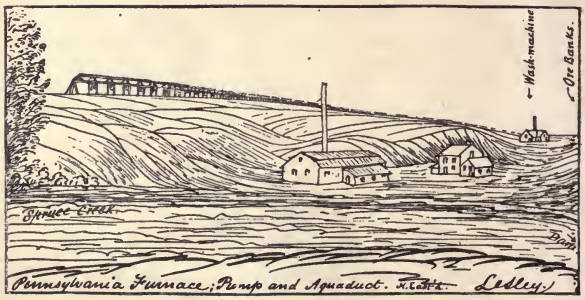
the lower ores may then be lifted to an extent which can hardly be estimated now.

The prism of ore *in sight*, technically speaking, if calculated roughly from the areas exposed by the old and new open cuts, and by shafts sunk at various times and in various parts of the floor, gives several millions of wash-ore, lump-ore and pipe or rock ore. Thus taking the area exposed at say 550×450 yards, and the depth at only 15 yards, we have 3,612,500 cubic yards, which on washing would yield 602,000 tons of prepared ore.

Of this, about 100,000 tons have been passed through the furnace, yielding nearly 50,000 tons of neutral cold blast charcoal iron of the best quality, leaving 500,000 tons of ore to be excavated.

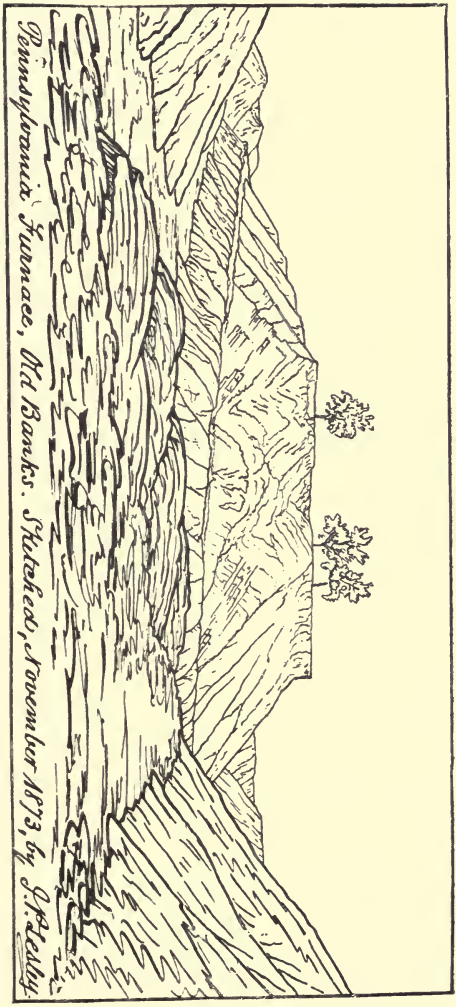
But this is only a portion of the deposit; for the ore ranges away beyond the high walls of the open cuts into the surrounding land an unknown distance. The large area stripped last year towards the north-east shows how extensive the deposit is in that direction.

Fig. 38.



Add to this the great depths to which the ore is known to descend, and it seems to me certain that a million of tons is as probable an estimate as a half a million. Large quantities of ore are left standing between the hard limestone ledges exhibited in Fig. 40 (taken from *a* in local map, Fig. 38,) and in Fig. 34, which is an enlarged view of the sharp promontory seen in Fig. 33, sketched to show its geological

FIGURE 39.


Pennsylvania Furnace, Mt Banks. Stokshead, November 1873, by J. P. Lesley.

structure. The dip of these limestones is to the S. 35°, E. > 35° to 40°; and they are exactly on range with the limestone outcrop along the road, at the quarry, and past the furnace, as shown in Fig. 37. Slight crumplings of the limestone vary the dip from 18° to 65°; but these are due either to movements in the yielding ore mass or to a deception caused by mistaking cleavage planes for bed plates. No such variations are apparent at a distance from the banks, the whole limestone formation descending uniformly beneath the foot of Tussey mountain with a dip of something under 40°.

The pictures Figs. 41 and 42 are views of the deep cut looking east from *a* in local map, Fig. 37. The view in Fig. 43 is taken looking northward into the main ore bank, from near *a*; and it shows the new incline, the washing house, and the ridge above it, along the crest of which the aqueduct is carried on trestles for 2000 feet. Fig. 38 shows the end of the aqueduct, where it is mounted by the pipe leading up the hill-side from the double Worthington pump in the engine-house, fed by another pipe from the dam. Behind the hill seen in Fig. 43, in a hollow on a level with the north-east end of the banks, is the settling-dam.

The height of the walls of the various excavations may be seen by reference to the ten-foot contour lines in Fig. 37. These also show that the ground now so deeply excavated once formed a high divide between a vale descending south-west to Spruce Creek, and a corresponding but shallower vale descending north-east to the settling-dam hollow. It looks as if the ore once filled both these vales, but has been swept away by the natural drainage into Spruce Creek, from the one which descends in that direction, and, perhaps, from the valley of Spruce Creek itself, down to and beyond the Furnace.

The entire walls of the cuts are of wash ore, and it is all torn down and taken to the washing machine. But the tops of pyramids of solid pipe ore are exposed in the floor, and some reached to, or nearly to, the sod above. At one of the deepest places in the floor, 60 feet below the sod a shaft was sunk 40 feet further through solid pipe ore, and

then limestone, and was stopped by water. Water does not stand in the present floors, on account of the free circulation at a still lower depth through crevices and caverns communicating with Spruce Creek, which itself issues from a cave.

The books at the Furnace show as an average for some years, 6 tons of wash ore to 1 ton of ore ; 2 tons 1 cwt. of ore to 1 ton of iron ; and $2.25 per ton of ore delivered at the Furnace represents the cost of mining, inclusive of all expenses.

Outcroppings of ore occur east and west of the Pennsylvania Furnace Banks on the southern slope of the anticlinal ridge facing Spruce Creek and the Tussey Mountain ; but no excavations have been made, because sufficient stock was always procurable at the Banks near the Furnace. It is to be supposed, therefore, that equally large and important deposits *may* be exposed by future systematic mining operations, when the completed railway shall make demands on this ore belt for supplying the furnaces of Eastern and Western Pennsylvania.

Some of these surface-shows of ore are near the top, others near the bottom of the hill slope. The ore surface is commonly high up on the slope, or on the flat rolling back of the anticlinal ridge.

John Ross has in his fields, north of Pinegrove Mills, miles east of Pennsylvania Furnace,) an old funnel-shaped hole, from which very rich pipe ore was taken, and more can be seen in its sides, but no surface-show ; and I have no data on which to base an estimate of quantity. The ore was sent to Monroe Furnace ; was rich ; but very red-short : lumps of pyrites being visible in the bombshell ore lying about the hole ; which is also coated with white sulphates.

Surface ore can be traced all the way from Ross' to Pennsylvania Furnace, but no search underground seems ever to have been made or called for.

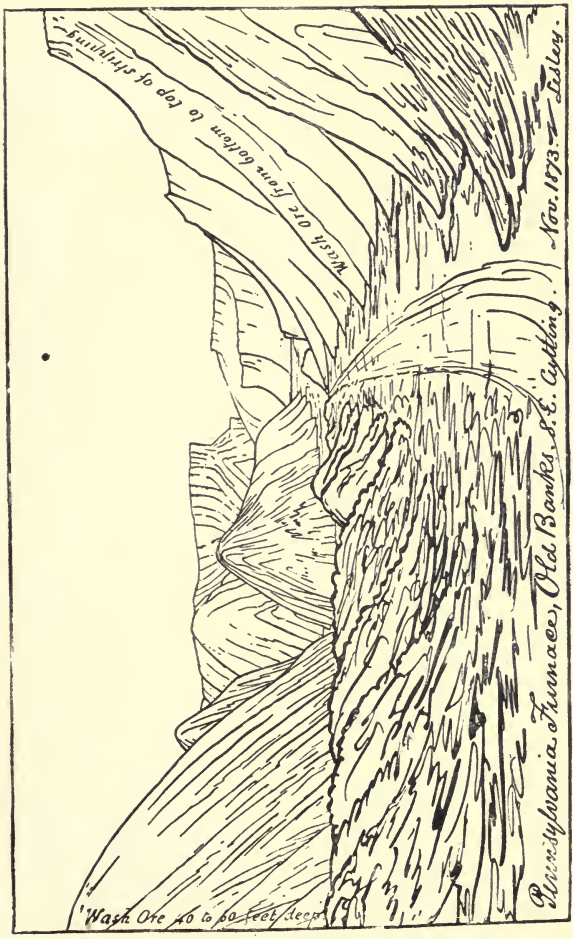
In the other direction, down Spruce creek, south-west of the furnace, a few outcroppings on the surface appear, but lie neglected for the same reason. A few trial pits seem to have been sunk near the school-house, and near Mr. Geo.

FIG. 40.

Lyon's mansion, south of the turnpike. Large pieces of pipe ore lie in the east corner of Mr. Thos. Lyon's fields, at the foot of Tussey mountain. Ore has also 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

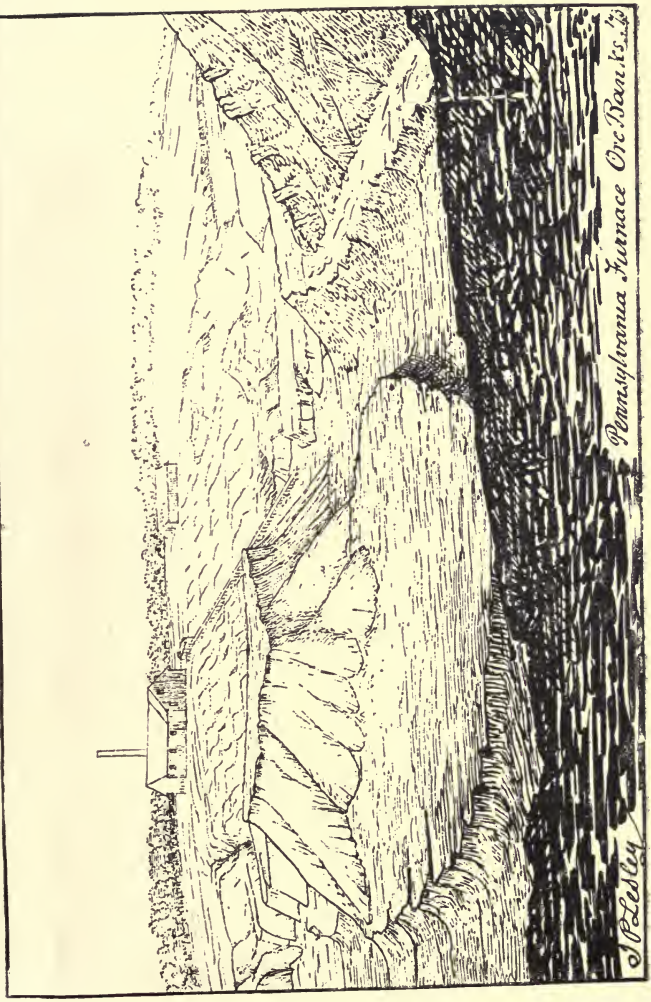
FIGURE 41.



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 semi-circle down Half Moon run and up Spruce creek and Tadpole run.

FIGURE 42.

FIGURE 43.



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.

ANALYSES

OF

NITTANY VALLEY IRON ORES

AND

LIMESTONES.

By Dr. F. A. GENTH, Prof. Chem. in the Univ. Penn.

No 11. Lytle Bank.—The sample received for examination consisted mainly of amorphous compact brown ore, intermixed with fine fibrous limonite. The fibers are from ¼ to ½ of an inch in length and form botryoidal coatings; sometimes divergent. The outside covered with yellowish ocherous ore.

The analysis gave:

Ferric oxide,	= 82.00	= 57.40 metallic iron.
Manganic oxide,	= trace.	
Alumina,	= 1.94	
Magnesia,	0.17	
Lime,	trace.	
Phosphoric acid,	0.37	= 0.16 phosphorus.
Silicic acid,	2.98	
Quartz,	0.44	
Water,	12.10	
100 iron contain 0.278 phosphorus,	100.00	

No. 14. Bull Bank.—The samples for investigation, five in number, were taken from piles of ore taken out about thirty years ago. One consisted of a beautiful fibrous limonite of a pale hair-brown color and silky luster, much resembling that from the Lytle bank, but of fibers two inches in length. The others represented the amorphous ores. They are compact, of various shades of brown, without

luster; they contain more or less cavities, partly filled with ocherous ore of a yellowish or reddish color. The amorphous ores have, on being breathed upon, a strong argillaceous odor.

a. Pure fibrous limonite.

Ferric oxide,	= 81.48	= 57.04 metallic iron.
Manganic oxide,	= 0.07	
Alumina,	= 0.49	
Magnesia, Lime,	traces.	
Phosphoric acid,	0.08	= 0.035 phosphorus.
Silicic acid,	3.98	
Water,	13.90	
100 iron contained 0.061 phosphorus,	100.00	

b. Average of the five samples.

Ferric oxide,	= 74.85	= 52.40 metallic iron.
Manganic oxide,	= 0.29	
Cobaltic oxide,	0.21	
Alumina,	0.42	
Magnesia,	0.12	
Lime,	trace.	
Phosphoric acid,	0.24	= 0.105 phosphorus
Silicic acid,	4.15	
Quartz,	5.92	
Water,	11.80	
100 iron contained 0.20 phosphorus,	100.00	

No. 15. Pond Bank No. 1.—Two of the four specimens received were of a dark brown porous amorphous ore with very little luster, more or less mixed with yellowish and reddish ocherous ore; the third piece was of a paler brown, and contained small quantities of fibrous ore; the fourth was an ocherous ore of a pale brown and yellowish color. An average of the four samples contained:

Ferric oxide,	= 78.68	= 58.08 metallic iron.
Manganic oxide,	= 0.42	
Cobaltic "	trace.	
Alumina,	2.89	
Magnesia,	0.20	
Lime,	trace.	
Phosphoric acid,	0.16	= 0.07 phosphorus.

Silicic acid,	3.17
Quartz,	1.71
Water,	12.77
100 iron contained 0.127 phosphorus,	100.00

No. 16. Red Bank No. 1.—Five samples of ore received. It is generally an amorphous, compact ore, with a considerable admixture of sand. Some is more porous, and has the cavities lined with fibrous limonite, and more or less filled with clay. Emits, when breathed upon, a strong, argillaceous odor. Part of the specimens had lost a portion of their water of hydration.

The analysis of an average sample gave :

Ferric oxide,	= 65.44 = 45.81	metallic iron.
Manganic oxide,	= 0.13	
Cobaltic oxide,	trace.	
Alumina,	5.31	
Magnesia,	0.16	
Lime,	trace.	
Phosphoric acid	= 0.21 = 0.09	phosphorus.
Silicic acid,	6.76	
Quartz,	12.78	
Water,	9.21	
100 iron contained 0.195 phosphorus,	100.00	

No. 19. Whorell Bank.—Two pieces of a fine brown porous amorphous ore of various shades, between yellowish and dark-brown ; some portions showing a slight pitchy luster ; the greater part is dull. Has a strong argillaceous odor when breathed upon.

The analysis of an average sample gave :

Ferric oxide,	= 69.71 = 48.80	metallic iron.
Manganic oxide,	0.46	
Cobaltic oxide,	trace.	
Alumina,	3.37	
Magnesia,	0.08	
Lime,	trace.	
Phosphoric acid,	0.97 = 0.43	phosphorus.
Silicic acid,	3.51	
Quartz,	9.60	
Water,	12.30	
100 iron contained 0.87 phosphorus,	100.00	

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.	
Alumnia,	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 iron contained 0.16 phosphorus,	100.00	

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 iron contain 0.28 phosphorus,	100.00	

No. 29. Pennsylvania Bank.

a. Two samples received for examination.

Amorphous brown compact ore mixed with ochreous yellowish or reddish ore; porous, some of the cavities lined with a very fine coating of fibrous ore.

b. So-called pipe ore.

Amorphous porous ore, in columnar masses, the cavities filled with ferruginous clay.

c. Quartz grains, cemented by brown amorphous limonite, and disseminated through it patches of hydrous manganic oxide and perhaps of psilomelane.

a. Average of two samples:

Ferric oxide,	= 81.55	= 57.10 metallic iron.
Manganic oxide,	0.10	
Cobaltic oxide,	trace.	
Alumina,	1.49	
Magnesia,	0.47	
Lime,	trace.	
Phosphoric acid,	0.16	= 0.07 phosphorus.
Silicic acid,	2.98	
Quartz,	1.55	
Water,	11.70	
100 iron contain 0.12 phosphorus,	100.00	

b. Pipe ore:

Ferric oxide,	= 83.74	= 58.62 metallic iron.
Manganic oxide,	= 0.31	
Cobaltic oxide,	trace.	
Alumina,	0.33	
Magnesia,	0.34	
Lime,	trace.	
Phosphoric acid,	0.14	= 0.06 phosphorus.
Silicic acid,	2.57	
Quartz,	0.44	
Water,	12.13	
100 iron contain 0.10 phosphorus,	100.00	

c. Sandrock:

Ferric oxide,	= 43.65	= 30.56 metallic iron.
Manganic oxide, Cobaltic oxide,	1.55	
Alumina,	2.43	
Magnesia,	1.64	
Lime,	0.12	
Phosphoric acid,	0.27	= 0.12 phosphorus
Silicic acid,	5.19	
Quartz,	36.52	
Water,	8.63	
100 iron contain 0.39 phosphorus,	100.00	

General Remarks.—The amount of metallic iron in the calcined ores is as follows:

No.	1.	East Pennington bank,	51.49 per cent.
"	2.	West Pennington bank,	57.07 "
"	6.	Rumbarger bank,	59.08 "
"	11.	Lytle bank,	65.30 "
"	14.	Bull bank—*a*, fibrous ore,	66.25 "
"	14.	" " —*b*, average,	59.41 "
"	15.	Pond bank, No. 1,	63.14 "
"	16.	Red bank, No. 1,	50.46 "
"	19.	Whorell bank,	55.64 "
"	21.	Rye bank,	61.17 "
"	24.	Dry Hollow bank—*a*, fibrous ore,	66.82 "
"	"	" " —*b*, average,	59.15 "
"	24*b*.	Red Bank of Dry Hollow,	63.23 "
"	27.	Kerr and Bredin bank,	56.43 "
"	28.	Hostler bank,	62.80 "
"	29.	Pennsylvania bank—*a*, average,	64.67 "
"	"	" —*b*, pipe ore,	66.71 "
"	"	" —*c*, sandrock,	33.44 "
Ore from old cut N. of Gatesburg,			57.52 "

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 iron produced from the same, is phosphoric acid; most of them, however, contain it in too small a quantity to do 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	"
Average ore of " "	0.12	"
Pond bank, No. 1,	0.127	"
Wrye bank,	0.15	"
Kerr and Bredin bank,	0.16	"
Red bank, No. 1,	0.195	"
N. E. or upper Pennington bank,	0.197	"
Average of Bull bank,	0.20	"
Lytle bank,	0.278	"
Hostler bank,	0.28	"
Rumbarger bank,	0.30	"
S. W. or Lower Pennington bank,	0.32	"

Fibrous ore of Dry Hollow bank,	0.37	phosphorus.
Red bank of Dry Hollow,	0.38	"
Sandrock of Pennsylvania bank,	0.39	"
Dry Hollow bank,	0.45	"
Whorell bank,	0.87	"
Old cut N. of Gatesburg,	1.43	"

Of all the ores submitted for examination only two appeared to be in a sufficient state of purity to throw light upon their constitution. These 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 *degeroeite*. The former is a crystallized 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 *anthsiderite*. 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 $=2Fe_2O_3$, $3H_2O$.

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 *degeroeite*, (a silicate of the composition Fe_2O_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 phosphate, 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 *psilomelone.*

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.

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.
" " manganese, ...	= 0.19	=
" " magnesia, ...	= 35.19	= 16.76 magnesia.
" " lime, ...	= 59.44	= 33.28 lime.

Quartz and silicic acid,	3.84
Alumina,	0.54
	100.00

Atomic ratio between magnesia and lime, 1 : 1.4,—which is the composition of some of the "pearlspar" varieties of dolomite.

2. Limestone in Hostler bank.

It lies 4 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.
" " manganese,	= 0.24	
" " magnesia,	= 42.52	= 20.25 magnesia.
" " lime,	= 51.82	= 29.02 lime.
Quartz and silicic acid,	4.33	
Alumina,	0.42	
Water,	0.17	
	100.00	

Atomic ratio between magnesia and lime, 1 : 1,—which shows it to be a true dolomite.

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.
" " manganese,	= 0.18	
" " magnesia,	3.98	= 1.90 magnesia.
" " lime,	72.67	= 40.69 lime.
Quartz and silicic acid,	18.05	
Alumina,	3.81	
	100.00	

Atomic ratio between magnesia and lime, 1 : 15.

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	

Atomic ratio between magnesia and lime, 1 : 1,—showing it to be a true dolomite.

5. *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	

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.**

* 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.)

Analyses of Limestones, by Otto Wuth, Chemist, Pittsburgh, Pa.

1. From quarry near the furnace—a gray, crystalline stone:

Silicic acid,	5.08
Alumina,	1.34
Carbonate of iron,	.69
" " lime,	91.53
" " 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
" " lime,	84.66
" " magnesia,	8.98
Sulphate of lime,	.11
Organic matter,	.21

3. Gray, crystalline stone, south side of road from Half Moon run to Hostler bank, near the Half Moon run:

Silicic acid,	2.71
Alumina,	.11
Carbonate of iron,	1.80
" " lime,	83.91
" " magnesia,	11.14
Sulphate of lime,	.12
Organic matter,	.21

4. Smooth, gray stone from north side of road near the foregoing:

Silicic acid,	6.87
Alumina,	1.35
Carbonate of iron,	.75
" " lime,	86.42
" " magnesia,	4.24
Sulphate of lime,	.21
Organic matter,	.16

Mining Methods, by J. W. Harden.

It will be seen from the above descriptions that mining operations have been mostly carried on in this region in an irregular and primitive style. I requested Mr. John W. Harden to give me the benefit of his great and varied experience as a mining engineer and superintendent, both in the English and in the American collieries and iron mines, in stating what ought to be the most economical mode of entering on and exhausting the Nittany valley iron ore deposits. His recent success in increasing the export of limonite from Pinegrove furnace banks south of Carlisle by a judicious application of a system of regular approaches justifies me in placing a high value on any practical suggestions he has to offer respecting similar deposits.

He therefore visited the Pennington, Dry Hollow, Kerr & Bredin, Pennsylvania Furnace and other banks above described, and the following extracts from his report will show that there is but one conclusion to arrive at, and that a very simple one, viz:

That the system to be almost universally adopted is that by open cuts, approached from the direction of the railway at the lowest possible levels, and worked to the right and left, in advancing slopes, one above the other;

That the deep, rich ores should be worked at the same time with the upper wash ores, or not greatly in arrear of them, so that the wash ore thus won may pay the expenses of uncovering the richer lower ores; and

That where surface water is scarce, bore holes should be sunk to serve the double purpose of exploration and water supply.

Whether additional and larger furnaces be erected in the valley, or whether the ores be sent by rail to the iron works in Eastern and Western Pennsylvania, in both contingencies an exploitation of ore must be provided for amounting to many hundred thousand tons per annum.

The largest mining operation in the valley being that of the Pennsylvania furnace, Mr. Harden takes the account-book of the works at that point for a practical basis of calculation of the cost of exploitation. It is evident that min-

ing conditions through the valley are very similar. No system of between-rock mining will be required for many years. But exploring drifts and shafts will be necessary; and under-cutting, where the clays are destitute of ore and too thick to remove. Most of the work, however, must be done in open cuts, of great extent, with simple machinery for obtaining water and washing the entire mass of ore-ground to the very bottom, or to the deep rock ores, which can be quarried and used without washing. In many cases the rock ore, and in some cases the clay ore, can be followed downward between solid masses of limestone rock; but this must be done in connection with the open-cuts.

At the Pennington bank there appear to be from 50 to 80 feet of wash ore and clays, overlying from 8 to 16 feet of rock-ore.

At the Dry Hollow banks there is a stripping at the surface from 5 to 15 feet deep containing but little ore; then wash ore with sands and sandy clays to a depth of 20 or 30 feet, before reaching rock ore.

At the Hostler banks a top stripping of 5 feet or more covers 50 to 60 feet of wash ore in clay, under which lie the pipe ores; which are reported as having been in one place over 40 feet deep; limestone layers covering and dividing the mass. The miner who sunk the last shaft informed Mr. Harden that it went down 60 feet through wash ore, 5 feet through solid limestone, and 7 feet in pipe ore on one side of it, and wash ore on the other side; water stopping further sinking.

At the Pennsylvania Furnace banks the entire mass from the surface to the floor of the quarry is wash ore mixed with clay and sand. The whole of this mass has been washed. "In one place a 13-feet face of excavation gave 3 to 4 feet of surface soil and sienna-colored sandy wash; the remainder, below it, being a sandy, whitish ocher, and sienna-colored clay, streaked and marbled with red and brown, and some, not large, lumps of ore. Scattered through the whole, in considerable quantity in some places, are small pieces of *quartz*, which are picked out after the ore has passed over the trays. In another part of the diggings this *quartz*, from

the size of shot to lumps 3 or 4 inches thick, is scattered through the mass.* Some masses of this quartz, of one or two cubic feet in size, lie about the quarry.

"In a deeper part of the diggings, where the face of iron and work measures 45 or 50 feet, in two heights of 15 and 30 to 35 feet, now being moved to the inclined plane for washing, the face is made up of sand and various colored clays holding ore, all of which is washed. Limestone appears at the bottom and pipe ore has been found underneath it."

Mr. Harden advises that the stripping of wash-ore be not carried on far in advance of the lifting of the rock and pipe ore at the bottom; because, even where the farming interest does not interfere, such a plan "disturbs the equal distribution of dead work" and prevents the rejection of those parts of the stripping which do not pay well for washing. Ample room ought to be got *early* for lifting the entire mass of rich bottom ores.

"With a good roomy open cutting the mass of wash-ore should cost no more to move than so much ordinary excavation." "The ore-earth is loaded into cars, carrying 29½ cubic feet, led by horses 300 to 500 feet to the foot of the incline, whence it is lifted 37 feet on a grade of 14°, to a level with the washers, by a 12-inch cylinder steam engine, 2-foot stroke, and a pair of 8-foot drums. The car load is again dragged 150 feet and dumped into the washing troughs, in which revolve three Archimedian screw-propeller shafts 20, 26, and 26 feet long respectively. The shafts are of decagonal timber, 15 inches in diameter, on the facets of which are screwed cast-iron blades. The ore travels 72 feet and is dropped into two classifying screens, the sand and mud being floated off to the settling dam. The screens have ¼ inch and $\frac{1}{1\frac{1}{2}}$ inch meshes. The ore falls on sheet-iron trays where the quartz is picked out. The washers are driven by a 16-inch cylinder engine, 54-inch stroke; the steam being generated in two double-flue boilers 30 feet

* Mr. Harden gives an analysis of this quartz: Water, 0.50; silica, 96.00; iron and alumina, 1.76; undetermined, 1.68.

long and 40 inches in diameter. The water arrives by an aquaduct 2000 feet long and mounted on trestles arranged along the top of the hill. It is fed by a pipe of 12-inch diameter laid up the hillside to a vertical height of 110 feet above a double Worthington pump with 20-inch steam and 15-inch water cylinders; the fall of aquaduct is 1 foot to 250. The steam boilers for the pump are also 30 feet long by 40 inches in diameter, driving also a Blake stone-crusher, used for the flux.

The digging of the ore is said to be done by contract at half the price of ordinary earth.

Six cubic yards of earth have been found to produce an average of one ton of washed ore, the diggers being paid 16 cents per car-load of 29.58 cubic feet = 23.67 of solid earth. A cubic yard will therefore cost 18½ cents and a ton of ore $1.09. The ore delivered at the furnace costing $2, there remains 91 cents for loading, raising, washing, picking, and delivery.

But the great economy of this operation can be duly realized only by remembering that the earth washed and earth utilized is that which under any other circumstances would be dumped on one side as "spoil," and as such chargeable against the lower and better ore. "Seeing also that in so utilizing this (otherwise) refuse just so much dead charge is removed, we are led to anticipate a less costly production of the ore which follows it; and we have ground for contemplating equally favorable results at other banks, the same course being pursued."

The furnace stands under the high bank of Spruce Creek, with its village occupying the upper slopes on both sides of the creek, and the farms stretching south and east to the foot of the mountain. It is a stack 43 feet high, 9½ feet across the boshes, 48-inch tunnel, slope of boshes 68°, hearth 5½ feet high, 48 inches wide at top and 30 inches at the bottom, with two cold air tuyeres, fed from blowing tubs 6.4 long, driven by a 16-inch cylinder engine, 4½ feet stroke.

A Cameron blast, 22-inch steam cylinder and 6 × 5 feet blowing-tub is held in reserve. Steam is generated in three 30-foot cylinders 42 inches in diameter, fed with creek wa-

ter by a No. 4 Cameron steam pump, with a No. 8 Earl steam pump in reserve. Another steam engine drives three lathes.

The uniform yield of the furnace has been 100 tons per week. It is now changed to hot blast, by the recent erection of a Pleyer oven $17\times5\times2\frac{1}{2}$ feet, with six tiers of pipes, in a building 17×12.

APPENDIX B.

Observations on the Geological Formations Nos. II, III, IV, V, VI, VII, VIII, in Center County.

By A. L. Ewing,
Prof. Geol. and Zool., State College.

Formation No. II.

Trenton, Chazy, Calciferous, &c.

Formation No. II is not sharply divisible into epochs corresponding to those recognized in New York. It consists of layers of sandstone and arenaceous limestone below, producing a sandy soil, while the upper portion consists of a blue, argillaceous, clay-producing limestone. Between these are all varieties of intermediate grades. Below, the limestone is more thoroughly impregnated with carbonate of magnesia; dolomite and limestone succeeding each other in alternating layers to a marked extent.

The *core* of the *State College well*, taken from the lower part of the series, illustrates the above points.

It represents over 100 feet of strata, and shows, with the more pure and compact limestone, several places composed of friable, calcareous sandrock.

According to the acid test it is composed of dolomite and calcitic layers varying from a few inches to a few feet in thickness.

Fig. 1. Plication produced by solution, as shown in a railway cutting in the Barrens of Centre county.

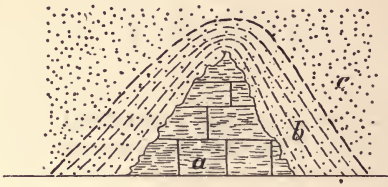


Fig. 2.

Section across Nittany valley at Penn'a Furnace.

A. L. Ewing. T4.

Although the upturned edges of the rocks are usually covered with soil, it is but a thin and nearly uniform coat of the rock mass disintegrated *in situ*, so that the generally undulating character of Nittany valley is dependent directly on the underlying rock.

A tendency to minor ridges and valleys parallel to the axis of the valleys is everywhere noticeable, these indicating the position of more resisting or more easily disintegrating strata.

The position of the *Nittany Valley anticlinal axis* is marked on the surface in most places by a prominent sandy ridge known as *the Barrens.* It rises in places 200 or 300 feet above the surface of the valley. It is more prominent toward the north eastern and south western portions of the county; dying away north east of Bellefonte, then reappearing gradually to the south-west, reaching its full height near Scotia.

Along the Bellefonte turnpike the position of the anticlinal may be pretty definitely located. A short distance south-east of the toll-gate, dark arenaceous limestone may be seen dipping from 6° to 10° S. E.; while the first rocks found *in situ* north-west of the toll-gate dip to the N. W.

In this region, however, there is little to indicate the source of the deep sandy soil found where the ridge is more prominent. The natural inference is that in the latter case rocks of a lower horizon, containing more arenaceous material, are brought to the surface and disintegrated.

The new Bellefonte and Buffalo Run railroad grade crosses the *Barrens* by a circuitous route in the vicinity of State College. Along the grade are exposures showing well the character of the soil and rocks of the *Barrens.* Within the *Barrens* the material is a mass of clay, sand, gravel, iron ore and bowlders, with ledges of solid rock. This material, however, is not intimately mixed, but in many places is stratified, preserving distinctly minor foldings and contortions, and indicating that it has been formed *in situ.*

Approaching the ridge from its south-east side the lowest strata exposed intact have a gentle south-east dip. From 1 to 1¼ miles from the crest of the ridge the limestone, in many places arenaceous and dolomitic, has a dip of from 7° to 11° S. E.

Nearer to the ridge, across *Big Hollow* reliable outcrop is very scarce, although partly disintegrated masses of sandstone and rotten arenaceous limestone are common.

Just where the grade crosses the road and enters the woods of the *Barrens* a *white sandstone ledge* is exposed under circumstances which indicate that it has not been disturbed from its original position. This has a dip of 4°, and is from ½ to ¾ of a mile from the probable position of the crest.

In through the *Barrens* cuts from 10 feet to 15 feet deep expose no strata the dip of which I can regard as reliable; although a number of horizontal or slightly south-east-dipping ledges are uncovered.

The above indicates that in this region the Nittany anticline has a very broad and flat crest. But minor *folds* or waves are to be found in this region.

One of these is nicely shown in limestone strata along the new grade on the farm of J. C. Crumerine. Here a *small anticline* is shown, only a few rods across, and parallel with the valley.

The plications in the stratified sands and clays in the *Barrens* doubtless owe their origin in some cases to the foldings in the original rocks; but in many cases the folds have been modified, or indeed produced, by an entirely different cause, viz: a smaller portion of insoluble material in certain places, thereby permitting greater settling, as a result of disintegration; or a more favorable exposure of certain parts to percolating waters, which have carried away a larger proportion of material, either mechanically or in solution. Probably both of these causes have acted at once.

This is shown to a marked degree in the new grade alluded to above. Here in several places the material is partly disintegrated on either side of projecting points of

horizontal siliceous limestone, so that it has materially settled, at the same time preserving its lines of stratification. The appearance is that of a sharp, anticlinal fold. Fig. 1 on page 402 represents these points; *a* represents the uneroded siliceous limestone; *b* represents the semi-disintegrated, shaly mass, showing stratification lines, but grading into the thoroughly disintegrated clay and sand, *c*.

Stratified clays, etc., having all varieties of dip are common throughout the *Barrens* as shown in ore banks and other excavations.

Although the rock intact may not be exposed beneath the positions of the crests of the folds, it may exist unexposed below, or being disintegrated may contain a superabundance of insoluble material, or be less favorably exposed to subterranean erosive agencies and produce similar results as shown above. This explains the dips and contortions in the ore-seams themselves as seen at Scotia and in other banks.

It is evident that the clay and sand of the *Barrens* have been intimately mixed in the original rock with the calcareous material that has been dissolved. Disintegrating ledges present themselves on the more exposed surface—a porous mass of sand and clay ready to fall in pieces on being struck with a hammer.

The *sandstone* where seen is generally very porous and friable, even in the few cases in which it outcrops as ledges, but more so in the case of bowlders.

Some of the rocks and bowlders in recently exposed cuts contain sand and limestone so intimately mixed that it is impossible to say to which class they belong.

With the above mentioned material are large amounts of *flinty bowlders*. These are of various shapes, generally very irregular, with uneven surfaces. In other cases they have a spherical form and concretionary structure. The latter are usually *hornstone*, while the former are of a lighter color sometimes composed of angular pieces of *flint*, giving the stone a brecciated appearance

Along the S. E. side of the *Barrens*, in the vicinity of State College, is found a rock, so far as I know peculiar to this locality. It has a general resemblance to *oölytic limestone*, but is composed of siliceous concretions, about the size of mustard seeds, imbedded in a siliceous matrix. Its color is usually white, though it is sometimes iron-stained. In other cases both concretions and matrix consist of *hornstone*. Large quantities of this material may be picked up from the surface in this region.

I found fragments of this same material near the *Barrens* in Walker township, near Snydertown.

At another locality three miles S. W. are found pieces of a compact siliceous clay of a drab color, containing concretionary cavities the size of a pea, some of which are filled with a fine white clay.

Sand is mined along the ridge for local use. It is generally highly colored by iron and is impure. The grains are considerably rounded. In places along the new grade almost perfectly pure *seams of sand* may be found, though of only a few inches in thickness, with layers of clay above and below of similar thickness.

Together with this semi-stratified mass of clay, sand, etc., *iron ore* is found almost everywhere in greater or less quantities. It is generally the hydrous oxide or limonite, and is usually imbedded in the clay. It is arranged in indefinite seams or strata.

Some of the clay seams contain an inconspicuous amount; while in other cases sufficient ore is present to make it apparent in a fresh cut.

When it is one half or one third ore, it is termed *wash* or *lump ore*, depending on whether the ore is in large or smaller pieces.

Wherever the ore is in sufficient proportion, say one fourth of the mass, it may be mined.

The point that I wish to make prominent here is that *the ore, flint, clay, sand, etc., are found in essentially the same condition*, there being simply a *different proportion*

of the above-named ingredients in the various strata as explained above.

In case of the sand, clay and flint it is impossible to doubt that they constitute the insoluble residue of the rocks disintegrated *in situ*. They are ingredients of the rocks still found intact, which fact, together with their stratification, makes the case a plain one.

From the porous condition of the fragments of sandstone remaining, and from the disintegrating arenaceous limestones found, it is probable that the sand is from arenaceous limestones or from calcareous sand-rocks rather than from sandstones pure and simple.

That so large a number of *flint bowlders* are found on the surface is merely a result of erosion which has carried away the soluble and finer materials.

That the *iron ore formed a part of the original rock mass* is scarcely less evident than in the case of the other materials. I believe that all analyses of limestones of this series give an appreciable amount of iron. It is common to find porous sandstones stained by a residuum of iron in the form of an oxide.

On A. S. Zimmerman's farm near Zion, in Walker township, at the foot of *Chestnut ridge*, is an outcropping ledge of *mottled limestone*, portions of which are of a dull red color. Tested by Prof. Bell, of State College, it gave 1 per cent. of metallic iron. This stone is in a disintegrating stage and is found only by removal of surface material.

In other regions analyses have shown greater proportions of iron, though these are exceptions rather than the rule.

One or two per cent. of iron, or even less, in the original limestone may at first seem inadequate to account for the vast quantities of iron ore found along the valley. It must be borne in mind, however, that by far the greater part, (probably 80 per cent.) of the limestone mass consists of carbonate of lime and magnesia, and that this has been carried away in solution by running water; that the sand, clay and iron left behind were merely the accessories or impurities of this limestone mass. There is this difference,

however, between the iron and the other substances: while they exist as stable chemical compounds passing from the rock to the soil without change, the iron is found in less stable compounds and may change from one form to another during the process of rock decay. The ore now exists as ferric oxide. The iron in the limestone is in some cases ferrous carbonate. The specimens alluded to above, from Zimmerman's, contained both the ferric and ferrous salts.

This seems to be evidence in favor of the opinion that the original condition of the iron in the limestone was as ferrous salts, in most cases probably ferrous carbonate; that as the rocks have decayed the ferrous salts have been converted by oxidation into ferric oxides; and it would seem that the rock from which the above specimen was taken was undergoing this process of change. It is probable that in most cases the change took place *in situ;* but to a certain extent it may have been transported mechanically by the action of flowing water.

A more important consideration is that the ferrous carbonate is soluble in water containing carbon dioxides. That there was decaying organic matter sufficient to supply the carbonic dioxide in certain cases scarcely admits of a doubt. Hence it is probable that portions of the ore have been dissolved, transported, deposited, and oxidized during the general process of rock decay; that the subterranean waters, in crossing through the rock masses in this region and dissolving out the soluble portions, have also to some extent changed the location and tended to accumulate the iron ore. Yet the facts would indicate that, as a rule, changes wrought on the iron have been wrought *in situ*, except so far as the whole mass has settled as a result of the removal of soluble portions; and this gives us an explanation of the apparent seams of iron ore and their various contortions.

It would seem possible then, from the nature of the case, to trace out *ore horizons* or *ranges*, and to calculate on the location of their outcrop.

This has already been attempted, and I shall allude to it in treating of ores from other horizons.

Along the *Barren ridge*, where the rocks are so nearly disintegrated, the tracing of ore ranges is attended with increased difficulties. It is enough to say that the enormous amount of ore in this region indicates that there were very thick strata of iron-bearing rocks among the lowest exposed along the anticlinal ridge.

The *Scotia bank* and the *old Ackley bank* are on a line about parallel with the axis of the valley.

Between these, on the same straight line, are two minor openings, one of which, I believe, is known as the *Lytle bank*. It would seem that these three, extending along a line of not more than two miles, and probably other openings in the *Barrens*, belong to the same geological horizon. Yet it will be seen from what has already been said that the seams are not definite enough to trace for any considerable distance, nor regular enough to calculate on far beyond the point of exposure.

I have alluded to evidence in the S. E. dipping rocks in Benner and Patton townships that Nittany has a broad, flat anticline.

In Walker township however the greater dip and steeper ridge indicate a more abrupt anticline. The admirable exposures in the vicinity of Bellefonte and along Logan's branch show the anticline to have a very moderate S. E. dip, but a very much greater N. W. dip. Throughout the valley the dip is much greater on the N. W. than on the S. E. side of the Nittany axis. This is consistent with the position of the axis being nearer to the Bald Eagle side.

In many places through the Buffalo run region and also in Marion township the N. W. dipping strata are vertical, or even overthrown so as to dip to the S. E.

To such an extent is this the case in the vicinity of Scotia that I will describe in detail the dips that I have observed here.

At the Scotia bank.

The *Barrens* are here from one to two miles wide, showing no reliable outcrop. As we emerge from this wilderness, facing north-west, we come upon a very prominent ridge. This is the ridge just north-west of the *Scotia bank*, on which are situated the Mattern store, church, etc.

This ridge is traceable, north-eastward, a considerable distance. Near its base, 40 or 50 rods from the *Scotia bank*, is a quarry in which the beds dip 32° >S. 35° E.

Numerous other outcrops are found along the ridge in both directions. On David Behrrer's farm, about one mile north-west, prominent ledges dip from 14° to 18° >S. 23° E. This is nearer the crest of the ridge.

One mile further north-west, near the new grade, the ridge is prominent, rising 100′ above the road-bed within 40 rods of the same, and showing numerous ledges dipping from 10° to 25° >S. E.

At the school-house north-east of Scotia is a quarry in which the rocks dip 24° >S. 23° E.

All of these exposures are near the same horizon, and show a rather gritty dolomite limestone which exhibits a black surface on weathering.

At Scotia a limestone is struck about 70 or 80 feet below the surface. Wells are said to pass through this rock, the wells averaging 400 feet in depth. It seems a natural inference that the limestone is the same or at any rate contiguous to that forming the ledge. I have been unable to find out the dip of the rocks in the wells, neither have I made any measurements to determine whether the above is the case.

About 150 rods north-west of the school-house quarry mentioned above, on S. T. Gray's place, in a limestone quarry the rocks dip 45° >S. E. This is a very good blue limestone, showing but little if any dolomite properties.

On this same minor ridge, and therefore on the same geological horizon, 1½ miles south-east, on G. Mattern's place, is an old quarry having a S. E. dip of 50°.

About ¼ mile north-west of Gray's quarry is a blue

limestone quarry, also owned by G. Mattern, in which the dip is 64° >S. E.

At a slight bend in the road toward Matternville, a short distance N. W. of the above, there is a dip of 65° S. E.

About half way between this and the Buffalo run road is a S. E. dip of 82°.

At the school-house near Matternville the dip varies from 83° >S. E. to vertical as you go north-west.

Here the *Trenton fossiliferous limestone* appears, and *Hudson River shales* dip from 80° >N. W. to vertical.

The only interpretation that I can put upon the above is that *in this region the Nittany anticlinal is overturned and collapsed.* The tolerable complete gradations in dip between the low S. E. dipping rocks at the ridge and the vertical rocks near the mountains, the character of the dolomitic and arenaceous rocks near the ridge, changing to argillaceous limestone towards the mountains, and the absence of evidence of a fault in this region, combine to indicate that all of these S. E. dipping rocks have taken part in the overturn. Even the limestone ridge at Scotia and the strata penetrated by the Scotia wells would seem to be *overturned.* It is inconsistent with what is known of No. II in other regions to find limestone intact so low down in the Calciferous sand-rock below so great a mass of sand as is exposed in the Barrens. Accordingly, then, the anticline is at Scotia, or some distance southeast of it, and the ore of the Scotia bank, or at least a part of it, has been formed from rocks disintegrated bottom side upwards.

The Barrens continue toward the southwest as a well marked ridge, though the rocks are overturned to a less degree.

Opposite Stormstown at the edge of the Barrens there is an exposure of vertical or slightly S. E. dipping limestone having a strike of N. 30° E. by S. 30° W.

In the opposite direction evidence of an overturn is to be found for only a short distance.

At the *Pond bank*, near the center of Patton township, there is evidence of the overturn. Here the ridge is much

less prominent, the barometer indicating a difference of about 200 feet.

Though minor ridges are to be found similar to those farther southwest indicating by their topography S. E. dipping rocks, I find no reliable exposure until near the washer in the Buffalo Run valley. Here the limestone dips 80°> S. 23° E.

Farther down the valley on M. Thompson's property is an exposure of dolomitic limestone with a low N. W. dip. As this is an isolated outcrop I do not place implicit reliance upon it. If it is a normal outcrop it indicates a rather sudden *termination of the overturn.*

Four hundred yards farther down the valley, on the township road between Benner and Patton, there are numerous N. W. dipping rocks, from 10° to 22°> N. 20° W. (on a hill south-east of Fillmore) to the nearly vertical limestone and slate of the mountain. Thus it is evident that the overturn does not reach this region.

In this vicinity the *Barren ridge* has subsided and become inconspicuous.

Spring Creek winds through the region of the anticline, making in places beautiful gorges, and exposing dark-weathering arenaceous limestone of low dip, resembling in character that seen along the Bellefonte turnpike. It is probable that the rocks here exposed belong to a horizon above those forming the loose material of the *Barrens.*

Northeast of Bellefonte, between Walker and Marion, the very prominent *Chestnut Ridge* is probably caused by an overturning of the anticline similar to that in the region just described as shown in Rogers' section from near Jacksonville.

In the absence of fossils it is difficult to say precisely to what geological epoch these rocks belong. That in the main they belong to the *Calciferous* and *Chazy* horizons is evident. Whether the base of No. II and the upper portions of the *Potsdam formation* are exposed in the county is a question of some doubt. As I have found no *Potsdam*

fossils, and considering the rather porous and friable nature of the sandstones exposed along the ridge, it seems safer for the present to regard all as belonging to No. II

At *Pennsylvania furnace* an anticlinal ridge may be plainly seen where the surface material has been removed to make mud dams for the furnace ore bank. Here the arenaceous limestone is horizontal. On both sides of it are ample exposures of rocks dipping in both directions.

At the cut near the depot, along Spruce creek, and in the quarry near the ore bank are excellent exposures of rocks dipping from 30° to 40°> S. E., evidently extending directly beneath Tussey mountain.

On the railroad, a short distance northeast of the depot, N. W. dipping rocks are seen; first, a low dip; then rising to 40° or 50°; so that this anticline is very definitely located.

Evidently the upper portion of the same arenaceous series that forms the disintegrated material of the *Barrens* is exposed here, forming a sandy, somewhat elevated, tract, though its extent is relatively small.

I have not traced this ridge northeastward; but opposite Pine Grove it has either entirely died out or else merged into the Chestnut ridge; for here, and two hundred rods farther northeast all the exposures I have been able to find are S. E. dipping.

Through a wide region here the rocks have a very low dip.

Most of the region lying between the ridges described above is of the same general nature as the *Barrens*.

Between the two ridges opposite Pennsylvania furnace is a local elevation known as *Gatesburg ridge*. It lies just southeast of Gatesburg, elevated above the surrounding regions about 150 feet. It is of the same sandy nature as the other ridges described; but, from dips on either side, its structure seems to be *synclinal*. Aside from the N. W. dipping rocks at the railroad described above, I found questionable N. W. dips at the southeast base of Gatesburg ridge. Northwest of Gatesburg I found rocks dipping 18°> S. 10° E. and 27°> S. 30° E. Accordingly the struc-

ture is as indicated in the section Fig. 2, on page 400. In making this interpretation I feel a difficulty in accounting for the sandy nature of this ridge.

The *Brush Valley anticline* lies between Brush and Nittany mountains, considerably closer to the latter. It is just northwest of the main road, at the extremity of Brush mountain. The dips rapidly increase on both sides of the anticline to 30° or 40° within ½ mile in either direction.

The *A. Gregg ore bank*, in Potter township, is in siliceous S. E. dipping rocks, about 80 rods from the foot of the mountain, the anticline being between this and the mountain.

Similar conditions obtain on the farm of J. S. Boal, 2½ miles southwest, in Harris, where dark blue, argillaceous limestone, dipping at one place in a sink 76°> N. 20° W. forms at the base of the mountain a *terrace ridge* (just below the *Hudson River shale* outcrop) not over 50 or 60 rods in breadth. Below it comes in a strip of land having a sandstone, or *freestone* soil, as it is called here and at Centre Hall.

This, as the dips a short distance into the valley indicate, represents the position of the anticlinal.

The arenaceous nature of the formation along this region and the very narrow extent of the limestone outcrop between this and the mountain can best be explained, it seems to me, on the supposition that a *fault* exists here, probably at the anticlinal.

In this region, *i. e.*, along the road leading across the valley from Linden Hall numerous exposures show only S. E. dipping rocks.

These dips vary from 15° at Linden Hall to 27° near the S. E. side of the valley. Accordingly the *Penn Valley anticline* proper and the *Brush Mountain syncline* have either entirely faded away before reaching this point or else have become inconspicuous and are concealed.

The *Brush Mountain anticline* is plainly shown at a bend in the road following Cedar run, near S. Gilliland's residence. Here horizontal rocks are exposed, with rocks dip-

ping away from them on either side. While the S. E. dips do not exceed 25°, so far as my observations go, the N. W. dips increase rapidly to 65° within 25 or 30 rods. The soil is scarcely sandy here. The material is probably above the lowest exposed at Gregg's or at Boal's. The anticline is also farther from the mountain than at the above places.

This anticline shows a similar structure where it crosses Spring creek near the Woolen factory.

The same anticline, doubtless, I found in Slab Cabin branch, about 100 rods below the entrance of Roaring run. Here horizontal, arenaceous limestone is exposed where the foundation of a building was being laid.

I have been able to trace this anticline no farther; still it must continue, for the *Nittany syncline* is traceable into the confines of Ferguson township, and the anticline is necessary to again change the dip of the rocks to S. E. It is probable that both folds fade away soon after reaching Ferguson, as the Penn valley folds must have faded in Potter township; for, as stated above, a short distance beyond the borders of Ferguson township only S. E. dipping rocks appear.

I regard this anticline as in no sense a continuation or reappearance of the one described at Pennsylvania furnace. If I mistake not, the latter is on a line to the northwest not only of the one just described, but also of the line of the Nittany synclinal.

In the vicinity of the axes just described are found large quantities of *iron ore*. These ores evidently belong to a horizon above those referred to along the Nittany axis. The most obvious peculiarity of these ores is that they are usually found in connection with the limestone, outcropping and dipping with it. There is also a large proportion of *pipe ore* in these regions. Its accompaniments consist more of clay and less of sand and flint.

The *Pennsylvania Furnace ore bank*, one of the oldest and most extensive in the county, though not at present in operation, is just southeast of the anticline alluded to in that vicinity. This opening extends about 100 rods across

the strike of the S. E. dipping rocks. As the dip is considerable (40° and less) it indicates that the original iron-bearing limestones of this horizen were of great thickness. It is important to bear these points in mind in attempting to determine the outcrop of this range in other regions.

Going northeast from Pennsylvania Furnace, the dip of the S. E. dipping rocks decreases, while their breadth of outcrop correspondingly increases; so that at the northeasternmost cross-road in Ferguson the S. E. dips vary from 18° on a hill S. E. of J. C. Crumerine's to 25° in the vicinity of Tussey mountain. Hence, we should expect to find the Pennsylvania Furnace range receding from the mountain. This makes it impossible, I think, to ascribe the ore on the farm of A. B. Ross to the Pennsylvania Furnace range, as that is nearer the mountain than the Pennsylvania Furnace bank.

It is more probable, I think, that the ore on the *Weaver place* belongs to the Pennsylvania Furnace range. On the cross-road in this vicinity northwest of Weaver's I found low S. E. dipping rocks, 10°, etc., but no evidence of folds.

The *Johnston bank* is a little northwest of a line extending from Pennsylvania furnace through Weaver's in S. E. dipping rocks. Yet it must be remembered that while at Pennsylvania furnace the rocks dip directly under Tussey mountain, at Johnson's the fading *Nittany syncline* and *Brush Valley anticline* intervene between the bank and the mountain.

Considering the probable thickness of the ore-bearing rocks at the furnace, and the lower dip as we go northeastward, it is possible that many of the ore-shows in this region belong to the same group.

The old openings on the farm of William Foster, known as the *Cooper* and *Blair banks*, are doubtless above any of the banks mentioned in this vicinity, as they are directly in line with the *Nittany Mountain syncline.* The Cooper bank is in S. E. dipping rocks.

Along the *Brush Valley anticline* are a number of ore-shows. The *Gregg bank* has been mentioned. On J. S.

Boal's place there is considerable ore under conditions so nearly like those at Gregg's that it seems evident that they are in the same range. Again on the *W. Emerick farm*, near Center Hall, is another ore-show under very similar conditions. The ore right of this property was at one time leased, but the lease ran out before work was begun.

The *Stover bank*, near Boalsburg, is just northwest of the Brush Valley anticlinal and probably belongs to the same range. Whether these belong to the Furnace horizon or not I am unable to say. I see nothing to preclude that idea.

The upper beds of No. II are found everywhere at the base of the mountains, dipping beneath No. III. As the lower strata of III are generally arenaceous, forming a sandy soil, the upper strata of II are argillaceous, forming a distinct clay soil. Between the two formations are intermediate grades of loam usually verging into clay. The soil is strong and productive, though in many places it has not been properly kept up.

The upper strata of No. II are dark blue in color, showing good joints in places and containing large quantities of good lime-producing stone. The color of the limestone probably results from the presence of organic matter.

The stone contains in many places cracks filled with pure white calcium carbonate. White calcium carbonate crystals are quite common.

On Jacob Bahrrer's farm near Buffalo Run, in Patton township, is a quarry composed entirely of *white crystalline limestone* or *marble*. At one time this was quarried, drawn to Hollidaysburg, and used for making gravestones. It makes an excellent flux for the manufacture of fine qualities of iron.

This is near the central portion of the series.

Quartz crystals are found in the limestone in places; but more often in the soil where limestone has dissolved. *Hornstone concretions* and *flint bowlders* are quite common throughout the formation.

The upper portion of No. II corresponds to the *Trenton*

formation of N. Y., as is shown by the fossils. Like the other parts of the formation, it contains iron ore, though to a much less extent.

Cavern deposit of iron ore.

On Sinking creek, as it rounds Egg hill, in Potter township, on the *Wagner place* (A. Kerr in county atlas), is an exposure of ore quite unique in many respects. *The ore occupies caverns* eroded out of the limestone. In this exposure most of the limestone is left intact. The ore that has been removed has been taken from openings into the solid mass where erosion has removed the material from one side. Even there it is necessary to remove large quantities of limestone in order to get the ore. Large masses of *pipe ore* are found, with *lump ore*, *bomb-shell ore*, and *wash ore*. Most of the ore taken out has been removed from one large triangular space, having sides about 20 feet in extent, and a depth of 15 feet, one side forming an opening from the bank of the creek-bed. Besides this, several small test-holes, drift, and slant openings have been made. Those within a range covering not more than 20 or 25 feet in thickness of rocks strike ore of the same character; those out of this range show but little ore. The ore is found in the worn joints imbedded in a tenaceous red or yellow clay.

As pipe ores are undoubtedly formed by the evaporation of chalybeate waters, which percolate through the mass, one might expect to find in a place like this evidence as to the time of the formation of these pipes.

The fact that all are broken off—none being attached to the limestone—implies that they were formed at a sufficiently remote period for subsequent waters to dissolve away the attachments.

The fact that the pipes are straight and generally parallel, implies that they were formed while the rocks were stationary, and not during a gradual upheaval.

It is inconceivable that they were formed while the rocks were in their original horizontal position; hence, it is altogether probable that they were formed after the Appa-

lachian upheaval, and while the rocks were in their present position.

One very interesting specimen from this region *has one of the pipes at an angle of 40° with the rest.* I think it probable that in this case the pipe had broken in falling, and had been cemented by subsequent depositions of the same material, as there is abundant evidence of later depositions *in thread-like pipes at right angles with the larger ones.*

As previously remarked, the probable condition of the ore while in solution, and at the time of deposition, was that of a ferrous carbonate. It is probable that oxidation began at the time of, or soon after, deposition. When the deposition was rapid, masses of carbonate and semi-carbonate were doubtless formed, which have subsequently been oxidized.

Evidence of this is seen in the larger masses found, especially here, of ore containing cavities, giving it a porous appearance, often called *bomb-sbell ore;** for as the carbonate of a low specific gravity changes to the oxide of a higher specific gravity there is a loss in volume. The change naturally beginning from without forms concentric layers of the oxide and leaves cavities within. Even the pipe ore is more or less porous.

The rocks in which this ore is found dip 45° S. E.

Thirty rods to the northeast, across the creek, there is an exposure evidently in the same range.

A few rods from this, in a quarry by the lime-kiln, *Trenton fossils* were found; and a short distance across the strike from the ore bank (not over 40 rods) come in the shales of No. III, dipping about 80°; so that this ore is within 300 or 400 feet of the top of the Trenton limestone formation.

The extent of exposure of this ferriferous horizon along the strike of the rocks is not over 40 rods. I am not aware that it has been sought outside of these limits.

This ore belongs to a horizon above any of No. II that I

*Amer. Jour. Sci., 3d Series, Vol. XXVII, p. 202; also Canadian Naturalist, Vol. IX, p. 434.

know of in this county. It is similar in character to that found on the *Ross farm*, in Ferguson township; yet it is clearly above that. In this case the ore may have been brought down by percolating water from rocks above, possibly from the shales of No. III.

Erosion by solution.

To comprehend the nature of a great portion of the erosion which has taken place in this region, producing the present surface features, it is necessary to take into account the chemical action of water on our limestones. This cannot be done better than by considering the chemical composition of the water of this region at the present day. Therefore, I give below a partial analysis (made by Professor Jorden of State College) of water taken from the State College well, 173 feet deep, bored through the middle or lower divisions of formation No. II. The water was drawn from a tap in the chemical laboratory:

Solids—Grams per liter.

No. 1,	.2218 grams.
" 2,	.2255 "
" 3,	.2240 "
" 4,	.2235 "
" 5,	.2347 "
" 6,	.2340 "
Average,	.2273 "

$Si.O_2$,		2.63 per cent.
SO_3,		1.69 "
CaO,	[lime]	25.30 "
MgO,	[magnesia]	18.66 "
Alkalies,		1.60 "
$FE_2O_3+Al_2O_3+P_2O_5$,		.30 "
Cl.,		2.20 "
CO_2,		36.34 "
Undetermined,	[carbonic acid]	11.28 "
		100.00 "

Nos. 5 and 6, which give the greatest amount of solids, were taken after considerable pumping had been done, and probably contained a small amount of sediment.

It is seen at once that most of the solid material is CaO, MgO, and CO_2; and that a very considerable amount of

these are to be found in each liter of water. But these are the substances that form the essential part of our limestones and dolomites. It is clear that waters percolating through these rocks, becoming laden with their constituents, then bearing them to the ocean, must, in time, produce a marked effect. We have further evidence that the above-named constituents come from the rocks themselves; in many places the rocks are seen to be porous, parts having been dissolved away. This is well shown in the *State College well-core* alluded to before.

Erosion, once started by the chemical action of water, permits the formation of subterranean currents, which greatly augment the process, in places, by the mechanical action of running water. The natural result of these activities must be a honey-combed structure of the underlying limestone, permitting surface water to descend, and, in places, a breaking away and caving in of the superincumbent mass, forming sink holes.

These phenomena are all to be found in the region under consideration. Sinking streams are abundant. It is almost the rule and not the exception that each stream sinks and rises before leaving the valley. Many of the springs are doubtless the rising of underground streams to the surface.

Along or near the more prominent anticlines there is a paucity of surface streams. Water is found only by sinking deep wells; hence rain water is generally used.

Sink holes are common. In places the cavernous nature of the limestone is finely exhibited in *caves*, a number of which are accessible in this county.

A cave in Gregg township.

One cave only I will allude to which not only shows the nature of the rest and illustrates the probable condition of much of the limestone beneath the floor of the valley, but also shows the essential structure of all limestone caves. It lies in Gregg township, about one mile west of the end of Brush Mountain. It is in dark blue limestone, having a S. E. dip of about 43.°, probably belonging near the middle

of Formation No. II. The entrance is from a deep sink. It extends along the strike of the rocks and contains deep, clear water. It is sufficiently large to allow navigation in a large row-boat. Its height in places is 20 or 30 feet, and its breadth about the same. The roof of the cave is formed for the most part by one thick stratum of limestone. In places, however, this has fallen away, leaving exposed the strata above.

The cave extends 1200 feet beneath the surface. At the far end the rocks dip in a more easterly direction, so that the roof comes down to the surface of the water. About 300 feet in, the cave divides into two parts, one wet, the other dry, the same stratum forming the roof of both.

The side toward which the rocks dip contains the water, the more open side apparently having its bottom filled by the *débris* fallen from above. The two arms are separated by a natural partition of uneroded rocks.

The dry cave may be reached by another sink in line with the opening alluded to.

Within the cave are stalagmites and stalactites of every variety of form.

About 80 feet from the far end of the cave is a deep ravine, and the *Fathomless Spring* known as the source of Penn's Creek. As the water in the spring stands at the same level as that in the cave, the two are probably connected ; and the cave is no doubt only one section of a much larger system of underground drainage ; for, a short distance nearly west of the cave, a stream sinks beneath the surface, and is probably identical with that which appears as Penn's Creek.

Big hollow; an ancient water way.

Several beds of ancient streams are noticeable in this locality. One of the most extensive of these appears to originate near *Johnston's ore bank.* Here several indistinct depressions converge into one ravine which crosses the road passing north-east of *Struble's bank.* The Bellefonte and Bufffalo Run RR. grade follows this ravine to the curve near Thompson's, where a branch ravine joins it ; which

the grade follows upward, diagonally, through the *Barrens*. This ravine is traceable to the vicinity of the *Pond bank*.

The main ravine, known as *Big hollow*, continues in a sinuous course north-eastward until it reaches Spring creek, one mile below Houserville. Big hollow has a distinct course of about five miles; its banks are in places from 50 to 100 feet high, here sloping and gradual, there steep and precipitous. As in the case of real river channels, the steep banks are on the inside of the curves.

The whole topography of Big hollow indicates that it is the bed of an ancient stream. An extensive area slopes toward this ravine. Several smaller ones join it on its course, yet I know of no evidence that water has flowed through it since the first settlement of Centre county; but I have found numerous *sink-holes* along the channel; and gravel deposits and other *débris* in the vicinity of some of them indicate that large quantities of water have flowed into them in times of freshet; and this makes it probable that there exists beneath the Big hollow an *underground channel* joining Spring creek.

Fossils of No. II.

Few fossils are found in the lower portions of No. II, and those found are mostly fragmentary and indistinct.

In the State College collection there are specimens of *graptolites* presumably from No. II in this vicinity; also very fair specimens of *Maclurea magna* labled "Centre Co."; the latter is of dolomitic limestone and contains chert and fine quartz crystals.

Near the lower part of No. II, I have found numerous specimens of a Gasteropod, probably *Pleurotomaria*, but it answers to no description that I have at hand. The columella is short, and it has 5 or 6 whorls with a very gradual increase in size from the apex. I found the same form in limestone outcropping in Jackson's ore bank near Bellefonte. Fragments of a few other Gasteropods are found, but not complete enough for determination.

Throughout the upper half of the rocks fossils are found, sparingly in most places. But in other places towards the

top of the series *strata are found composed almost entirely of fossil remains.* These fossils correspond to the *Trenton forms.* I have been able to determine the following genera and species, some with reasonable certainty, while of others there is doubt.

Schizocrinus nodosus—stems.
Streptelasma corniculum—heads.
Orthis testudinaria—very common above.
O. tricenaria.
O. pectenalinea?
O. lynx?—a part of one specimen.
O. subequalis.
Strophomena alternata—very common above.
Leptaena sericea—common above.
Lingula curta—one specimen.
Pleurotomaria lenticularis.
P. ——?
Murchisonia gracilis.
Leperditia.
Trinucleus concentricus.
Calymene — ?
Chaetetes lycoperdon—common above.

The following are some of the localities at which Trenton fossils may be found:

On the road between Lemont and Oak Hall, in both N. W. and S. E. dipping rocks;
On the creek below bridge, at Pine Grove.
On the road, two miles E. of Boalsburg.
At Matternville, in rocks joining No. III and above;
Between Bellefonte and Milesburg.

Formation No. III. Hudson River and Utica Slate.

The rocks of this formation are found bordering the valleys described under formation No. II, and extending into the mountains, whose bases they form. They consist of black, carbonaceous, fissile shales below, grading into slaty, arenaceous shales above. I have made no attempt to dis-

tinguish between the two groups as recognized in the State of New York.

The formation produces a light clay loam soil, which has a very good reputation among farmers for productiveness; yet it is not regarded as so strong a soil as that formed from No. II. It has not been cultivated as long, hence it has not been put to so thorough a test. Cultivated fields of this soil may be seen in places extending half way up the mountains.

No. III is exposed in most of the mountain gaps, though many of these outcrops are meager, offering but little opportunity for studying the formation. The S. E. dipping outcrops usually incline from 25° to 40°, while the N. W. dips are from 50° to vertical. At Matternville there is an extensive exposure of these shales. Here the base of the formation may be seen, in Buffalo run, grading through calcareous layers into the Trenton limestone. In this I found *fossils common to the Trenton and Utica.*

There are exposures here, for a distance of about 600 feet, of shales, dipping 80° to 85° N. W. The uppermost of these may be seen behind a blacksmith-shop near the mountain. It is a light drab, sandy shale, containing a few fossils. The upper surface of the formation is not exposed, but from what may be seen here, I should estimate the thickness at 800 feet or upwards.

In Nittany mountain, between Lemont and Oak Hall, the No. III shales may be seen, at first having a dip of 23° >E. 30° S., then apparently at the trough of the syncline having a N. E. dip of only about 10°. A little further on there is a N. W. inclination of 12°, with no further exposure until the Trenton limestone is reached, which dips 64° N. W. These shales are drab in color and sandy, probably belonging to the upper portion of the formation. The north-easterly dip noticeable here indicates the shoaling up of the Nittany syncline.

At the south-west extremity of the Egg Hill syncline No. III is exposed from its union with No. II (near a church)

along the end of the mountain for a distance of at least 40 rods. The dip varies here from 80° >S. E. at its lowest portian to nearly horizontal. There are few fossils at this exposure.

At Spring Mills there are good exposures at the Spring Mills house, and in the railroad cut, of low, S. E. dipping clay and sandy shales, showing well the character of the formation.

On the road south-east of Egg hill may be found *Trenton fossils* and shaly limestone, indicating the transition between II and III.

All along up the side of the mountain the outcrops of No. III may be found.

At a point 320 feet above Spring Mills, and again 80 feet above this, fossiliferous outcrops occur, having a dip of 20° >N. W. With this shale are layers of impure limestone.

The top of Egg hill is by barometer 625 feet higher than Spring Mills, and seems to be composed largely of No. III shales.

Near Pleasant Gap village is an exposure of weathering No. III shales, showing numerous fossil casts.

Near the gap between Jacksonville and Howard are several exposures of No. III shales. The rocks in this region are probably overturned, as the Trenton limestones dip from >80° or 85°>S. E. at the Jacksonville quarries to 50°>S. E. nearer the mountain. Still closer to the mountain is a S. E. dip of 32° in No. III shale. Near the base of the mountain is a tough, carbonaceous and calcareous shale, having a dip of 60°>S 30° E.

On the road near the J. Hoy house, but little nearer the mountain, the shale has a N. W. dip of 78°. Again at the base of the mountain shales holding fossils similar to those found on Egg hill dip 82°>N. 30 W. This is doubtless near the upper surface of the formation, as within 15 rods of this, at the Flour mill, the Oneida gray sandstone crops out with a similar dip.

The above low south-east dips in this region are quite ab-

normal. As I am not aware whether they are local, I will offer no explanation.

Fossils in No. III.

The following fossils occur in this formation in Centre county:

Glyptocrinus decadactylus—stems.
Orthis testudinaria.
O. subquadrata (*?*) cast.
O. (*Sp. ?*)
Strophomena alternata.
Leptæna sericea.
Bellerophon bilobatus.
Murchisonia gracilis.
Modiolopsis modiomorpha.
M. curta.
Ambonychia radiata.
Orthonota.
Trinucleus concentricus.
Callimene Beckii.
C. (*Sp.?*)
Orthoceras.

It will be noticed that most of these forms are found also in the Trenton limestones.

Formation No IV. Oneida and Medina Sandstone.

The rocks of this group lie above No. III, and form the greater part of all the mountains in the region under discussion. The most extensive exposures in the county are at Bellefonte, at Pleasant gap, and at Washington gap. Isolated ledges and cliffs are quite common at the various gaps. The Bald Eagle ridge is monoclinal, while the various other ridges are synclinal in structure. The triple division of No. IV is most easily recognized in the Bald Eagle mountain. Here the strata incline from 70° to vertical.

Lying next to No. III is the Oneida gray sandstone forming the inside or terrace ridge. This stone is of coarsish texture, gray, and often contains iron-stained pits. It may

usually be recognized even when found in floating fragments. The Oneida ridge is usually subordinate in height to the main crest, but in the Bald Eagle mountain is of about the same height, or in places even higher.

The second ridge or crest is formed by the Upper Medina white sandstone; a finer-grained, more compact sandstone. It is lighter in color, often of a greenish tinge. The Bald Eagle mountain has its north-west side covered with bowlders mostly of this division.

Between the two ridges is the Lower Medina, softer, argillaceous sandstone, with layers of shale. The narrow valley between the ridges is formed by the disintegration of this division. In places the bed extends to the top of the crest. This valley is generally cultivated. There is evidently sufficient clay in the sandstone to form a fair soil. Standing in the center of this valley one can readily distinguish between the red soil on the north-west Medina slope and the lighter soil on the south-east Oneida slope.

Throughout the district the Medina crests are much less broken than the Oneida terraces, the drainage being through the numerous gaps in the latter. Near these gaps *erratic bowlders of No. IV* may be seen strewn for some distance into the limestone valleys. It is evident that in some past time torrents have rushed through these gaps over the beds now occupied by our modest streams.

In the Nittany syncline there are but two ridges southwest of Pleasant gap, while normally there is the double ridge on either side of the trough. The explanation of this is that the part forming the crests (the Medina white) has been carried away, leaving only the Oneida gray, forming the ridges, with the Medina red between.

In pleasant gap there is a quarry in Medina red, from which very good flagging stone is taken.

Nittany mountain near its terminus (north-west ridge) rises 2000 feet above sea level, Lemont, at its base, being 1000 feet.

Bald knob, near Boalsburg, is 2200′ A. T. These are among the highest points in the county.

Bald Eagle mountain is about 1700′ in the region of Julian.

I know of but one fossil found in No. IV in this county, the sea-weed *Arthrophycus Harlani*, found in the Medina white sandstone.

Formation No. V. Clinton Group.

This formation is found in Bald Eagle valley lying against the mountain and reaching one half or two thirds way to the top. Its limit may usually be seen below the steep rocky slope of the crest where the more luxuriant vegetation ends.

So far as I know there is but one exposure of the Clinton formation in the county offering opportunity for its study; that is at Howard. Here, at the base of the Bald Eagle mountain, the Clinton is exposed in two places, with an interval of about 20 rods between them. These exposures show black fissile and olive shales with sandy and calcareous layers. Near the lowest part of the exposure is a thin stratum of *fossil iron ore*, which was mined on a small scale sometime ago. Fragments of the ore are to be found at present. These shales have a dip of 85° N., 20° W. Fossils were found in places in both the upper and lower part of the exposure; *Orthis*, *Atrypa*, *Strophomena*, etc.

Near the base of the mountain, at Port Matilda, 200 feet above the railroad, I found calcareous shale having a S. E. dip of 30°, and probably belonging to No. V. The water in the stream in which this was found had formed an incrustation of calcareous material over the stones in its bed. In another place near this I found a similar shale having a like dip. The abnormal dip is probably owing to a minor flexure.

The so-called "Paint springs" in this region probably flow either from red shale of No. V or from its fossil iron ore.

Formation No. VI. Lower Helderberg &c. limestone.

The rocks of this formation form a narrow belt along the base of the Bald Eagle mountain, overlapping No. V. In

places the position of No. VI is indicated by a terrace ridge, but for the most part this is quite inconspicuous. Exposures are rare. There are a number of old openings where No. VI was quarried in time of the charcoal furnaces, but these serve only to point out the locality of the formation and afford loose fragments of the stone. There are quarries at Unionville, at Milesburg and at Curtin's. These exhibit a rather poor argillaceous limestone, in places containing horn-stone.

At Unionville the dip is 74° S. E. The rocks contain weathered fossils, *Atrypa reticularis*, Corals, etc., and the formation forms a ridge.

At Milesburg, on the south-west side of Spring creek, No. VI dips >34° N. 25° W. in an old quarry, and 70°, N. W. along the railroad nearer the mountain.

On the other side of the village in the quarry the dip is 25°, N. W.

Towards Curtin's there are outcrops showing a dip of 45°, N. W. to 80°, N. W.

The following fossils occur: *Atrypa reticularis*, *Strophomena rugosa*, *Spirifer perlamellosa* (?) *Trematospira* (?), *Zaphrentis*, Corals.

Formation No. VII. Oriskany Sandstone.

This formation is very peculiar and irregular in its dips in Centre county. The southernmost exposure I have found is between Julian and Martha. Here on John B. Mattern's farm is a wooded ridge presenting on its south-east side a precipitous ledge of Oriskany calcareous sandstone.

The rocks containing some of the characteristic fossils of this group, indicate a thickness of 60 or 70 feet. They dip 20°, N. W. This ridge is about 40 rods in length and compels the creek to wind around it, passing between the ridge and the mountain. This ridge does not reappear in either direction.

Between Julian and Unionville there is a quarry known

as the Alexander quarry, located half way up a terrace ridge 120 feet above the creek. Some of the layers are hard siliceous limestone, and have been burned for lime. Others consist of coarse grains of sand, cemented by calcium carbonate. On being treated with acid this completely disintegrates, leaving only the loose grains of sand. The material of this quarry has a S. E. dip of 45°. On the top of this same terrace, 250 feet above the creek and about 12 rods nearer the mountain, is another quarry in vertical strata of the same general nature as that just described. Both openings contain the ordinary Oriskany fossils, but from the lower, more sandy rocks I found most of the following fossils: *Merista lata*, *Spirifer arrectus*, *S. arenosus*, *Rensselæria ovoides*, *R. suessana*, *Orthis musculosa* (*?*), *Strophomena.*

Between the two outcrops mentioned above and quite near the lower is S. E. dipping shale with calcareous layers, in which I found a *Discina*, the cast of an *Orthis* and a *Strophomena.* Although these specimens were too badly weathered to admit of specific determination, their general appearance indicates that they belong *above the Oriskany.* Accordingly, the explanation of the conditions described above is that there is a sharp synclinal fold in this region. The only other explanation admissible is that there is an overturn here; that the lower quarry consists of the overturned Oriskany, while that above belongs to No. VI. This interpretation is contrary to lithological and palæontological evidence. Whatever explanation answers for this locality would also probably explain the abnormal dip in the No. VI quarry at Unionville.

At Milesburg No. VII is seen beneath the railroad bridge in Bald Eagle creek, having a N. W. dip of 25°. Again near Curtin's it is exposed in a small hill with normal dip, and is a ferriferous, coarse grained sand, with weathered casts of fossils.

At Howard, where material has been removed to build dams for the Lauth foundry, I found thin ledges of limestone, probably No. VI, having a dip of 30°>N. 15° W. Four rods north of this is a thin ledge of calcareous sand-

stone, doubtless belonging to VII, having a dip of 60°>N. Along the old canal, about ⅔ miles northwest of the village, is a prominent ridge of sandstones, similar to the above, dipping from 55° to 80°, S. E. Between these two points the material is shale, forming the soil beneath Howard village. Apparently there is a syncline in this region forming a sub-plateau, crowding the Bald Eagle creek out into the valley. I found no Oriskany fossils in this locality.

Formation No. VIII, a. Upper Helderberg group.

The extensive outcrop of No. VIII forms the floor of the greater part of Bald Eagle valley. The lower part of the formation is to a great extent covered by river deposit along the Bald Eagle creek flats, hence opportunities for its study are rare. Back from this the rocks of the Hamilton period in part and of the Chemung period form monoclinal ridges parallel with the valley. Numerous cross valleys divide these ridges into more or less isolated hills.

No. VIII, b. Hamilton group.

Two miles south-west of Unionville in the bed of Bald Eagle creek is an extensive outcrop of black carbonaceous shale and shaly limestone, having a dip of 40° >N. 25° W. This material in a fresh condition has a smell resembling crude *petroleum*. Some of the layers are very fossiliferous, but the forms are fragmentary and difficult of identification. *Orthis limitaris*, a *Spirifer*, a *Strophomena* and *Tentaculites* are among the fossils of these rocks. There is a quarry in No. VI between this opening and the mountains. These rocks probably belong to the *Marcellus*. I know of no other exposure of the Marcellus in the county.

Along the road at the foot of the first range of hills are numerous outcrops of Hamilton rocks. The lowest portions seen consist of a black fissile shale, often iron stained. Above these are calcareous shales grading into limestone. In the eastern portion of the county the limestones pre-

dominate. The fissile shale seems to contain no fossils. Above are *Tropidolepius carinatus*, *Atrypa reticularis*, *Phacops bufo*, *Orthonota undulata*, *Strombodes distortus*, *Chonetes*, *Discina*, and others not determined.

The dip of these shales varies from 20° to 40° >N. W. Near Julian there is an abnormal dip. On the farm owned by J. B. Mattern, northwest of the No. VII outcrop alluded to above, the black fissile shales dip 45°, S. E., on the railroad near his house, and 80°, S. E., 80 rods northwest. The change of dip extends for some distance into the valley. Between the outcrop at the railroad and the No. VII ridge is about 50 rods of shale soil. Thus there appears to be another small syncline in this region.

On the road near Matilda is an extensive outcrop of compact olive shale having a dip of 40° or more N. W. The only fossil found here is *Lunulicardium fragilis*. Possibly this belongs to the *Genessee*, but stratigraphically it does not appear to be above the other portions described as Hamilton proper.

No. VIII, c. Chemung group.

Back from the railroad, ¾ of a mile or more, along the second range of hills the shale becomes more sandy, the dips range from 15° to 30°, N. W., and there is a change of fossils. Though the line of division between this and the Hamilton is not well marked, evidently this belongs to the Chemung period.

Back of Unionville are numerous very large bowlders of coarse sandstone or *conglomerate* resembling somewhat the Oriskany sandstone and indicating by their position strata of this character in this vicinity. This probably locates the Portage group. Above this horizon are found sandy olive, drab, and red shales with sandstones.

In the lower part of this group within one mile of Julian are *Cyrtina Hamiltonensis*, *Productella* (?) *Spirifer mucronata* (a loose specimen,) which, so far as fossils are concerned, leave the question in doubt as to whether it is Hamilton or Chemung.

Above, in the upper part of the formation, fossil evidence is more certain. *Atrypa reticularis* of the large Chemung type, *Leiorhynchus mesacostalis*, *Strophomena cayuta*, *St. chemungensis* (?), *Spirifer disjuncta*, *S. mesostrialis* (?), *S. mesacostalis*; these spirifers occurring as casts. *Productella Sp.* (?), *Avicula decussata*, *Chonetes*, *Avicula damnoniensis* are found in the upper portions of the Chemung.

The division between the Chemung and Catskill (VIII and IX) as fixed at the beginning of the red sandstone, is generally readily made out. It occurs between the third and fourth ranges of hills from 2 to 3 miles from the railroad.

Near the upper surface of the Chemung, *iron ore* is found in places. On the farm owned by D. Yethers, in Huston township, is an opening where fossil ore was removed for the Julian furnace. Fragments of sandy fossil ore may be found here at present, though the opening is closed.

INDEX TO T⁴.

NOTE.—*Where a locality is more fully described the page is marked by an* *.

THE PUBLICATIONS

OF THE

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

REPORTS FOR 1874, 1875, 1876, 1877, 1878, 1879, 1880, 1881, 1882, AND 1883–1884.

Reports have been issued by the Board of Commissioners, and the prices thereof fixed in accordance with the law authorizing their publication, as follows:

ANTHRACITE COAL FIELDS.

A². SPECIAL REPORT TO THE LEGISLATURE UPON THE CAUSES, KINDS, AND AMOUNT OF WASTE IN MINING ANTHRACITE. By Franklin Platt, Assistant Geologist, with a chapter on the METHODS OF MINING. By John Price Wetherill, Mining Engineer. Illustrated by 35 figures of mining operations, a PLAN OF THE HAMMOND COAL BREAKER, on the Girard estate, and a SPECIMEN SHEET, scale 800 feet to 1 inch, $\frac{1}{9600}$ths of nature, illustrating the PROPOSED PLAN OF MAPPING THE ANTHRACITE FIELDS. By Chas. A. Ashburner, Assistant Geologist, 1881. 8 vo., pp. 134. Price, $1 10; postage, $0 12.

AC. REPORT ON THE MINING METHODS AND APPLIANCES used in the Anthracite Coal Fields. By H. M. Chance: with an atlas of 25 plates; 54 plates and 60 illustrations in the text. Price, $1 40; postage, $0 25.

AC. ATLAS. Coal Mining Plates I to XXV. By H. M. Chance. Price, $1 40; postage, $0 12.

AA. FIRST REPORT OF PROGRESS IN THE ANTHRACITE REGION, with a description of the Geology of the Panther Creek Basin, or Eastern End of the Southern Field. By Chas. A. Ashburner, Geologist in Charge; with an atlas of 13 sheets of maps and sections; 6 page plates, and 2 folded plates in the Report. Appendix A: Determination of the latitude and longitude of Wilkes Barre and Pottsville. By Prof. C. L. Doolittle. Appendix B: Theory of Stadia Measurements, with tables. By Arthur Winslow, assistant. 1883, 8 vo., pp. xlvii and 407. Price, $0 58; postage, $0 18.

AA. ATLAS SOUTHERN ANTHRACITE FIELD, VOLUME I, PANTHER CREEK* to accompany First Report of Progress AA, 1882. Contains 13 sheets, as follows: 3 mine sheets, 3 cross section sheets, 3 columnar section sheets, 1 topographical sheet, and 1 coal bed area sheet, all relating to the PANTHER CREEK BASIN IN CARBON AND SCHUYLKILL COUNTIES; also, 1 miscellaneous sheet, "General Preliminary Map, Anthracite Coal Fields," and 1 miscellaneous sheet containing chart, showing total annual production of Anthracite since 1820. Chas. A. Ashburner, Geologist in Charge, and A. W. Sheafer and Frank A. Hill, Assistant Geologists. Price, $1 50; postage, $0 12.

AA. ATLAS WESTERN MIDDLE ANTHRACITE FIELD, Part I, 1884. Contains 11 sheets, as follows: 4 mine sheets between Delano and Locust Dale, 3 topographical sheets between Quakake Junction and Mount Carmel, and 4

NOTE.—*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.

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AA. Atlas Northern Field, Part I, 1884. Contains 6 mine sheets between Wilkes Barre and Nanticoke, 3 cross-section sheets and — columnar section sheets, all relating to the Wyoming Basin in Luzerne county. In press. Chas. A. Ashburner, Geologist in Charge, and Frank A. Hill, Assistant Geologist. Price, $; postage, $.

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BITUMINOUS COAL FIELDS AND SURROUNDING AREAS.

F. Part II. East Broad Top District, Huntingdon County. By Chas. A. Ashburner. (See Reports Central Pennsylvania.)

G. Report of Progress in Bradford and Tioga Counties—1874-8. I. Limits of the Catskill and Chemung Formation. By Andrew Sherwood. II. Description of the Barclay, Blossburg, Fall Brook, Arnot, Antrim, and Gaines Coal Fields, and at the Forks of Pine Creek in Potter County. By Franklin Platt. III. On the Coking of Bituminous Coal. By John Fulton. Illustrated with 2 colored *Geological* county *maps*, 3 page *plates*, and 35 *cuts*. 8 vo., pp. 271. Price, $1 00; postage, $0 12.

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L. Appendix II. A Report on the Use of Natural Gas in Iron Manufacture. By John B. Pearse. (See Miscellaneous Reports.)

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Communications relating to the work of the Survey should be addressed to J. P. Lesley, State Geologist, No. 1008 Clinton street, Philadelphia, and those intended for the Board of Commissioners, to William A. Ingham, Secretary, No. 907 Walnut street, Philadelphia.

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J. SIMPSON AFRICA,
Secretary of Internal Affairs,
Harrisburg, Pa.

April 1, 1884.