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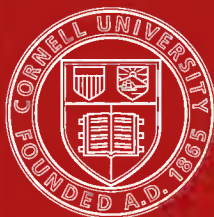
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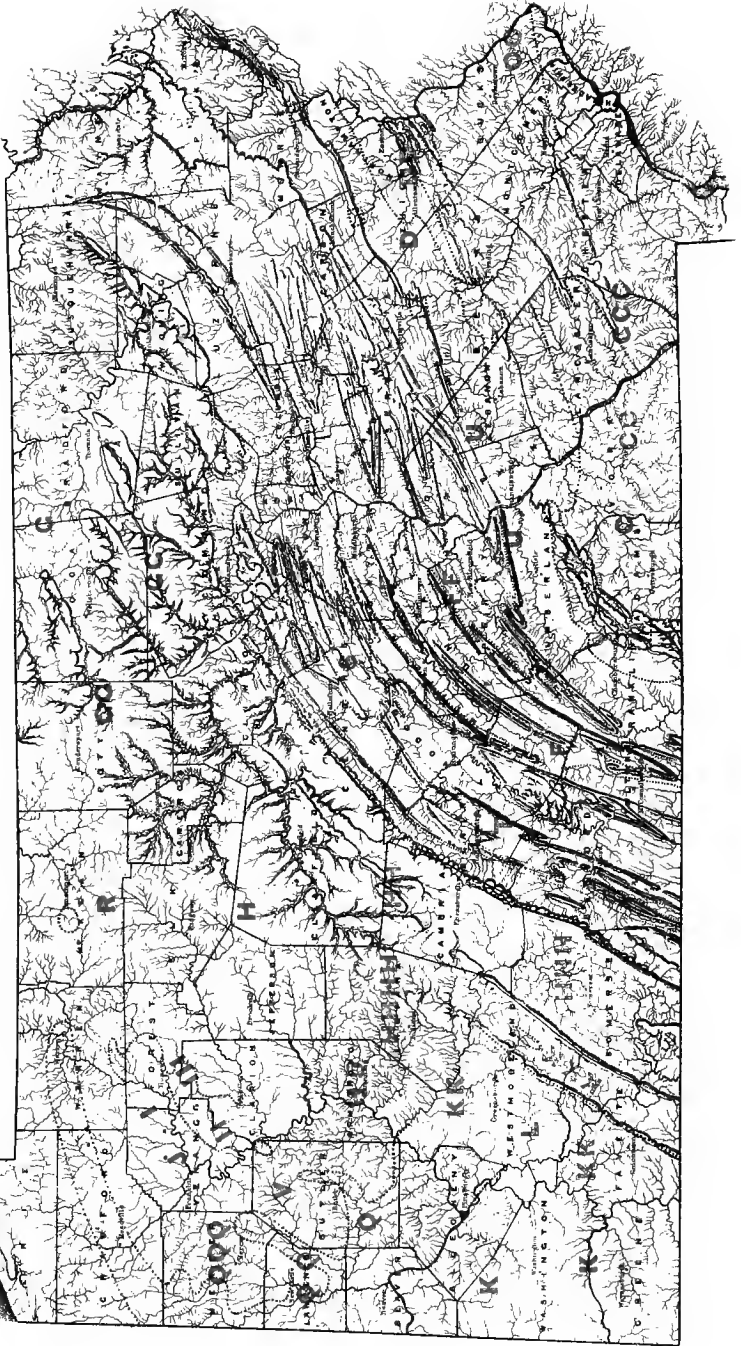


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Map of Pennsylvania, Showing the Areas Surveyed in 1874, 1875, 1876, 1877 & 1878.



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA:
REPORT OF PROGRESS IN 1877.

QQ.

THE GEOLOGY OF
LAWRENCE COUNTY.

TO WHICH IS APPENDED

A

SPECIAL REPORT

ON THE

CORRELATION OF THE COAL MEASURES

IN

WESTERN PENNSYLVANIA AND EASTERN OHIO.

By I. C. WHITE.

WITH A COLORED GEOLOGICAL MAP OF THE COUNTY
AND 134 VERTICAL SECTIONS.

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

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Entered, for the Commonwealth of Pennsylvania, in the year 1879, according
to acts of Congress,

By WILLIAM A. INGHAM,
Secretary of the Board of Commissioners of Geological Survey,
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WEST VIRGINIA UNIVERSITY,
MORGANTOWN, *April 15, 1878.*

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

DEAR SIR : I have the honor to submit the detailed report of my work for the season of 1877, during which time I was engaged in the survey of Lawrence county.

Field work was prosecuted from June until September. It was the original intention to cover both Lawrence and Mercer counties during the season of 1877, but in June I was elected to the chair of Natural History in the W. Va. University, and was thus compelled to bring my field-work to a close when the survey of Lawrence was completed, leaving Mercer to be surveyed during my summer vacation of 1878.

I also transmit the report on my work done along the Ohio Line in 1876. This work was prepared for publication in Q, but as that volume was already sufficiently bulky with the county reports, it was thought best to retain the Ohio Line work for QQ.

I have been treated with uniform kindness by the citizens generally, and am under particular obligations for many favors received on behalf of the Survey from Rev. Wm. M. Taylor of Mt. Jackson ; Mr. Jno. Connelly and Mr. J. K. Shiner of New Castle ; Mr. Walter Pierce of Sharpsville ; and Mr. Bell of Sharon.

Very respectfully,

Your obedient servant,

I. C. WHITE.



P R E F A C E .

In presenting Prof. White's able reports to the Board of Commissioners, for publication as volume QQ of the series of Reports of Progress of the Second Geological Survey of Pennsylvania, I invite attention to their evident value not only to the proprietors of lands and mining rights in Lawrence county, but to geologists engaged in the final settlement of the order and characteristic features of the Carboniferous System.

Indexes to this volume have cost more time and labor than usual to prepare on account of the minuteness with which Mr. White has illustrated, both in his sections and descriptions, the series of beds outcropping in his district.

The First Index contains references to all names of persons and places in both reports.

The Second Index refers to all statements of structure and topography, soil, terraces, drift, fossils, &c. in both reports.

The Third Index, intended for the use of students of geology, is a table of contents for the report on Lawrence county alone, with references to every place in that report where any coal, limestone, clay, sandstone, shale or ore bed is mentioned ; arranged in the natural order of superposition, from above downwards—from the highest bed in the county, the Brush Creek Coal, down, through the Freeport, Kittanning, Clarion, Mercer, Quakertown and Sharon groups, to the Sharon Conglomerate. This index is therefore a summary of the report. And to make it more useful, I have added, in what spare space an index allows, in-

dications of thickness, quality, &c. in order that a birds-eye view of each bed in its extent and variability may be presented to the reader.

A Fourth Index of the Ohio Line Report might be looked for ; but the serial arrangement of its sections, both separately and in their relative positions one to another, makes an index unnecessary. It is therefore omitted.

Anticlinals.—The assertion, on page 21 QQ, that definitely marked axes of elevation are absent from Lawrence County, needs only to be slightly modified, or rather explained, by reference to page 75, where northwest dips are shown to affect the beds along Slippery Rock Creek between its mouth and Wurtemberg.

These dips prove the neighborhood of the Homewood anticlinal, which undoubtedly cuts across the extreme southeast corner of the county.

On the map of Beaver county, published with Report Q, the Homewood anticlinal axis, seen crossing the Connoquenessing creek $\frac{3}{4}$ mile below Hazen's bridge, and Beaver river half way between Homewood and Clinton, is continued *hypothetically* by Mr. White across the highlands of New Salem and the Ohio State Line to Fredericktown, with a general course of south 55° west.

This course is so different from the south $40^\circ \pm$ west course of all the other anticlinal axes of Western Pennsylvania as to throw serious doubt upon the identity of the Fredericktown axis with the Homewood. In fact, if the Homewood axis be projected on that N. 55° E. course, it would bury itself in the middle of the great synclinal basin of North Butler county.

If, on the contrary, a course about N. 40° E. be adopted for the Homewood axis it would keep on up the east side of Slippery rock creek, and become Mr. Chance's Scrub-grass anticlinal axis, which is distinctly visible on Muddy creek about 2 miles above its mouth, on Slippery Rock Creek a mile or more west of Centreville, and on the high road two miles east of Harrisville, and thence runs under Clinton and crosses the Allegheny river below the great

bend at the mouth of Scrubgrass in Venango county. See *Mr. Chance's forthcoming Report of Progress V, on North Butler.*

The presence of this anticlinal explains the course of the Slippery Rock Creek ; and partly explains the mode of the junction of the Connoquenessing and Slippery rock creeks, and of the Connoquenessing with the Beaver river. The curious topography of this locality must however be partly due, and in some way not easy to explain, to the great local enlargement of the Homewood sandrocks.

Erosion.—On pages 118, 119, Mr. White offers in evidence of the power of the northern ice-sheet to plane down the country over which it passed the lower general surface level of Little Beaver township. His arguments are—1. That while the high land of Big Beaver township, to the east of it, contains many patches of the Freeport Upper coal, that bed in spite of a general westward dip is only caught by one knob in Little Beaver township; and—2. That the hills of Little Beaver lack the abruptness as well as the elevation of those nearer the Mahoning river.

These arguments might be regarded as conclusive were it not for a circumstance bearing directly upon the case, namely, that the Mahoning Sandstone has been the protector of the Freeport Coal Group from *pre-glacial* erosion throughout Western Pennsylvania ; that its power of protection in any given locality must have been exactly proportionate to its thickness, coarseness and solidity, (being itself destroyed where thin or shaly); and that therefore we should be in a much better condition for deciding what was the agent of erosion if we knew under what lithological aspect the Mahoning Sandstone existed over the present surface of Little Beaver Township before it was removed.

Before granting to the extreme glacialists all the power they claim for ice we should first exhaust the resources of that ordinary and universal agent of erosion *running rain water.* Before we assign any given part of our topography to the extraordinary agencies of the Glacial age, we should

be sure that it could not have been accomplished in the ordinary way before the great glacier invaded the district.

Buried river valleys.—Objections have been raised by correspondents of the Survey to what Mr. White asserts in pages 14 to 17 of Report Q respecting the existence of an old and now filled up Beaver River channel, narrower, straighter and a hundred feet deeper than the present bed of the stream. Such objections are met in this report by a still more precise description (pages 13 to 15), proving the fact from exposures on the river side, and from well borings on both sides of the river. There is indeed an *apparently* unbroken rock bed to the present water-way, from the Paper mill, 2 miles above the Railway bridge to a point one mile below the bridge; the river between the two points meandering between perpendicular rock cliffs on both sides of the valley. Any buried river bed must cut these meanders. Mr. Ramsay however had driven a pipe down 50' below present water level on the west or Beaver Falls side of the river, and Mr. Coole another equally deep on the east or New Brighton side. A careful examination of the river bank in the half mile interval between the R.R. bridge and the Beaver Falls dam, along the old Beaver and Erie canal, resulted in the discovery of a sudden stop of the Homewood SS. rocks at a point on the east bank about 100 yards above the bridge. Here the outcrop is cut squarely off and no bed rock can be seen in the river bed, but only loose drifted fragments. Above and below the place, however, solid rock forms the whole present bed of the stream. Here then was the old deep channel, now filled up with the trash through which the two drive pipes descend.

That this is a *glacial* groove may be doubted; but its existence, with all the consequences (glacial or otherwise) which can be logically deduced from it cannot be doubted.

A similar phenomenon at Parker, on the Allegheny river, has been noticed by Mr. W. G. Platt in his survey of Armstrong county, and will be mapped and described by Mr. Chance in his report on Clarion county.

The Clarion river, flowing at a higher level than it now

does, occupied a channel which crosses the present line of the Allegheny river above Parker,—made an oxbow back of the Parker cliffs,—turned south and east and recrossed the present line of the Allegheny river south of Parker,—made a second oxbow to the east and south,—and returned to the river some miles lower down. This ancient channel of the Clarion was then filled to a great height with gravel. Subsequently the Allegheny river—grown to be a mighty stream by the breaking through of the ridge below Tidioute and the accession of all the northern waters, which until then had flowed into Lake Erie—cut a straighter and deeper channel across the two oxbows of the Clarion river, and established its present valley bed. See Report I.I.I.

Erratics.—In the last volume of Geological reports (8, 9, 10) of the State of Indiana, just published, may be found an interesting description of the old cut-off channel of the Ohio river in Dearborn county, in connection with a layer of true Northern Drift (100 feet thick) on the highest hill tops of Boone county in Kentucky; proving that the glaciers of the North, descending the valley of the Wabash, crossed the present line of the Ohio river and reached into Kentucky. This Drift is so securely cemented that the edges of its patches stand in vertical cliffs; upon summits 1000 feet above ocean level, or 500 feet above the present bed of the Ohio river. Boulders of Canadian granite are intermingled with sub-angular pieces of fossiliferous Hudson River flagstones from Indiana, pieces of Lake Superior copper, specks of gold, crystals of corundum, &c. &c. in unstratified confusion. Terraces of clay lie at much lower levels along the river slopes; and new channels for the Ohio have been excavated.

In Professor White's forthcoming report of Mercer county QQQ he revises and corrects his statements in Q respecting the erratic blocks lying on the surface of the high-lands of Beaver, having discovered multitudes of them embedded in the Drift. He now concludes that the erratics on the surface also were once enveloped in Drift, and that they have been set free and isolated by aerial washings,

by the withdrawal of the clays and gravels which once surrounded and concealed them.

If he be correct in this inference, then the argument in my Preface to Q loses its foundation of facts, so far as it concerns the erratics as witnesses of the former flotation of icebergs upon a water surface 1300 feet above tide ; at least until some genuine *originally isolated erratics* be proved to exist.

Unequal deposition.—Of the local dumping of large masses of gravel and sand here and there during the coal era, a fine instance was described by Mr. White in his report on Beaver (p. 225 Q), in the case of the great Homewood (Piedmont, or Tionesta) Sandstone, the top surface of which at Homewood station swells up to the horizon of the Ferriferous Limestone, and in fact still higher, causing that limestone to thin away and disappear.

Another instance of the same sort is adduced on page 84 of this volume. The entire Mercer group of coals and limestones, shales and iron ore, at Eckert's bridge on Slippery Rock creek, is obliterated from the section, Fig. 15, by the rise of the top of the Connoquenessing Lower Sandstone until it meets the bottom of the Upper ; the two together making then a stratum 110 feet thick. The Upper sandstone seems here to swell upwards in like manner, and to prevent the deposit of the Brookville Coal.

In Fig. 79, on page 193, representing a section of the same sandrocks on the Mahoning river near the Ohio State line, they have the unusual thickness of 149 feet, if Mr. White's identification of the Quakertown coal be correct, and the top of the Upper sandstone reaches to within 32 feet of the Mercer Upper Limestone. This is called by Mr. White "a kind of hillock or hump in the ancient sea bottom," over which the M. U. Limestone and the 32 feet of intervening shales have been deposited in a curved plane; so that from this plane upward to the Ferriferous Limestone is only 100 feet, whereas the usual interval is 120 to 130 feet. These irregularities of the bed of the shallow

Carboniferous sea should be carefully recorded wherever they occur, as they form important indications of the workable areas of the lower coals, and throw some light upon the deposit of the Oil sands.

Unequal intervals between horizontal strata at very short distances mark the same local irregularity of deposit in the midst of great uniformity; or parallelism, in the series taken as a whole. The interval between the Ferriferous Limestone and the Kittanning Lower Coal bed above it for example, varies from 15 to 25 feet in 50 yards. See page 212. Other instances may be found by consulting the third index.

Limestone replaced by limonite.—On pages 40 and 101 of this report the reader will find interesting statements explaining the origin of our Buhrstone* and other brown hematite deposits, confirming the results of recent researches into the manner of the deposit of similar ores in Kentucky and Ohio. At Houk's "big ore bank," on the north township line of Wayne, where the Ferriferous Limestone is 22 feet thick, the whole stratum has been locally dissolved away and the vacant place filled with iron ore, the mass of which abuts sideways against a smooth wall face of limestone. On page 103 Mr. White makes a practical application of this theory to the prospecting of the ore, showing that the local accumulations have taken place always towards the southwest, down the dip; and therefore on the hill slopes facing the south and west.

The precise *modus operandi* of the *transmutation of the limestone into the limonite* seems to me still obscure.

The *date of the emplacement* should be more exactly fixed. Was the transfer made particle by particle, the whole mass remaining always solid; or were grooves, pot holes, caverns first made into the limestone and into these the clays were conveyed in which the limonite was afterward developed.

*The buhrstone deposit itself is assigned, with some hesitation, to an animal origin, in Ohio Geology, Vol. II, p. 142.

The first view seems to be the favorite ; and is supported by the fact that much of the ore lies *upon* the limestone, or but slightly embedded in its upper strata. It is hard to take any other view in such cases as that of Hartman's ore-banks in West Virginia, where the edges of all the blocks into which the limestone layers are divided are mere selvages of limonite ; and where, if the process had been carried far or long enough, the whole bed would probably have been converted. But it must be remembered that Hartman's limestone is a double carbonate of lime and iron ; whereas the Ferriferous Limestone is usually a tolerably pure limestone.

The second view is sustained by such cases as that quoted above from page QQ 103, where the smooth side wall faces of limestone are more like those of a previously excavated cavern.

It is very desirable that some good explanation be offered of the curious and I think important fact that very few—hardly any caves are known in the Ferriferous Limestone of Pennsylvania ; whereas thousands of caves are reported to open along the outcrop of the analogous Coal Measure limestones in Eastern Kentucky, and to extend horizontally to great distances beneath the over-rocks which form the ridges between the branching valleys and ravines. Why this difference ? Has latitude anything to do with it ? Would it be explained by restoring our northern measures to a horizontal position—by sinking the Pennsylvania limestone country until the top of the Champlain clays at Montreal reached sea level or were sunk any required hundreds of feet beneath it ? In a word, have the Kentucky caves always remained open, while what caves there were in Pennsylvania have been choked by submergence or otherwise, and filled with ferriferous clays ?

This is no place for such a discussion, but only for suggestions. All the facts must be regarded ; among others, the fact that the occurrence of limonite on and in *some* coal measure limestones, is as common in Southern Ohio and Eastern Kentucky as in Western Pennsylvania ;—and again the fact that the Kentucky limonite seems to be con-

fined to the western parts of the coal area, as those of our Pennsylvania limonites are which relate to the Ferriferous Limestone; for where this thins to nothing through Indiana county the limonite disappears with it. But other limestone beds carry limonite much further east; e. g., the Johnstown ore in Cambria and Somerset counties.

I judge therefore that, while there can be but one chemical process, there have been several different geological methods of accomplishing Coal Measure limonite deposits; and that we must have a complete census 1, of the several iron-bearing limestones; 2. of their chemical analyses; 3. of the shapes of their several ore banks; and 4, of all their geographical relationships, before we can be done with the theme.

Pipe ore limonites.—I venture to suggest here, for the consideration of geologists, an hypothesis for explaining the genesis of our *pipe ore limonites*.

I know of no rational and generally accepted explanation of these singular steeples of botryoidal and radiated iron ore from which so much of the finest stock at our furnaces in Middle Pennsylvania has been taken. They rise from the solid ore at the bottom of some of our great mines to heights of 50 and even 100 feet, through deposits of ore-bearing clays which fill vast pots in the limestone country.

I have long held that these deposits were made in caverns, the roofs of which have been carried away in the general erosion of the earth-surface. But their great width was a difficulty, for how could such a roof be supported.

There has just been published in a popular form (and therefore not trustworthy in its details) an account of the recent discovery of a cavern in Algeria, through which a river runs, which when explored widened into a lake 2 miles long and $1\frac{1}{4}$ miles wide, the roof of which was held up by multitudes of stalagmite steeples rising to meet stalactites pendant from above; in other words, by cathedral piers of calcite. If such a cavern, with all its piers finished, were to have its outlet choked, and to be filled with water through which insensible currents moved, it would become

filled with ferruginous clays, and in the end all its piers of calcite would be metasomatized into limonite of the variety known as pipe ore. The ordinary erosion of ages would remove the roof rock, make the clay the country surface, and the piers, being all of hour glass shape, their waists would become the apexes of immense steeples, projecting from the surface soil and descending with broadening bases to the floor; while the tops of lesser stalgamites would be reached by miners at various depths beneath the sod; precisely what happens in the great mines of Morrison Cove, Spring Creek Valley, &c.

The infrequency of such steeples of pipe ore in the great mines of the Cumberland, Lebanon and Lehigh Valley is easily explained by reference to the fractured condition of the mother rocks, as compared with the slightly broken upturned layers of the interior valleys; the drippings in the one class being universal through the cave, and in the others at local points on the floor.

A limestone parting between two benches of a coal bed, is mentioned on pages 58 and 209. Sometimes, as on Slippery Rock Creek, the limestone thins away to nothing, allowing the coals to come together; or changes into a thin layer of fireclay; or, as at Volant P. O. into a bed of chert. This is analogous to the occurrence of the well known bed of fossiliferous iron ore which separates two benches of a coal bed in the Deep River basin of N. Carolina; and to the other cases of the same kind. Fig. 83 shows another instance at Wallace's mine, Pulaski township, of a limestone bed, 2' thick, lying between two beds of a Mercer Coal; the upper coal has its regular underclay (1' thick), under which lies the limestone; with the additional very interesting feature of having a top layer of carbonate of iron. (See page 205.) Iron ore separating the benches of coal 2 (Mercer) in Holmes Co. O., is noticed by Dr. Newberry in his Report, Vol. II, Geology, 1874, p. 136.

Fire clay.—The thick and valuable deposit described in Report Q, and repeatedly alluded to in this Report, QQ, un-

derlying the *Kittanning Coal*, is but one of a number of such in other parts of the Appalachian Coal Field, equally stimulating to the curiosity of the geologist. Since Sir W. E. Logan first published the fact that every true coal bed has its underclay, efforts have been made to explain its cause; but not with entire success. There is still room for suggestions, and I make the following:

A peat bog, and still more truly a lake invaded on all sides by sphagnous vegetation, must have a water circulation set up by evaporation from the central surface, and by percolation from the surrounding land. But this circulation must be feeble, capable of carrying only the finest mud. In the course of ages the amount of clay, all of it fine, and all of it of one kind, thus abstracted from the dry grounds and transferred to the peat filling hollows, must be very large. The dry grounds are chiefly a mixture of fine gravel, rounded grains of quartz, and rounded grains of feldspar. The pebbles and sand are not soluble; the feldspar is. The former remain behind; the latter follows the indraft, and settles beneath the evaporating surface through and beneath the floating peat.

If, however, the area of forming coal bed be surrounded by clay land, instead of sandy or gravelly land, then the percolation is reduced to a minimum, and with it the solution of feldspar. The supply of water in the pool or marsh is kept up from the land *surface* and not from the underground; and under such conditions the incoming rain water must be much less muddy, and the deposit of underclay is reduced to a minimum.

We might look then for a law somewhat like this:

Where a coal bed has a heavy underclay, the margins of its basin were probably sand or gravel banks. Where a coal bed (of such a size as to argue for its great age) has a small underclay, it grew within a circle of older tight clay deposits. Where a limestone underlies a coal bed, stretches of exposed older lime deposits must have been within drainage-reach all around, or on some principal side of it.

The corollary follows: that the thickest underclays should belong to beds next or near above the great Sand-

rock members of the system; and it is a fact, that our largest and most persistent fireclay beds belong near the base of the Lower Productive Coal Measures. And the few great fireclay deposits high in the series have other coarse-grained sand rocks not far below them.

Another logical consequence of such a supposed law would be, that the sandrocks lying geologically close below great underclays should be more open and discreet, purer sands and gravels, than others which had not been robbed of so large a quantity of interstitial clay. I say *geologically* close below—for of course the coal bed itself would protect from this operation a sand or gravel deposit lying actually or *topically* underneath it.

Where the surrounding land was not only sandy or gravelly, but contained iron, we might expect ball ore in the fireclay. In fact the ponds of the New England and other Northern States, surrounded by hills of Drift, resembling our Coal Conglomerates except in some of their constituents, not only receive such accumulations of iron ore and clay, by side percolation, but of peat by surface growth.

If the picture sketched above have any verisimilitude it follows that in the Coal age there was always (or at frequent intervals) a great deal of dry (or comparatively dry) land surrounding and separating the coal-making pools, and that the connection between pool and pool was made by a sheet of moss over the surface of this land, resulting in a formation of coal subordinate in thickness and perhaps in value, and superior in altitude above tide, to the main bodies of the general coal bed developed in the swamps. Every coal miner in Northwestern Pennsylvania and Northern Ohio is prepared for, or rather has himself already arrived at this conclusion, from his own observation of facts.

But it also supports an important generalization of high scientific value, viz, that in spite of the infinite variations of each coal bed of the series, in thickness, quality, roof and floor, it yet may be traced and identified singly and separately from the coal beds below and above, over areas of great extent, one might almost say over the entire Coal Field. And this must be true of the smallest and poorest

of our beds, as of the largest and finest of them. In fact the labors of the last five years have collected all the proof we require for the establishment of this truth; and consequently, for the reasonableness and reliability of our scale of named coal-beds. In this sense there are in reality no "local coal beds;" for by this term we are merely permitted to designate the more favorable localities of development—the thick and valuable portions—of a universal outspread of vegetation over land and water flourishing at one date, interrupted here and there by unfavorable lands. For as the growth of a moss sheet was inward toward the centre of a water basin, so also was it a slow creeping outward over the unsubmerged intervals. The larger coal beds, requiring 100 feet or more of moss before compression, easily overtopped all the accidentations of the region, concealing even those high and somewhat steep banks which have given us our local dips. The smaller beds had too short a life either to fill up their ponds, or to spread continuously over all the intervals. But even they must have grown on the slopes, which, ascending, reduced and, descending, increased the vertical distances of bed from bed.

The identification of individual coal beds when these are too thin to mine except at special localities, far apart, is always a difficult task, and becomes nearly impossible in the case of individuals of a group of small beds lying near together. One or other of the group is pretty sure to be absent or unrecognizable in this or that local section, causing systematic confusion. A perfect scheme can hardly be made out unless a district be gone over with extraordinary care, and a great number of local sections be made near together; or unless some unmistakable key-rock be discovered as one member of the group.

Mr. White has been fortunate in both these respects. While he has been unwearied in sectioning the hill slopes, using the long known *Ferriferous Limestone* as his chief guide, he has demonstrated the persistency of the two *Mercer Limestones*, and their utility as a duplex key to those

parts of the country from which the Ferriferous Limestone has been eroded.

Nevertheless there are doubts expressed in this report concerning the correct identification of certain locally opened coal beds in some parts of the field and of one or other coal bed in certain figured sections. In all such cases the doubt is indicated by a note of interrogation, or is stated at large in the text. But in one or two instances Mr. White has come to a conclusion upon the identity of a bed on what may possibly appear hereafter to be insufficient data. Such cases, taken in the order of the series downward, are as follows:—

The Freeport Group.—The isolated patch of coal mined by Mr. Foy in Wayne township (page 91, 92) is assigned to the Brush Creek Coal. and the limestone 30' beneath it, is not thought to be the Freeport (Upper) Limestone, *because*, on the opposite side of the valley, the Freeport (Lower?) Limestone is opened at 70' or 75' beneath the same coal. It must be remembered that both the Freeport Upper Coal and the Freeport Lower Coal have limestone beds beneath them in many parts of Western Pennsylvania. The name Foy's limestone given to the bed in the Third Index is merely a convenience for avoiding the difficulty in making the Index, and is not intended to advocate the insertion of a third coal bed in the Freeport group.

The Kittanning Group.—If there be any confusion of ideas generated in the mind of future field workers by this report it will take place in connection with the very difficult adjustment of the Kittanning group of coals, of which Mr. White recognizes only two members, whereas it has been recently and amply proved by Mr. W. G. Platt in Indiana and Armstrong counties, and by Mr. H. M. Chance in Northern Butler County, to contain three: Kittanning Upper, Middle and Lower Coals.

Mr. White in this report as in Report Q, has uniformly spoken of but two coal beds, calling the upper one the *Darlington*, and the lower one the *Kittanning*. Difficulties arising from variations of interval between the "Darlington" and "Kittanning" beds can probably be overcome

by making search for the third or missing bed of the Kittanning Group.

Mr. White indeed reports "local beds" in this group, and those probably represent the missing third bed, or are local enlargements of one or other of the three beds at such localities. For it is now amply demonstrated that there are few districts in which more than one of the three beds is of workable size and quality at any one special locality.

Throughout Northern Butler Mr. Chance has found the intervals between the members of this group remarkably regular and to be represented by the following formula :

K. U. C. (interval 40') *K. M. C.* (interval 40') *K. L. C.* (interval 40') *Fer. L.*

The upper bed of the three may therefore always be *looked for* at 120' above the great key limestone of Western Pennsylvania, and the middle and the lower beds at 80' and at 40'. Yet local variations will change these intervals somewhat at any given point, and sometimes with startling rapidity within a space of fifty or a hundred yards.

It is evident then that, on page 35, for "The Kittanning Coal" should be read "The Kittanning *Middle* Coal" described there as lying from 35 to 50 feet beneath the Darlington (*K. U. C.*) and that a part of the description of this bed on pages 35 to 38 *may* appertain to the Kittanning *Lower* Coal.

A more serious systematic doubt (of no practical importance however) hangs over the identification of Miller's coal bed mined in the hill tops between the Shenango and Neshannock creeks ; a doubt which therefore affects the coloring of that part of the geological map of Lawrence county accompanying this volume. On page 180 Mr. White confesses the uncertainty he feels about this being an outlying patch of the Darlington, and gives its inferior quality as his reasons for suspecting that it is the Kittanning ; "there being" he adds "no way of definitely settling the question" on account of its distance ($1\frac{1}{2}$ miles) from the nearest outcrop of the Ferriferous Limestone. Its height above the water (380' or more) is in favor of its being the Darlington.

A similar patch of very good coal lying at an elevation of 380' feet above the Neshannock at Newcastle, and between the Shenango and Mahoning rivers, in Union County, is called on pages 186, 187, the Kittanning bed, "since the Darlington ought to come at a higher elevation." The obstacle to precise knowledge in this case is due to the thinning away of the Ferriferous Limestone in the hillsides below, or its concealment by drift. It seems, however, quite possible for some local mining engineer to settle this question by opening the outcrops or discovering some natural exposures of the Ferriferous Limestone and of the Kittanning lower and middle coal beds, and then running one or two spirit level lines up to the mines above.

The Ferriferous Limestone has been used since the year 1837 as a geological base of measurement and key to identification in Western Pennsylvania; a rock perfectly well distinguished, by its size, aspect and fossil contents,* from the other limestones of the Barren and Lower Productive Coal Measures.

The geologist can take it as his guide immediately after passing to the west of the Indiana Anticlinal, and keep it as his guide throughout Clarion and Jefferson counties; in the coal basins of Elk and McKean, nearly to the New York State line; and in Southern Venango, Northern Butler, Lawrence and Beaver counties, to and far beyond the Ohio State line.

Its outcrop makes bluffs and sometimes cliffs along the steep side slopes of all the valleys where the bed has a moderate range above water level, and around the isolated knobs which mark its high position upon the upland. Huge, angular, cubical blocks of it, as large as houses, may often be seen halted in their progress down to, or safely landed at the bottom of the ravines.

It has a lower blue layer not valued by ironmasters, and an upper gray layer much esteemed and largely quarried for furnace, farm and building purposes at a hundred localities.

* See this point stated clearly on page 220 Q.

Finally, it always carries on its upper surface quantities of iron ore, often very large, apparently derived by percolation and precipitation from the ferruginous shale deposits overlying it, and characterized by a more or less localized mixture of buhrstone or chert produced by the same agency.*

The careful geologist, accustomed to take into account all the features of each exposure, and grown familiar once for all with the character and relationships of this remarkable member of the Lower Productive Coal Series, the base of the Kittanning Group, can hardly ever be deceived into mistaking it for the thinner and less fossiliferous Freeport limestone beds, 200 and 250 feet higher in the series, or for the ore bearing Johnstown Cement bed (Butler limestone) under the Darlington Coal.

Still less can he be so misled as to confound it with the two thin iron bearing and peculiarly fossiliferous limestones of the Mercer group, which underly it at a considerable distance in the series, locked up between the two Connoquenessing Sandstones.

It is however not to be expected of furnacemen and farmers that they shall not often fail to observe these geological distinctions. Nor could the geologists of the First Survey avoid such false identifications forty years ago, at a time before the country was well cleared; before the coal beds were definitely numbered and arranged; and before the existence of other persistent limestone strata other than the Ferriferous, and underlying other coal beds than the Kittanning Lower Coal, had been discovered and proved.

The doctrine of sporadic "local coals," and accidental "bastard limestones," was then in vogue. Fifty charcoal furnaces were in blast in the great forest covered region of the Allegheny and Beaver rivers, and one ore and one limestone were all that people knew or sought for. Isolated finds of ore, and isolated exposures of limestone were naturally referred at once to this well known deposit; and any coal

* Dr. Newberry, in his Report of 1874, suggests another view of the origin of the ore and chert, as a substitute for the above theory adopted by the geologists of the first geological survey of Pennsylvania.

bed opened above such exposures in its vicinity was identified as a matter of course with the Kittanning, whether it lay 30, 60, or 100 feet higher in the hill side.

This is but one illustration of the fact that it has required all the work expended on Western Pennsylvania by the Second Geological Survey since 1874 to reconstruct in a more accurate form the series of coals, limestones, ores, shales and sandstones, and to rectify a hundred local blunders innocently made by the first reconnoissance, conscientiously and laboriously as that was carried out.

The same difficulties have of course been encountered by geologists working in the Coal Measures of Ohio and other States; and the same kind of mistakes were naturally made on both sides of the artificial meridian line which separates Ohio from Pennsylvania.

But obstacles in the way of an early and accurate differentiation of the series in Ohio were in one respect even greater than in Pennsylvania. In Pennsylvania we had the great advantage of two thoroughcut valley systems, that of the Beaver river, and that of the Allegheny river, which revealed in an unmistakable manner, and at the very outset of the First Survey, the general order and thickness of all the deposits from above the Pittsburgh coal to far below the base of the Conglomerate. And we had no embarrassing overcoat of northern drift to strip off from the body on the table before its nerves and muscles could be dissected out. Along these great river trenches through the Coal Measures he that runs can read. Huge cliffs of the Mahoning Sandstones above, and equally visible steeps of the Conglomerate below, confine all the measurements of the Lower Productive coal series within fixed limits; while the Ferriferous Limestone drew its blue line across the section for more than a hundred miles.

The mistakes of the First Survey in Pennsylvania were therefore all mistakes of *mere detail*. The Second Survey has had no mistakes of *order* to correct. The number of groups (or series, as they were at first called) remains the same in 1879 that they were in 1839. Even the number of beds has not been increased or diminished; they have only

been converted from sporadic and local to systematic and persistent beds ; and this has merely increased the number of *named* beds. An examination of the Final Report of 1858 will furnish abundant evidence that all the beds were actually inserted in one or other of the sections ; but many of them unnamed, because their general significance was then unknown and a proper identification was impossible.

In Northeastern Ohio such continuous section lines do not trench so deeply into the Coal Measures ; and the surface of the country is smoother, and lies often buried beneath a covering of northern drift, so that the geological connection between separate valleys cannot be so well executed and verified.

This was especially annoying when sections made along the Mahoning river, were to be compared with sections made along the lower part of the Little Beaver river ; for the intervening high land is entirely concealed beneath the drift. Hence the mistake was once made of supposing the Ferriferous Limestone at Lowelville, on the north or Mahoning side of this high land to be the same Freeport Upper or White Limestone which appears on the south side of it, along the Little Beaver and river valleys—a mistake which, if made, would necessarily place the group of the three Kittanning coal beds *underneath* the Lowelville limestone along the valley of the Mahoning, whereas they are wholly or partially eroded from the hill tops *over* it.

As a conclusive settlement of such a case was of general importance to prevent the systematic loss of 250 feet of measures, I directed Professor White to make a continuous series of hill side sections from Lowelville, in Ohio, down the valley of the Mahoning to its junction with the Beaver ; down the Beaver and Ohio rivers to the mouth of the Little Beaver ; and as far up the valley of the Little Beaver towards Lowellville as exposures could be found ; and this series of 42 sections he has figured and described in the Second Report embodied in this volume. As the sections follow each other at intervals of a mile or two in regular order around the circle, there is no need of a geological index to this part of his Report. Its geographical and personal in-

dex is included in that of the general report on Lawrence county.

It will be seen by these sections (located geographically on page plate IV, page 214,) that the Ferriferous Limestone can be persistently traced around the circle, except at one place upon the Beaver river where it thins to nothing, and except again where it is concealed beneath the drift covered divide south of Lowellville; but the local disappearance of the Limestone on the Beaver is supplemented by the persistency of the next overlying coal beds; so that the train of sections remains unbroken, and the demonstration may justly be considered final.

The vertical column of Coal Measures published on page 131 of the Geological Report of Ohio, Vol. II, 1874, will no doubt be modified so as to include the results of subsequent researches on both sides of the State Line; and the Mahoning Valley Sections Nos. 6 and 7 on Chart I accompanying the report of 1874, will be lowered 250 feet so as to make the massive limestone at their tops coincide with the 3' limestone (with a 2' to 3' coal bed under it) seen in the Little Beaver river Section No. 8, next above the top of the boring; the effect of the change being to put all the Clarion and Mercer coal beds into their proper places in the boring; with the Sharon coal bed coming in as it should do at the bottom.

The section thus modified will be almost entirely acceptable as it stands to those who read the series on the Pennsylvania side of the Line, thus :

- No. 25. { *Mahoning Sandstone and Shale.*
- 24. }
- 23. *Freeport Upper Coal*, (No. 6; Straitsville; Big Coal.)
- 22. *Freeport Upper Limestone*, (White Limestone.)
- 21. ——— Interval, 25' to 50'.
- 20. *Freeport Lower Coal*, (No. 5; Mineral Point; Newberry; Roger Coal.)
- 19. } ——— Interval, 23' to 46'.
- 18. }
- 17. *Freeport Lower Limestone* (Putnam; Gray Ferrif. of S. Ohio.)
- 16. *Darlington K. U. Coal*, (No. 4, Flint ridge cannel; Strip.)
- 15. } ——— Interval, 22' to 102', { *Kittanning Middle Coal.*
- 14. } { *Kittanning Lower Coal No. 3a.*
- 13. *Ferriferous Limestone.* (*Zoar Limestone.*)

- 12. *Scrubgrass Coal* (No. 3 Creek ; Lower Limestone Coal.)
- 11. Pottery clay bed.
- 10. ———Interval, 30' to 50.' { Clarion Coal.
Brookville Coal.
Tionesta (Homewood) Sandstone.
- 9. *Tionesta Coal.* (No. 2.) Strawbridge coal.)
- 8. } { Mercer Limestones.
- 7. } { Mercer Coals.
- 6. } { Connoquenessing SS. } Massillon SS.
- 5. } { Quakertown coal. }
 { Connoquenessing SS. }
- 4. *Sharon Coal* (No. 1 Briarhill ; Massillon ; Jackson coal.)
- 3. } { ———Interval, 13' to 55'.
- 2. }
- 1. *Sharon Conglomerate* (Ohio Conglomerate.)

But this modification of the views held only five years ago goes to enforce the teaching of experience that no basis of nomenclature in geology can be so unsound as that of numbers ; since it now appears that a series of really persistent beds numbered in Ohio from 1 to 6 must be enlarged so as to number from 1 to 13. For on the Pennsylvania side of the Line we certainly have the Sharon (1) ; Quakertown (2) ; Mercer group (3, 4, 5) ; Clarion group (6, 7, 8) ; Kittanning group (9, 10, 11) ; and Freeport group (12, 13,) of coal beds. In other words coal bed No. 6 from the bottom of the Ohio survey is the plain equivalent of the *thirteenth* bed from the bottom of the Pennsylvania survey ; and it is agreed that No. 1 the Sharon coal is the same in both series.*

The Clarion group between the Ferriferous Limestone

* It is my duty to add here that it was most unfortunate that in 1840 I persuaded my friend and colleague James T. Hodge, to letter our principal coal beds in Cambria and Somerset counties from the bottom upwards, A, B, C, D and E, and that in the rapid survey of Northern Pennsylvania which I was ordered to make in 1841, through Tioga, Bradford, Potter, McKean, Jefferson, Clarion and Armstrong counties, as far south as Freeport, I employed this same lettering for my imaginary identification of the coal beds there.

My unadvised adoption of this imperfect and erroneous nomenclature in my Coal Manual in 1857, has embarrassed subsequent surveys, and introduced confusion into the nomenclature of the Reports of Progress of 1875, '6 and '7.

This boyish nomenclature has crept into our literature and been a hindrance to broad views of our carboniferous geology. Indefinite in its very nature, but with a pretentious claim to extra definiteness, it has been necessarily misquoted by more than one author, owing to an inadequacy of data for deciding which was lettered A, which B, &c.

Thus in Dr. Newberry's trial harmony of the Ohio and Pennsylvania coal beds in Report Vol. II, Part 1, Geology, 1874, page 130, he writes: "Our coal

and the Conglomerate has been as embarrassing, both to the Old Survey and to the New, as any other part of the Coal Measures. The Clarion and Brookville Coals were recognized as persistent; but the Scrubgrass coal was doubted or confounded with the Clarion; as in unexplored districts, the Brookville still is with the Tionesta beneath it when the Homewood Sandstone is absent or concealed. Mr. White's section on Hettenbaugh run, however, in Scott township holds all three coal beds;* so that they might safely be named the Clarion Upper, Middle and Lower coals, were it not for Mr. Chance's observations first in North Butler,† and now more recently in Clarion County, making it probable that the *Scrubgrass* is merely a rider to or top bench of the *Clarion*.

The *Homewood Sandstone*.—In the Second part of this volume I have substituted this name for the one elsewhere used by Mr. White, the *Tionesta Sandstone*, because no adequate survey of Forest County has yet been made, and it was in Forest County that in 1841 I gave this name to the great sandrock which forms the long divide stretching away northeastward into McKean County, considering it at that time the first great sandrock overlying the Conglomerate No. XII of the Allegheny Mountain, the *Pottsville Conglomerate* of Eastern Pennsylvania. The identity of the *Homewood* in Beaver with the *Tionesta* in Forest county is still doubtful; nor can the coal beneath the *Tionesta Sandstone* in Forest county be yet identified with the first coal beneath the Homewood Sandstone.

The East Brook "four foot" Coal, the Newcastle "Dirt

No. 1, being the Sharon coal of Rogers, Coal A of Lesley;" (a) explaining in a foot note, "This is *above*, not under the Conglomerate, as represented by the Pennsylvania geologists." Whereas James T. Hodge and myself always took *the first workable bed above* the Conglomerate along the Allegheny mountain belt as our bed A. In the Clarion region I therefore assigned that letter to the Brookville coal, but never to the Sharon coal, which Hodge, McKinney, Rogers, Carll, Chance, White and myself have separately and at various times proved to *underlie* the Conglomerate as that term (*Conglomerate*) was understood, before the Ohio Conglomerate was discovered to be another and still lower deposit. (a) Repeated on page 132.

* See pages 49; 169, Fig. 66; 175, Fig. 69 QQ.

† See Report V, page 26 and Fig. 3.

Vein," is called *Tionesta Coal* by Mr. White,* but, as just said, the propriety of the name is still doubtful. It lies only from 60' to 75' below the *Ferriferous Limestone*; which raises a suspicion that it may perhaps be the Brookville; for there seems to be no room for the Homewood Sandstone.

The Mercer Group † has been worked up by Mr. White into a most important member of the Carboniferous system.

The two limestones of this group were known in 1837, but were put to no scientific use. Their importance was not suspected and they were only occasionally noticed. It can now hardly be overestimated, for they have kept the geology straight throughout Lawrence, Mercer and Crawford.

These *Mercer Limestones* have been employed with great skill by Mr. White in bringing into order what has hitherto been a confused and incomprehensible mass of observations since the beginning of the First Geological Survey of the State. Their peculiar fossiliferous character distinguishes them from other limestones, and although they resemble each other almost exactly and are not always present together, yet they are so frequently exposed, naturally or artificially, one a few yards above the other, in the same vertical section, each with its stratum of coal or coal slate under it, that they are now an established guide to the geologist, a sure key to the series.

It is noticeable that in this case the limestone deposits closely overlie the coal beds. In all other parts of the Coal Measures the rule holds good that limestone more or less closely *underlies* a coal bed.

Mr. White asserts, no doubt with correctness, that the Mercer *Lower* ‡ Limestone is the more persistent of the two, and therefore has selected it in all cases where, as on page 172, the question arose which of the two was present.

The Waverly fossil forms abounding in these limestones argue for the correctness of the old identification of the

* See pages 55, 127, 137 QQ.

† The heading "Sharon Group" on page 54 QQ is a misprint for "Mercer Group," not noticed until after the printing of the sheets.

‡ Wrongly printed "Upper" on page 60 QQ.

Mercer Group with No. XI, *Mauch Chunk Red Shale*, and its *Mountain Limestone*.

Mr. W. G. Platt's surveys, stretching from Blair county, through Cambria, Indiana and Armstrong counties, to the border of Butler, and his discovery of the same sandy limestone (of XI) in the Blairsville Gap, and on Redbank creek at the Jefferson—Clarion County line, would also identify the *Mercer Group* with No. XI, and confine the Pottsville Conglomerate No. XII entirely to the Homewood Sandstone, thus returning us after forty years to the classification of the First Survey. But I refrain from further discussion of this very difficult and doubtful point, until the connecting surveys through Jefferson, Clarion and Forest counties are finished.

The *Connoquenessing Upper and Lower Sandstones* are considered by Mr. White to represent the *Massillon Sandstone* of Ohio, split into two to receive the *Quakertown Group*. What are their single or double representatives in the more eastern and northern counties remains to be seen.

The *Quakertown Group*, consisting of a coal bed and iron bearing shales, inserted between the *Connoquenessing Sandrocks*, is justified by its exhibition in several places in this district; but its extension to other districts of Western Pennsylvania is a matter of doubt. Even here in Lawrence county, as at Wampum (page 66 QQ), and on Hickory creek (page 125 QQ), coal, ore and shale suddenly vanish, and nothing remains but huge unbroken cliffs of sand-rock (Upper and Lower combined) 90' to 100' thick.

The Mountain Limestone?—In Professor White's Report on Mercer county, QQ, now ready for the press, is announced and described his discovery of a missing member of the series on the Mahoning river, which must have an important bearing on our final classification of the rocks of Western Pennsylvania and Ohio according to the names which they have received in the middle and eastern parts of the State; and which has caused him to modify somewhat his views respecting the synchronism of the Sharon

group. I leave his discussion of the facts in their place in the Mercer county report.

A *thin siliceous fossiliferous limestone* was found by him in 1878 at Lowellville, O., on the Mahoning river, near the State line, in a mass of calcareous shales, 91' below the *Lower Limestone*, and 230' below the Lowellville (*Ferriferous*) limestone.

On the north side of the river at Lowell the 91' is increased to 120'.

Its place would then be *just above the Connoquenessing Lower Sandstone*, or at the bottom of the Quakertown group; or under the *Quakertown coal* if the coal were there.

It is quite fossiliferous; but none of its fossils were of types peculiarly subcarboniferous. Mr. Whitefield, to whom they were submitted, pronounced them good Coal measure species. But most of the species are the same as those found in the *Mountain Limestone* (Umbral, Mauch Chunk, XI,) in Fayette county.

Mr. White sees in this limestone the westward extension of the 40' limestone (of XI) found in the various gaps of the Chestnut ridge and described in Reports of Progress K², K³, and H⁴—just as Mr. W. G. Platt finds the same limestone exposed on the Red Bank creek in Jefferson county near the Clarion county line.

Mr. White would identify it also with the 25' limestone at 889' in the Boyd's Hill well at Pittsburgh (Report L, p. 227,) the chippings of which, now in Mr. Carll's care at Pleasantville have been tested with acid and found to be limestone; and, when examined out of the bottle, have the physical aspect of the Mountain Limestone.

I consider it unsafe to accept the identity of these deposits yet. We must wait a little longer, until the connections through Clarion, Jefferson and Forest counties are accomplished. Then, when the great semicircle commencing at Lock Haven, in Clinton county, and sweeping round by the Susquehanna, Allegheny, Beaver, Monongahela and Youghiogheny rivers into Virginia, has been traced at all points, with cross connections along the Connemaugh river, and Mahoning and Redstone creeks, binding the whole together,

—we will no doubt be in a case to say whether the three formations IX, X and XI, between the Chemung and Coal Conglomerate, extend into the State of Ohio or not.

For, if this new limestone be really the Mountain Limestone of the Allegheny Mountain, Laurel Ridge and Chestnut Hill, then the Sharon coal group sinks to the horizon of Mr. Ashburner's Pocono Coal group (in X); the red rocks of the Oil men become the representatives of the Catskill (IX), and the Oil Measures fall into the Chemung.

The *Sharon Group* is only hinted at in the report on Lawrence County, which makes the first part of this volume; becomes a prominent object in the second part; and is fully discussed in the forthcoming report on Mercer County, where its block coal is largely mined. Very little systematic importance was attached to it by the First Survey; but it is now recognized in Warren, McKean, Elk and Cameron counties, where it is sometimes workable.

The *Sharon Conglomerate* is but slightly touched upon in this volume, because it nowhere appears above water level, although it may be seen in the Oil Well sections Figs. 45* and 47*. The proper place to discuss it is in the report on Mercer County, for it rises above water level near Sharon, and has been traced by Mr. Carll westward into Ohio and by Mr. White eastward as far as Warren. It is undoubtedly part (or the whole) of the *Ohio Conglomerate*. But whether it be the base of—or whether it have anything whatever to do with—the *Pottsville Conglomerate* will be seen hereafter.*

* The reader of this volume must be on his guard against Mr. White's prepossession in favor of the assumption that the *Homewood, Connoquenessing and Sharon*, taken altogether, represent the great *Pottsville Conglomerate*, No. XII, a proposition derived from the fact that in West Virginia No. XII is 1200 feet thick and includes a whole coal measure system with a dozen coal beds. He therefore often speaks of this *Sharon (Ohio) Conglomerate* as the *base* of the *Conglomerate*, as for example on page 70; and again on page 196, where he argues against the assertion of geologists in Ohio that their No. 1 coal (*Sharon*) *overlies* the *Conglomerate*. Mr. White here merely means to say that the *main body* of the *Conglomerate*, No. XII, is always *over* the *Sharon*; and that in Pennsylvania the *Ohio Conglomerate* (*White's base* of

It seems to be the *Garland Conglomerate* of Warren County, the *Olean Conglomerate* of McKean county, and the top covering of many of the mountains in Potter county.

It seems also to be the *First*, and not the *Second*, *Mountain Sand* of Venango county.

The *Cuyahoga shales* of Ohio can as yet be only indefinitely identified in Pennsylvania, because corresponding shales with corresponding fossils† intervene 1. between the *Connoquenessing Lower Sandstone* and the *Sharon Conglomerate*,—2. between the *Sharon Conglomerate* and the *Shenango* (ferriferous, fish-bed) *Sandstone* next below it,—3. between the *Shenango Sandstone* and the *3d Mountain Sand* lying still lower in the Series.

The *Shenango Sandstone*, thanks to Mr. White, is a new apparition in our series, and one whose value grows with every step of our survey; as the reports on Mercer, Crawford, Venango, Warren and McKean counties will testify.

It is massive and coarse, and distinguished by multitudes

XII) sometimes fines away and vanishes, leaving the Sharon Coal *wholly beneath the Conglomerate*. That this disappearance is not general is evident from an inspection of the Well records at Beaver Falls and elsewhere. See what he says on page 68, ¶ 4; page 95, Fig. 21; 113, Fig. 28; page 124, ¶ 5; &c.

This prepossession entirely disappears in Mr. White's Report QQQ on Mercer county, in which he withdraws all opinions based upon it expressed in this Report QQ on Lawrence county, and expresses his conviction that the *Mountain Limestone* which he afterwards discovered (as described in the text above pp. xxxii, xxxiii) settles the question, that the *Pottsville Conglomerate*, No. XII, must be confined to the *Homewood Sandstone*, or at the most to the *Homewood* + the *Upper Connoquenessing Sandstones*.

If the Mercer group can be regarded as representing the upper part of the Umbral (*Mauch Chunk*, No. XI) formation then the *Homewood Sandstone* is all that is left to represent the *Pottsville Conglomerate*, No. XII.

† This matter of Cuyahoga fossils up to the very base of the Connoquenessing Lower Sandstone (see page 68, ¶ 4) is not an easy one to handle. No general systematic conclusions can be based on such phenomena. Fossils afford very little assistance in such a case; for it is evident that the animal life would continue unchanged in any given locality so long as the sediments at that part of the general water basin continued to be of the same character. The Cuyahoga mollusca must necessarily be expected to survive in the Sharon shales wherever there was no irruption of the gravel deposits of the Ohio Conglomerate to cover them up and put an end to their propagation *in loco*; but the time of the Sharon shale deposit was too short to allow of immigration after destruction.

of ore balls and by remains of fish. Mr. White thinks he finds this rock in the Wallace well, Wayne township (Fig. 21, page 95), 47' beneath the 50' white sandstone which he considers to be the Sharon Conglomerate. Whether this be so or not, he has experienced no difficulty in tracing the outcrop of this rock in the counties to the north, and it becomes an important key to the identification of the Sandstones and Conglomerates above and below it.

The *Meadville Upper and Lower Limestones* are another important more recent contribution made by Mr. White to our list of key rocks. They are not mentioned in this volume, not being detected in the Lawrence county wells. In fact they were not looked for, for they were not known to extend beyond the vicinity of Meadville until Mr. White's survey this summer (1879) extended their area over Crawford county, (40 miles long by 20 wide,) and detected their existence at Jamestown in Mercer, and at Tidioute below Warren on the Allegheny river, where the *lower limestone* may be seen 130' beneath the *Shenango Sandstone*. At Meadville they lie about 50' and 150' beneath it.

Respecting the Third Mountain Sand, and Oil Sands struck in the Lawrence county wells, it is wisest to say nothing at present; and any indications of a fixed opinion respecting these which the reader may light upon in this volume should be permitted to carry little weight until more is known about them.

J. P. LESLEY.

1008 Clinton Street,
Philadelphia, Aug. 5, 1879.

PART I.
SURFACE GEOLOGY OF LAWRENCE COUNTY.

CHAPTER I.

General Description of the County.

Lawrence County lies on the Ohio State line, next north of Beaver County, and is bounded on the east by Butler County, and on the north by Mercer.

In shape it is nearly square, the western boundary being a portion of the State line, and therefore originally run on a meridian of $3^{\circ}.03'$ West from Washington, is in length 20 miles.

Its southern line, east and west, passing through the mouth of Connoquenessing creek, measures about $18\frac{3}{4}$ miles to the Butler county line.

Its eastern border runs north along the Butler county line $9\frac{1}{2}$ miles to a corner; thence N. 45° E. $6\frac{1}{2}$ miles still along the Butler county line; thence about N. 40° W. $4\frac{1}{4}$ miles along the Mercer county line.

The northern border runs $5\frac{1}{2}$ miles west to the Neshannock creek a mile north of Volant post office; thence north, $\frac{3}{4}$ of a mile; thence west $13\frac{1}{2}$ miles to the Ohio state line.

The area of Lawrence county is given in Gray & Walling's Atlas as 358 square miles, or 229,120 acres, sustaining a population in 1860 of 22,999, and in 1870 of 27,298.

New Castle, its county seat, was laid out in 1800, and Lawrence county itself was set off from Beaver and Mercer March 25th, 1850.

It is subdivided into 17 townships, arranged somewhat as follows:

Pulaski		Wilmington	Washington	Plain Grove
	Neshannock			
Mahoning		Hickory	Scott	
	Union			
North Beaver,	Taylor,	Shenango,	Slippery Rock	
Little Beaver,	Big Beaver,	Wayne,	Perry	

Surface Features.

The surface of the county is greatly diversified, but, like that of Beaver to the south, it may be described as broken and hilly.

Along the Beaver, and its main branches, we sometimes find broad level areas formed by the Terraces, but very frequently these have been eroded, or the channels have been cut down through the massive rocks of No. XII, and are therefore too narrow to furnish room for anything except the river beds.

The southern part of the county is much more rugged and broken than the northern; the hills being higher and their slopes steeper.

This marked difference in the contour of the northern and southern halves of the county was observed to be immediately connected with the distribution of the *Drift*, or rather the southern line of the Drift was seen to form roughly the dividing zone between the two portions which exhibit such diverse surface features. Hence, the explanation was easy; the ice-sheet, which moved southward, during the Glacial epoch, cut off and plowed down all the northern area of the county pretty much to the same level, and consequently we find wide level areas on the summits of the hills, which subsequent erosion has very little changed, and the streams that have since been flowing through these areas have not yet cut very deep channels. South of the Glacial area no such planing down and leveling off of the pre-Glacial hills took place, and we consequently find the streams flowing in deep and narrow valleys with long and often steep slopes, leading up to the summits of the ridges, which, instead of forming broad level areas like those at the north, are merely narrow "Hog-back" divides, separating the sources of different streams, and not infrequently rising in solitary conical peaks, as monuments of the long continued erosion to which the region has been subjected.

Notwithstanding the abrupt and precipitous character of the surface along many of the streams, yet, when we pass up toward their sources until their beds have risen above

the massive rocks of No. XII, we find their slopes quite gentle and capable of easy cultivation, so that a large portion of the county consists of arable land.

The influence of a massive rock in modifying topography is finely illustrated in passing along the Big Beaver from New Castle to Homewood. For 10 miles below New Castle the rocks of No. XII are quite variable in composition, being not at all massive, and we consequently find the surface along either bank very broken, and the little streams, putting into the same, have eroded their channels down to the level of the river for a long distance back from the same, but, after passing Wampum, a great change takes place in the character of the underlying rock and a consequent change in topography. The upper member of No. XII, which has hitherto been thin and shaly now develops into a solid massive stratum 100 to 150 feet thick, whose top forms a wide and often level plain 200 to 250 feet above the level of the stream, extending back, in some cases, on the west side, more than a mile from the channel. This extensive plain, doubtless, at an ancient period in the valley's history, formed the bed of the Beaver, from which it gradually receded to find a more yielding passage through these massive rocks in the channel which it now occupies.

Drainage.

The county is drained almost entirely by the Big Beaver and its tributaries, and these are, beginning at the south: Connoquenessing Creek, Mahoning River, and Shenango Creek.

The Connoquenessing puts into the Big Beaver from the east at the southern margin of the county, and of itself drains a very insignificant portion of the area we are considering, but its main tributary, the Slippery Rock, flows along and drains the entire eastern border of the county.

This stream rises in the highlands of northern Butler and enters Lawrence in its north-eastern corner. It is there a comparatively sluggish stream, flowing between low and gently sloping banks of the Productive Coal Measure rocks, with wide plains bordering it on either side. But,

as we follow down its course to the south-west, it soon cuts down into No. XII, and then a great change takes place in the character of the stream and its surrounding topography. The broad valley suddenly contracts to a narrow gorge, the low and sloping banks are replaced with high and almost vertical cliffs of massive rock, while the hitherto gently flowing stream becomes a rapid torrent, dashing along amid monster blocks of sandstone, which fill up its channel and impede its course. The average fall of this stream from Kennedy's upper mill to its mouth, is not far from 30 feet per mile, while, for short distances, it often rushes down at double this rate.

The scenery along its banks is most varied and enchanting, often rivaling that of the mountains in its wildness and grandeur.

Its only tributary of any importance is Muddy creek, which enters it on the east from Butler county. The strange spectacle seen at the mouth of Slippery Rock, where it flows full into the face of the Connoquenessing, has been described by Prof. Lesley in Wrigley's Report on Oil.

As we pass up the Beaver from the mouth of the Connoquenessing, we find nothing but small streams entering it on either side, which rise on the highlands three to four miles back from the river, and pass down with a rapid fall. But almost ten miles above, we come to the junction of the Mahoning with the Shenango, which two streams form the Big Beaver.

The Mahoning is the larger and enters the county from Ohio on the west, where it drains a large area. It has a moderate fall and carries a considerable volume of water, but receives no tributaries of any consequence within the county, except Hickory creek.

The Shenango comes in from Mercer county on the north, and flows a little east of south until it unites with the Mahoning, after flowing almost parallel with it for several miles, and separated from it by only a broad high ridge, 1 to 3 miles across. Where this stream meets the Mahoning, a wide valley has been excavated out of the Conglomerate Series, and, at many places, it is $1\frac{1}{2}$ to 2 miles broad.

The Shenango also carries a considerable volume of water, but its bed, lying mostly in the Cuyahoga shale, it is consequently not a rapid stream. The old Erie and Beaver canal passed along this creek.

Its only tributary of any importance is Neshannock creek, which puts into it on the east at New Castle. This stream resembles the Slippery Rock in many respects, since it flows in the Conglomerate for nearly its entire length, and is consequently a bold and rapid stream. It enters the county from Mercer in two branches, called, respectively, Little and Big Neshannock. They soon unite, however, and then the course of the creek is a little west of south until it enters the Shenango.

Neshannock Falls, a short distance above the mouth of the Little creek is a wild and romantic place much visited by pleasure parties. The fall is formed by a ledge of No. XII.

Big run is a considerable little stream which enters the Neshannock below New Castle. Throughout the upper half of its course it is a very sluggish stream. It flows in an old eroded valley between the Slippery Rock and Shenango, and the "divide," at its head, is so low that it can with difficulty be made out where the drainage starts the other way into the Slippery Rock. It is possible, that, in pre-glacial times, this valley was occupied by the Slippery Rock itself, which then had its mouth not far from New Castle; but the Drift having closed up the old channel, it found an outlet at a lower level by way of the Connoquenesing. This old valley may have been scooped out by glacial action however. About two miles from the Shenango, Big run cuts down to No. XII, over which it tumbles in a series of falls descending 250 feet before it enters the former stream.

A small area in the south-west corner of the county is drained by the head waters of the Little Beaver.

Soils.

The soils of the district may be divided into two classes; those derived from the decomposition of the native Coal

measure rocks, and those derived from the Drift. The latter in accordance with the distribution of the Drift is found as the principal soil over all the northern half of the county, while the former constitutes the soil of the southern portion.

The Drift has vast numbers of small limestone boulders scattered through it, which have been brought from the far north, where the Devonian and Silurian limestones come to the surface.

There is also a large amount of felspar in the boulders of gneiss and granite, which are so plentifully distributed through the Drift, and the decomposition of this, together with the limestone and other material, forms a very strong and rich soil, on which most excellent crops of wheat, corn, oats and grass can be grown.

The soil, which is derived from the Coal measure rocks, while not so rich as that from the Drift, is yet very good, since it is supplied with plenty of lime from the great Ferriferous bed, which comes far up in the hills, and is often 20 to 25 feet thick.

But while the husbandman is thus furnished with a productive soil originally, in nearly every case, yet, from failing to take the proper care of the same, much of the farming land of the county has become comparatively poor. It seems that farmers will have to have "line upon line and precept upon precept" before they can be induced to try the use of lime upon their soils, as a fertilizer. While a few of the more intelligent farmers of Lawrence have learned this important lesson in agriculture, the great majority make no use of lime whatever in their farming operations. There having been so much lime in the original soil, the supply was, of course, kept up for a long time; but the annual extraction of crops has, at last, almost entirely exhausted this essential element of the soil, and the farmers grumble about the decreasing yield of their wheat crops, without even attempting to find, or apply the remedy, when it is pointed out to them.

Nor can it be pled in excuse here, as was often done in Beaver and North Allegheny, that the limestone is inacces-

sible ; for the great Ferriferous bed spreads over a large portion of the county, and when it is absent, the Mercer and Mahoning are almost invariably present, so that there are only a few farms in the county on which plenty of limestone cannot be easily obtained, as also the coal with which to burn it.

CHAPTER II.

Surface Geology of Lawrence County.

Drift.

The great sheet of ice which moved southwards during the time known to geologists as the Glacial Period, has left many traces of its presence in Lawrence county ; for, covering the tops of some of the highest elevations, we find a continuous bed of Drift. It consists of rounded and angular bowlders of granite, gneiss and other crystalline rocks, together with fragments of limestone, sandstone, &c., imbedded in a matrix of clay, fine sand, mud, or gravel, the whole mass often attaining a thickness of 40 to 60 feet on the hill-tops where the eroding agencies have been least active.

The exact southward limit, reached by the ice, is rather difficult to fix, since, so far as we have been able to trace it out, this limit was greatly modified by the topography and other causes, so that, instead of reaching south to a certain uniform parallel, its southern margin formed a very sinuous line, stretching down the valleys in long finger-like projections, and bending backward around the ridges with a constantly northward trend when followed to the east.

In the valleys of the Big Beaver we find evidence almost incontestible that it extended at least to the village of Wampum, only four miles north from the Beaver county line ; for there, at an elevation of 275 feet above the level of the river, we find a layer of Drift 30 feet thick exposed at one of the limestone quarries. It may be said, however, that this is only the remnant of a terrace deposit which once filled the valley, and is merely the result of that secondary transportation and re-arrangement of the true Gla-

cial drift which occurred during the Champlain period, but, if this view were true, it must have extended down the Beaver at this horizon to its mouth, and been continuous with the other terraces below. I have shown in "Q" that not a single trace of the Drift material is found in the Beaver Valley above the third or 125 foot Terrace from the northern line of Beaver county to the Ohio river; and it would be asking rather too much of our credulity to believe that erosion could have so destroyed this upper and most extensive terrace of all as not to have left a single metamorphic boulder above the 125 foot level from Wampum to the Ohio, a distance of 18 miles; so that the proof may be regarded as positive that at least one great tongue of the ice reached nearly to the southern boundary of Lawrence, and, as we shall hereafter show, very probably extended in an ice stream down the Beaver to its mouth.

As previously stated, the drift extends further to the south along the western line of the county than along its eastern or middle portions, since, east from the Beaver valley, we find no traces of it more than three miles south from New Castle. This irregularity of distribution may have been due in part to the topography, but it is not improbable that the real reason will be found in the fact that the ice came from a direction to the west of north, since the nearest point (Sharon) at which scratches have been observed confirms the south-eastward tendency of the movement.

In the vicinity of Mt. Jackson, at an elevation of 400 feet above the Mahoning river, wells have been sunk 40 feet in the Drift without reaching its bottom. The material is there an alternation of layers of gravel, sand, clay, bowlders and fine mud. Whenever a "mud vein" was found in digging the wells, they would have to be abandoned, since nothing could stop its perpetual oozing out into the water. There is nothing like regularity in the layers, however, since another hole, put down only a rod-away, would probably find no "mud veins."

On Slippery Rock creek the Drift seems not to have passed further south than Kennedy's upper mill, and a line drawn from this point to the mouth of Big run on the

Shenango would correspond quite closely with its southern limit over the eastern half of the county.

Erratic Boulders.

Besides the Glacial Drift proper, we find another class of metamorphic bowlders of greater size scattered over a large part of the county. These "*erratics*" belong to the same class with those which we have described in Report of Progress "Q," as being found over a large part of western Beaver. While studying their distribution in Lawrence I have been constantly on the lookout to see if I could discover any connection that they might have with the true Glacial drift by which their transportation could be referred to the same general cause, but, thus far, I have not succeeded in finding any such relation; for, in every case, these larger bowlders are found resting on top of the Drift proper, and have never been seen commingled with it. True this is mostly negative evidence, since sections exposing the constitution of the Drift for any considerable extent are so rare that the bowlders in question might really belong with the true Drift, and yet be absent from it at the few localities open to examination. There are some facts connected with their distribution that could be accounted for much more satisfactorily if it should eventually turn out that they were transported by the ice which brought the Drift; but, until this can be shown by indisputable evidence, we shall have to accept the theory of Dr. Newberry, which makes their transportation due to icebergs, which subsequent to the Glacial period, and during a time of continental submergence, floated over from the Canadian Highlands, and melting in the warmer waters to the south, dropped their imbedded rocks upon the present surface.

They are of all sizes from 1 to 6 feet in diameter, and are often grouped in colonies like a huge flock of sheep. Many of them have a rounded, polished or water-worn appearance. A short distance above New Castle, along the Neshannock, they are seen commingled with the Champlain deposits in the third terrace. This fact taken in connection with the circumstance that they occur much

further to the south than the Drift is known to extend, may be considered as definitely settling the question that they were transported from the north by icebergs during the Champlain submergence.

Terraces.

Terraces exist along all the principal streams in Lawrence, but they are most marked on the Beaver, and its continuation the Shenango.

These deposits are best preserved at the junction of streams; for there the valley is broadest, and the terraces have suffered least from erosion, or rather the terraces were there most extensive, and erosion has not yet removed them.

At New Castle, where the Shenango and Neshannock unite, the terraces are very finely exposed and occur at the following elevations above water level:

Top of Third Terrace above the Shenango,	. . .	125'
“ Second “ “	. . .	60'—80'
“ First “ “	. . .	10'—30'

It will thus be seen that we have the same succession of terraces here that we get at the mouth of the Beaver, along the Ohio, and which have been described in “Q.”

The *First Terrace* is the one on which New Castle is principally built, and it has suffered much from erosion, since along the stream it rises only 10 feet above the same, but, as we pass back, it gradually slopes up and attains an elevation of 20 to 30 feet. The material composing it consists of sand, small metamorphic cobble-stones, clay, sandstone and limestone boulders, all polished and rounded. The Reis, Brown & Bergher deep well commenced on this terrace 10 feet above water-level, and passed through 145 feet of the same material before reaching any rock *stratum*. This same terrace constitutes the broad and level bottoms between New Castle and Mahoningtown, the Fair Grounds being situated on it, as well as Mahoningtown.

Up the Mahoning river it extends in a wide, level plain first on one side of the stream and then on the other, being more than a mile broad in the vicinity of Edenburg.

Along the Big Beaver, the same terrace is almost universally present, except where the channel is so narrow that the stream occupies the entire valley. It is distinguished from the other terraces by the fineness of its material, which may possibly be due to the fact that the material has been worked over and re-handled several times, since it constitutes the flood plain of the streams.

The *Second Terrace* has suffered greatly from erosion and is consequently seldom seen. It is distinctly traceable, however, at New Castle, especially on the west side of the Shenango, where it forms the sites for many buildings. It is also seen along the Mahoning river on its left bank, a short distance above Mahoningtown. Along the Big Beaver this terrace has suffered so much from erosion, as scarcely ever to be recognizable, there being a gradual slope from the top of the Third Terrace down to the First. The only place where its constitution may be seen is above Mahoningtown, and there it consists of rounded bowlders varying in diameter from 1 to 6 inches, very numerous and lying in a matrix of coarse sand with sometimes a little clay intermixed. On the Slippery Rock above Wurtemberg, at the bridge, a fine terrace is seen at 60 feet above the stream which very possibly corresponds with this one. Metamorphic bowlders and gravel also occur with it there.

The *Third Terrace* has a wide extent in the vicinity of New Castle, and it has there been quarried away extensively for cobble stones, and in grading the roads, so that its constitution can be very conveniently observed. Near Mr. Patterson's, where it has been extensively dug away in grading, we see the following, commencing with its top :

- | | |
|--|-----|
| 1. Soil, | 4' |
| 2. A mixture of coarse and fine sand, often stratified, as though deposited in water, together with rounded and angular bowlders of granite, gneiss, sandstone, limestone, and also fragments of coal, | 30' |
| 3. Clay, | 2' |
| 4. Bowlders, gravel, sand, &c., | 10' |

The rounded bowlders are generally small, varying from 2 to 6 inches in diameter, but the angular ones are quite large, some being as much as 2 feet in diameter. They are

quite rare here, however, and only a few were seen that had been dug out of the terrace deposit. About one mile above New Castle a deep cutting on the New Castle and Franklin R. R., makes a fine exposure of this terrace, and there we see many large granite boulders in these deposits, some of them being 3 to 4 feet in diameter. These boulders belong to the same class as the "erratics" which we find scattered over the surface in Lawrence and Beaver counties, and we here get a possible clue to the age of their transportation.

Croton, two miles above New Castle, is built on this Third terrace, and it is also frequently seen along the Big Beaver, though like the Second below, it has there often suffered much from erosion.

This terrace marks the upper limit to which the old valley was re-filled during the Champlain, and thus confirms the conclusion reached when studying these deposits along the Ohio, and lower part of the Big Beaver in '76. Along the lower portion of the Beaver, in this county, we get a broad, level bench at 160 to 180 feet above the stream, but it is vastly older and has nothing to do with the terraces that we have been describing, as it merely marks a stage of the valley in the original cutting down and corresponds to the 4th terrace at New Brighton, which always has a rock escarpment, while the escarpments of those below always consist of the deposits themselves, and then no drift material is ever seen on this one, except the erratic boulders.

Buried River Channels.

The Big Beaver and its two important tributaries, the Mahoning and the Shenango are now flowing over beds of gravel, sand and detritus which extend down 150 to 200 feet below their present channels. This fact has been revealed by the numerous borings which have been made for oil and other purposes along these streams. At New Castle, in the deep boring of Reis, Brown & Bergher, no rock was found for 135 feet below the level of the Shenango, but the drive pipe passed through nothing but loose

material of various composition. The hole was bored east from the centre of the old channel or the depth to the bottom of the filled up valley would probably have been much greater.

Along the Mahoning River, numerous holes were bored for oil, and, when the wells were situated near the middle of the buried valley, pipes had to be driven down 175 to 200 feet before the rock was reached, and these figures may be taken as the depth to which the old channels extended below the present ones.

In Report of Progress "Q," I have given some facts with regard to the water channels buried and otherwise, which it will be interesting to have repeated in this connection, in order to have all the facts before us. On pages 14-17 "Q" we read: "The Ohio river flows around this district on a bed of bowlders and detritus which extends to an unknown depth, as no explorations have ever reached its bottom. The piers of the railroad bridge across the Big Beaver near its mouth are built in the old channel of the Ohio, and no rock foundation could be found for them at a depth of sixty feet below its present surface. No data have yet been obtained which can settle definitely the depth to which this buried channel extends, but from what is known of the ancient bed of the Big Beaver, the Ohio must once have flowed considerably over 100 feet below its present level, and possibly more than 200 feet below it. At least this is true of that portion of it below the mouth of the Big Beaver.

To one hastily passing up the Big Beaver, it would seem that this stream could never have flowed at a lower level than we find it now; for in the vicinity of New Brighton and Beaver Falls, a massive sandstone is seen stretching across its bed from bank to bank in such a manner that there would appear to be no place for a buried channel. This in view of known facts was quite puzzling to myself until I had obtained the data which put me on the track of its ancient bed. I discovered that about seven miles above its mouth this stream leaves its ancient channel far to the right, and coincides with it again for only a short distance

between this point and the Ohio River. Between New Brighton and Beaver Falls, the present channel passes almost at a right angle across the buried one. This old channel is much straiter than the present one, and as traced out by means of well borings, and other explorations it passes approximately along the following line :

It leaves the present channel two miles above Beaver Falls, a short distance above the Paper Mill, and keeping to the right passes down through the borough along the present valley of Walnut Bottom Run. The Beaver Falls Cutlery Works are situated near its centre. Passing out of Beaver Falls, it crosses the present channel of the Beaver, a short distance above the railroad bridge, and goes down through New Brighton near the centre of the Second Terrace, and coming over close to the present channel, enters it at the lower end of the town near the mouth of Block House Run. From this point the two channels coincide for some distance, but about one mile above the mouth of the Beaver, the old channel again veers off to the right through Bridgewater and Beaver, and passes into the Ohio somewhere between Vanport and Beaver Station. To what depth this old river bed extends has never been determined. However, we know it was more than 100 feet below the present bed of the Beaver; for, in building the cutlery works, no rock foundation could be found at a reasonable depth, and to test the matter an iron rod was driven down which still found no rock at a depth of 100 feet below the level of the Beaver.

In this same old channel, a short distance south-west from the paper-mill, Mr. Ramsey informed me, that from the bottom of a well 35 feet deep, he drove a pipe 50 feet through quick-sand and gravel, without coming to any rock.

At the woolen mills, in New Brighton, this old channel seems to pass along the very edge of the present one; for Mr. Coale informs me that here, on the left bank of the Beaver, he drove a pipe fifty feet below its level without finding any solid rock. It is very probable that in Beaver county the filled up channel extends down 200 feet below

the present channel of the Beaver; for, according to Dr. Newberry, the oil wells bored at the junction of the Mahoning and Shenango found no rock for 150 feet below their present beds.

To what *agent* then shall we ascribe the *erosion* of these now deeply buried channels along the Big Beaver and Ohio? I have spoken of them as though it had been done by the rivers themselves during a period of continental elevation, since this is the commonly accepted theory. But a class of facts was observed in this district for which the above theory fails satisfactorily to account.

It was observed that all the tributaries, both large and small, which enter the Big Beaver and Ohio within this district are now flowing over rock bottoms within a few rods of their mouths.

A short distance above the mouth of the Little Beaver, a massive sandstone is seen stretching clear across its bed, while a rocky escarpment, rising on either side to the summit of the hills, absolutely precludes the possibility of a buried channel. Of course, it is incredible that a stream carrying so much water as the Little Beaver could have flowed to within a few rods of the Ohio on a bed 200 feet above that of the latter stream.

At the mouth of Raccoon, a large stream which enters the Ohio from the south, there is a rock bottom, with vertical cliffs rising on either side, so that there is no place for an old channel.

On the Connoquenessing, which enters the Big Beaver near the northern line of the district, we see it flowing on a rocky bed only one fourth of a mile above its mouth, where it is hemmed in by cañon-like walls of the conglomerate which rise from the bed of the stream, and likewise exclude all possibility of a buried channel. The numberless smaller streams, many of which are of considerable size, all tell the same story.

It is simply inconceivable that all these tributaries could ever have emptied into rivers which flowed 200 feet below their mouths, without, at the same time, cutting down their own channels to near the same level. The topography

along these rivers also shows that their tributaries could never have occupied any other channels than those in which they are now flowing.

We must then accept one of two conclusions: either the drainage lines which are now occupied by these tributaries had no existence during the long period in which the Big Beaver and the Ohio were excavating their now deeply buried channels, or else their excavation was not done by water, but by streams of ice, which came down their valleys from the north during the Glacial Period, grinding down and ploughing up their channels far deeper than the rivers themselves ever flowed. The reader can take whichever horn of the dilemma he chooses."

Since the above was written many new facts and data have been obtained, which go to confirm the theory there hinted at that those buried valleys were excavated not by running water, but by streams of ice which projected southward through the valleys from the continuous sheet at the north. Not the least important of these facts are those that throw serious doubt on the statement which we have quoted from "Q," as giving a great depth to the buried valley of the Ohio. This conclusion as expressed in "Q" that the old bed of the Ohio probably extended to a depth of 200 feet below its present channel was not sustained by any positive evidence, but only followed as a necessary consequence, if the old channel of its tributary, the Big Beaver, had been excavated by running water during a period of continental elevation. But during the past season we have obtained some positive evidence that the Ohio channel is not so deeply buried as supposed.

About one mile above Smith's Ferry, is a long, narrow island in the midst of the present water-course. Its escarpments are composed of silt and detritus, and, at no point, does it reveal any rock structure above the level of the stream, though its head and sides are constantly washed by the floods.

On one extremity of this island an oil well was once sunk to a depth of 1100 feet, and I learned from a Mr. Allen who worked at the well, that only 45' of drive pipe was used

when solid rock was struck. The island is a remnant of the First Terrace which usually has a height of 30 feet, so that here the bottom of the old channel is only 15 feet below the present level of the Ohio.

Of course it may be said that this island may have always been there, but the boring shows that this could not have been the case; for its rock bottom was not reached until the pipe had passed 15 feet below the present level of the stream.

Near Steubenville the Upper Freeport coal has been mined clear across the present channel at a depth of only 175 feet below the level of the same, and forming the roof of the coal is a very massive sandstone which must extend up for several feet, so that the old channel cannot here be more than 125 feet deep at its maximum.

The same class of facts noted last year concerning the rock bottoms of the Little Beaver, Raccoon, Connoquenesing and other tributaries of the Big Beaver and Ohio and quoted from "Q" into these pages, has been observed with regard to all the affluents of the Mahoning and Shenango.

Hickory creek, a large stream which puts into the Mahoning, a short distance above the latter's mouth, is found flowing over the soft shales of the Cyahoga, only a short distance above its mouth, while immense cliffs of No. XII rise almost perpendicularly on either side.

The Neshannock carries nearly as much water as the Shenango, and, where it empties into the latter stream the old filled up valley is nearly 200 feet deep; yet one mile above its mouth we find it flowing on the soft rocks of the Waverly, hemmed in by vast ledges of No. XII which rise 200 feet above its bed.

The topography of the country, as well as an unbroken line of rock outcrops, along these old valleys, show us that there can be no old filled up channels which these tributaries could ever have occupied, but on the contrary everything goes to prove that the channels, which they now occupy, they have always occupied ever since the present configuration of the surface was outlined.

The detection of the path of ancient water-courses is

quite an easy matter in a region of such high hills and irregular surfaces as the one under consideration, and it is not possible that any such could lead into the streams in question and have escaped our observation.

That great changes in the direction of water-courses have taken place, since the channeling of the surface was begun, cannot be doubted; in fact we have strong evidence that the Slippery Rock once emptied into the Shenango, a short distance below New Castle near the present mouth of Big Run; for, as we go up this latter stream towards Slippery Rock, we find ourselves in an old Drift-filled valley which continues on without scarcely any appreciable "divide" across to the Slippery Rock valley at Kennedy's upper mill, while both north and south the hills rise 150 to 200 feet above, so that either the creek once flowed along this line and excavated the valley in the distant past, or else a glacial stream came down Slippery Rock and was by some means diverted across to the Beaver Valley.

If the excavation was accomplished by the creek, it ceased to flow in this channel, however, when its bed was yet 200 feet above the present level of the Shenango; for we see a constant line of outcropping strata at that elevation all along the Beaver and Shenango valleys. Thus while we do not claim that there have been no changes in the water-ways, we do assert that where such changes have taken place in a country so broken as Lawrence and Beaver records must be left which will lead to their detection.

Agent of Erosion.

What then was the agent which excavated these now deeply buried valleys of the Beaver River System?

The evidence in the case may be briefly recapitulated. We have shown that all the tributary streams, both large and small, which debouch into these buried valleys, are now flowing on rock bottoms up to within a short distance of their mouths, and that they could never have flowed at a lower level through channels which are now buried or concealed.

We have also seen that all the attainable evidence points

to a very shallow depth for the buried valley of the Ohio, and that it cannot possibly have a maximum depth of more than 125 feet, while its tributary, the Beaver, has, even in the upper part of its course, an eroded channel extending down 200 feet below its bed.

We have proven in the chapter on Drift that a Glacial stream unquestionably extended down the Beaver valley to Wampum, only 18 miles north from the Ohio river.

If we take any of the southern tributaries of the Ohio, such as the Monongahela, which, by the way, drains a far larger area and carries a much larger volume of water than the Beaver, we soon find it flowing over a rock bottom; for, when we pass above McKeesport, the rock bottom is seen at numerous places between that and the Virginia line, while at the new Government Lock, that has lately been built 8 miles below Morgantown, a solid rock foundation was found for the dam clear across the river, which is there bordered by almost perpendicular walls of the out-cropping Barren Coal strata, so that no buried channel can be present.

This state of affairs is in strange contrast to what we find in going up the Big Beaver an equal distance from its mouth; for there, on the Mahoning, we find an old channel extending down 200 feet below the present one.

The different character of the strata through which each river has carved its passage will not explain it; for, had that been the cause, the Monongahela valley should have been the deeper, since it is cut out of the Lower Barrens, a much more yielding series of rocks than the Great Conglomerate through which the Beaver system has been compelled to flow. This fact of the rock-bottom of the Monongahela also goes to confirm the shallow depth of the Ohio's buried valley; since, if it be said that the latter channel has indeed been eroded to the depth of 200 feet below its present level, then we should have a fall of 250' in the old channel, from McKeesport to Rochester, which is of itself sufficient evidence that the Ohio cannot have a channel so deeply filled.

We are driven then to the conclusion that the buried

valleys of the Beaver system were excavated by Glacial action, and that the rivers themselves have never flowed at a much lower level than we now find them ; for in no other way can we reconcile the facts which present themselves to us for explanation.

This Glacial stream very probably extended in a long finger-like projection down the Big Beaver to a short distance beyond its mouth, where its advance was checked, and melting left the vast amount of moraine material which we now see in the terraces along the Ohio at Rochester and Beaver. This theory, it will be seen, fully explains the otherwise inexplicable fact, that the tributaries which flow into the Beaver system all have channels so much above the bottom of the buried ones, and also the equally puzzling fact that a tributary stream like the Beaver should have a buried channel so much deeper than the Ohio into which it debouches.

It has been contended by some that Glacial action has no power to erode such channels, but here geologists differ widely in opinion ; for so eminent an authority as Dr. Newberry maintains that even the enormous basins of our Great Lakes were excavated entirely by such action.

While, therefore, we cannot claim that the Glacial theory for the buried valley erosion has been proven absolutely, yet the difficulties in the way of any other supposition are so great, and the facts that can be explained by any other so few, that we are compelled to accept the *ice* theory of erosion as against the *water* theory.

PART II.
SYSTEMATIC GEOLOGY OF LAWRENCE COUNTY.

CHAPTER III.

The rocks found in Lawrence county belong exclusively to the Coal measure, and Sub-carboniferous formations; the highest rocks exposed being those at the base of the Lower Barren measures, while the lowest lie about 50 feet below the Pottsville Conglomerate, No. XII.

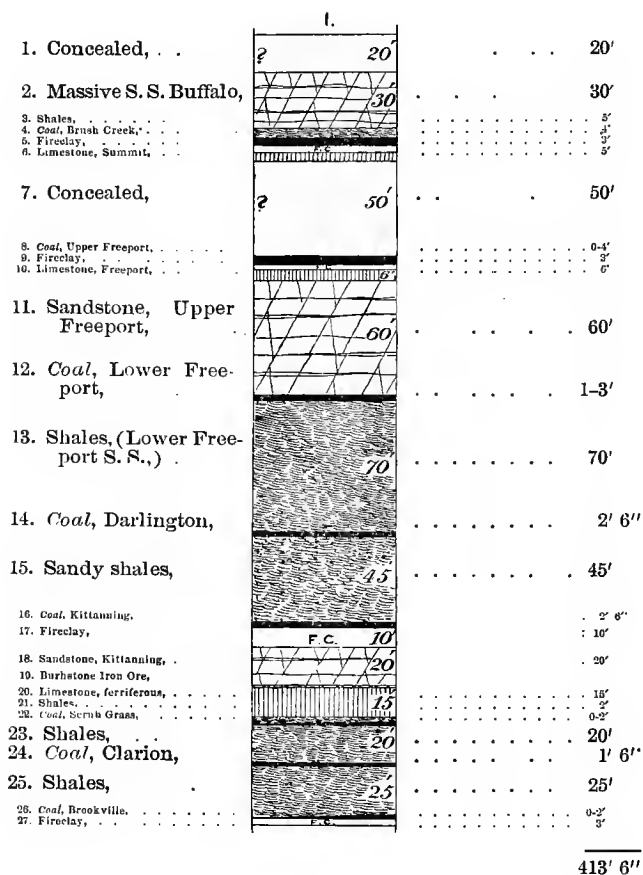
Structure. Absence of Folds.

The forces whose operation uplifted and threw into vast folds the strata to the south-east along the Alleghenies, seem to have expended their activity before reaching Lawrence; for there is an entire absence of any definitely marked Axes, and the strata rise uniformly to the north-east, though the rise is much more rapid to the north than to the east.

This upward thrust of the rocks, as is well known, continues on north from the area we are considering, to the lakes and beyond. The explanation of this continuous southward dip is doubtless to be found in the great downward bending or geosynclinal movement which was taking place throughout the Appalachian region to the south, all through Palæozoic time. It is possible that a portion of this tilt may be due to the Appalachian revolution, but how it could have produced such an effect does not clearly appear.

The rise of the strata to the north is seldom more than 15 feet to the mile in Lawrence, and often not more than 10, but, of course, there are the usual local dips which are sometimes much steeper and occasionally reversed.

Fig. 1. Generalized Section of the Lower Productive Coal measures of Lawrence county, with a part of the overlying Barren measures.



CHAPTER IV.

Generalized section of the Lower Productive Coal measures of Lawrence, including the base of the Lower Barren measures.

The following section typifies, in a general way, the succession of the Lower Productive Coal Measures in Lawrence. It has been constructed from several widely separated exposures, since there is no single locality where the whole column is to be seen. See figure 1.

Lower Barren Series.

The only members of this series of coal rocks that occur in Lawrence are those included in Nos. 1 to 7 of the preceding section, the gradual northward rise of the strata having carried the most of this series far above the tops of the highest remaining hills. They are confined to a few isolated areas along the southern border of the county and cap the summits of some very lofty hills.

Buffalo Sandstone.

The highest exposed member of these rocks is what we have termed in "Q" the Buffalo Sandstone, from its great development along Buffalo Creek in Butler county.

In Lawrence it is confined exclusively to the lofty ridges of Perry township which occupies the south-east corner of the county. There it is seen making sharp and very steep bluffs, or scattered over the ground in ponderous masses. It is in many places a typical conglomerate, being a mere aggregation of quartz pebbles which vary in size from a pea to a hickory and nut. This characteristic is by no means persistent, however. Near Mr. Miller's, a well was put down through it for 25 feet, and in all the débris brought up from the hole I could not find a single pebble, but it was there a very hard and coarse brownish sandstone.

Brush Creek Coal.

Separated from the preceding rock by only a few feet of shale, and often in immediate contact with it, we find in Perry township a very superior coal, which I have identified with the Brush Creek coal of Beaver county.

It is not at all persistent, and, when found on one farm, is often absent from the adjoining one.

I was at first inclined to identify it with the Upper Freeport, and the sandstone above it with the Mahoning sandstone proper, but a short distance above Wurtemberg I got a direct measurement between it and the lower members of the series, which made that identification inadmissible; for I found it coming 200 to 220 feet above the Darlington coal, and 280 to 300 feet above the Ferriferous Limestone, so that this was regarded as conclusive evidence that it was the first coal above the Upper Freeport, which we often find at this horizon in Beaver and Butler, and which in the Reports of the first survey was wrongly identified with the Elk Lick.

It comes at the same horizon as the coal worked by Mr. Cable in Butler county, on the Little Connoquenessing Creek, and which has been described in "Q."

The coal in question is mined in Lawrence by only a few persons, since its distribution is so limited. Messrs. Miller, Francis, Weimer, and one or two others being the only operators.

It is generally separated into two benches by a band of slate or slaty coal near its middle, which varies in thickness from 2 to 6 inches. The upper bench is inclined to run into the "*block*" variety, and at Miller's is a genuine "*block*," having been used in the raw state for smelting iron at the old Lawrence Furnace, on the other side of Slippery Rock. It is generally very pure, and is preferred by the farmers and smiths to any other coal in the region.

The only other area of this coal outside of Perry township is found in Wayne. About $1\frac{1}{2}$ miles above Wurtemberg, one of the Slippery Rock hills extends up over 500 feet above the level of that stream, and catches four or five acres of the coal near its summit, on the land of Mr. Foy.

The coal seems to be quite slaty and impure, but this may have resulted from its long exposure so near the surface.

The following analyses show the character of this coal in Perry township. (McCreath.)

I. From the upper bench at Mr. Miller's bank, Perry township.

II. Lower bench of the same.

	I.	II.
Water,	1.940	1.930
Volatile matter,	39.265	40.125
Fixed carbon,	55.828	55.606
Sulphur, . . . . .	.727	.849
Ash,	2.240	1.490
	100.00	100.00
Coke, per cent.,	58.795	57.945
Color of ash,	Reddish gray.	Reddish brown.

Summit Limestone.

In Report of Progress "Q," I have described a local bed of limestone which occurs immediately below the Brush Creek coal in the north-western portion of Beaver county. It is seen there near the *Summit cut* on the P. F. W. & C. R. R., and has been designated from that locality.

I supposed then that it was a mere local development, and never expected to meet with it again, as it had never been seen in any other part of the district reported on in Q, hence I was quite surprised to find the same limestone in one of the high knobs of Perry township, possessing the same slaty and slab-like appearance, which characterized it at the few localities where it occurs in north-west Beaver.

It would be well for whoever works up the geology of Armstrong, Northern Butler, and Clarion to keep this fact in mind, since, should it ever prove persistent over a considerable district, the coal above it might very readily be confused with the Upper Freeport, if it has not already been in some cases.

During the First Survey it was not discovered that the

Lower Freeport coal is frequently underlaid by a limestone, and hence, whenever a coal was discovered in this part of the section having a bed of limestone below, it was immediately referred to the Upper Freeport, since that was the only coal known to have such relations to a limestone.

To how much confusion and error this mistake led, I have fully shown in "Q," but now it seems that matters may have been still further complicated by the occurrence of a *second limestone* unknown to the First Survey, so that the geologist should now be doubly careful when making sections and identifications in the region to which reference has been made.

That there can be no doubt about the existence of the three at times is certain, for at the summit cut in Beaver county I get them all in a vertical section, but one, two, or all may be absent at times and here is the source of confusion.

The Mahoning Sandstone.

The Mahoning Sandstone should be found in the interval, No. 7, of our Type Section, but at every point, where this part of the column is below the hill-tops, it was covered up with débris, so that the character of the rock could not be seen. However, from the gentle slope which it makes in the topography the inference is drawn that it contains no massive sandstone, and is, like we frequently find it in Beaver to the south, merely a sandy shale.

West from the Beaver river, in Big Beaver township, the very base of this stratum is seen capping the summit of a lofty hill, one mile south from Wampum and what there is left of the rock is quite massive.

CHAPTER V.

The Lower Productive Coal Series.

This group of the coal rocks has been limited by the Mahoning Sandstone above, and the Piedmont or Tionesta below, though so far as containing productive coal beds is concerned, it might with equal propriety be extended up to the base of the Buffalo Sandstone, and down to the base of No. XII, since valuable coal beds occur throughout this entire interval; nevertheless, the old nomenclature has become so generally established that we have thought it best to make as few changes as possible.

The series as thus restricted spreads over by far the larger portion of the county, though the highest members are found only along its southern margin, while, in the extreme north, the gradual rise of the strata in that direction has carried the lowest members above the general level of the country.

The total thickness of the group does not vary much from 300 feet, being somewhat less than we find it (345') to the south at New Brighton. This difference is largely confined to the interval between the Ferriferous Limestone and the Piedmont Sandstone; for, while in Lawrence it seldom exceeds 45 feet, in Beaver the same interval is often 75 to 80 feet.

The Upper Freeport Coal.

The Upper Freeport Coal, like the Brush Creek above it, has only a small area in Lawrence, and by far the larger part of this is barren of the coal; for, in passing into Lawrence, it seems to retain the irregularity of distribution which characterizes it in Beaver county at the south.

It has the largest area of outcrop in Perry, but at only one or two points does it attain workable dimensions in the township.

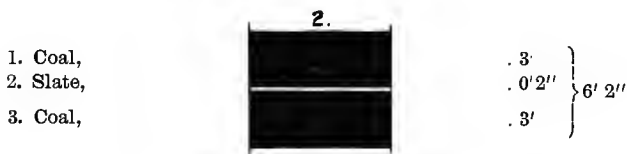
On the land of Mr. McCrackin near the center of Perry this coal was once mined and is reported to have been 3 feet thick, but rather slaty and impure.

Along the high ridges that occur in this township, we frequently see the blossom of a small coal 60 to 70 feet below the Brush Creek coal, and this would represent the Upper Freeport. It is doubtless thin, however, and has not been tested.

West from the Beaver river, in Big Beaver township, it again comes into the summits of the hills and there attains workable dimensions, though it comes so near the surface and is caught in such small patches that it is of no practical importance.

About one mile and a half south-west from Wampum, it was once opened near the top of the ridge by Mr. Whan, and mined for a short time. He reports it as being 6 feet thick, yet quite rotten and friable from long exposure near the surface. The same bed occurs in many of the hills south and west from Wampum and is known as the "Six foot bed," though it has seldom been opened.

It comes 130 to 140 feet above the Darlington coal, and there is but one point in the county where it is now being mined. This is on the land of Mrs. Gilkey in Big Beaver township about $1\frac{1}{2}$ miles north-west from Wampum, and it has there the following structure :



It comes in the top of a high knob and there are only a few feet of rock above it. The coal is rather slaty and contains considerable pyrites.

The Freeport Limestone.

Coming 60 to 65 feet below the Brush Creek coal and its underlying limestone, we find in Perry township a very

massive limestone which we have identified with the "*Freeport.*"

It is seen at the spring-house below the road, a short distance south from Mr. Miller's, and is there 8 feet thick in three very hard, grayish-white, and compact layers.

On Camp run it is quarried and burned by Mr. Cuffert, and is a very hard massive rock considerably stained with iron, and non-fossiliferous. It requires very careful burning to get it to slack, but makes a very good lime for agricultural purposes.

The same bed is seen in the road as we pass west from Mr. Miller's toward Harris's Fording, and there appears to consist of several thin layers, separated by fireclay, or argillaceous shales.

West from the Beaver river it has not been seen, as everything is covered up at the horizon where it should be looked for, and it has not been observed outside of Perry township, since it comes so near the top of the section that its horizon occupies only a small area along the southern margin of the county.

The Upper Freeport (Butler) Sandstone.

In Report of Progress "Q," I have described under the name of the "Butler Sandstone," a stratum which locally becomes massive between the Upper and Lower Freeport coals.

Prof. Lesley has suggested that it would be desirable to call this the Upper Freeport, and the old Freeport sandstone the "Lower Freeport," since this would give a general harmony in the classification, as we would then have two coals, two limestones and two sandstones, all designated by "Freeport," there being an "Upper" and a "Lower" in each case.

It is an objection to this arrangement that no representative of the "Upper" Sandstone or "Lower" Limestone is to be seen at Freeport, but this may not be valid when compared with the advantages of the nomenclature proposed.

The sandstone in question is seen forming massive ledges

along the hill above the Welsh Coal Bank, one mile below Wampum. It is there a very coarse, hard, grayish-white rock, and at one locality some small pebbles were seen in it. From this point on down to the Beaver County line it continues massive, and is the only locality in Lawrence where it is seen forming cliffs.

The Lower Freeport Coal.

At an interval of 65 to 70 feet below the Upper Freeport coal, we find another more or less persistent bed, which is locally known as the "*Five-foot vein*," and sometimes as the "*Four-foot vein*," accordingly, as it is thicker or thinner. This is the Lower Freeport, and like the other members of the series above it is confined almost exclusively to the southern tier of townships, though, in some portions of Shenango the hills rise high enough to catch small areas of it.

This coal has been mined in Perry township, on the land of Mr. Thomas, and is there reported to be 5 feet thick. No coal was out when I visited the mine, and the drain was filled with water, so that I could not examine it, but from the sulphurous aspect of the water which flows from the mine I should term it a rather bad coal. It has been used by only a few families, since the very pure Brush Creek coal in the immediate vicinity is preferred by every one.

West from the Big Beaver it has frequently been opened, though only two or three mines are in operation on it now. One of these is near the northern line of Little Beaver township, at the site of the old steam saw-mill. There the coal attains a great development on the land of Messrs. Mitchell, Robinson, Weatherspoon, and others, and has been extensively mined.

At Mitchell's bank we see 6 feet of solid coal at the mouth of the Drift, and Mr. M. reports that it even gets some thicker when followed into the hill. The coal is richly bituminous, brilliant and is highly prized by the smiths. The area of its maximum development is quite limited, however, and the coal rapidly deteriorates in qual-

ity, when followed in any direction from the Mitchell tract, becoming slaty and sulphurous.

The most northern outcrop of the coal is found in the north-western corner of Slippery Rock township, where it is seen 70 feet above the Darlington coal on the land of Mr. Armstrong, and just east from there it was once opened by Mr. Criswell and found to be two and a half feet thick, but it was so near the surface that it could not be mined.

The area of this coal is so small and its development so variable and uncertain that it adds very little to the mineral wealth of the county; for, except on the Mitchell tract, previously referred to, and on a few of the adjoining farms, there is no other area in the county worth considering.

The Lower Freeport (Butler) Limestone.

In Report of Progress "Q," a limestone termed the "Butler" was described as occasionally coming into the section immediately below the Lower Freeport coal. Prof. Lesley has suggested that it be named after its overlying coal in order to make it harmonize with the Upper Freeport coal and its underlying limestone.

The stratum in question was not seen in Lawrence, as its horizon was seldom, if ever, exposed so that there was no opportunity of seeing it even if it had been present.

But as it occurs in Beaver county in only about one section out of five it may well have been entirely absent here.

The Lower Freeport Sandstone.

As has been previously stated, the term Lower Freeport Sandstone has been suggested by Prof. Lesley for the stratum which has hitherto been known simply as the Freeport Sandstone, and this nomenclature we have adopted in the present report.

The stratum occupies the interval between the Lower Freeport coal and the Darlington, and has seldom been seen massive in Lawrence.

On the Ohio river, and northward along the Little Beaver, nearly to the Lawrence county line, it occurs in im-

mense massive cliffs, 65 to 100 feet high, but, on following the same stratum up the Big Beaver, it is seen to thin down and pass into flaggy sandstone, or finely laminated arenaceous shale.

It is well exposed in the numerous cuttings along the old projected New Castle and Darlington R. R., and is in every case a finely laminated sandy shale.

Near the western line of the county, in North Beaver township, this stratum thickens up to some extent and is quarried by Mr. Sauer. The whole mass is there about 60 feet thick. The lower half is found in layers 4 to 6 inches thick, and is used for flagging, while, in the upper portion, the layers are thicker, and have been used for building stone. The rock is very hard, however, and the builders take it simply because nothing else is obtainable.

This same rock has also been quarried to a small extent by Mr. Woods, $2\frac{1}{2}$ miles south-west from Mt. Jackson.

The Darlington (Upper Kittanning) Coal.

We come now to the most important and persistent coal in the series as exhibited in Lawrence.

We have described in "Q" how the earlier geologists of the First Survey were led into the error of neglecting and overlooking in their nomenclature of the Lower Productive Coal Series, one of the most valuable members of the group. We have also shown in the same report, that the coal, in question, is the one which attains such a great development in the cannel coal near Darlington, and have named it from that locality, the Darlington coal.

Immediately south from Lawrence County, along the Big Beaver, in the vicinity of New Brighton and southwards, the coal is mostly too thin to mine and is entirely overshadowed by the *Kittanning*, which comes a few feet below, but, as we pass northward, along the same stream, the *Kittanning* thins away to only a few inches, while the *Darlington* at the same time, strange enough, thickens up, and becomes the more important coal before we reach the Lawrence county line.

It was formerly supposed, that the coal, which has been

mined so extensively along the E. & P. R. R. between Homewood and Wampun, was the *Kittanning*, but we have traced the two beds continuously up the Beaver from the Ohio River, and have been able to show that the "*Clin-ton coal*" is the *Darlington*, for we get the two beds in a series of closely connected sections, and see the change gradually taking place by which the upper coal becomes the thicker and better.

The Darlington coal comes low enough in the column to overspread a large portion of the county, and only after we pass to a considerable distance north from the middle line of the same does it begin to over-shoot the summits of the hills.

It varies in thickness from two to four feet, but is generally not more than $2\frac{1}{2}$ to 3 feet. It is characterized by always possessing a band of slate in some portion of the bed, and usually near its base, but sometimes it is found near its top, and again near the center.

The coal varies much in quality in different portions of the county. Along the Big Beaver valley it is exceptionally pure, and is largely mined for shipment to the iron mills, and as a gas coal, for which latter purpose it is most excellently adapted. It probably attains its greatest purity and value on Hog Hollow, a tributary putting into the left bank of the Beaver about half way between New Castle and Wampun. The Gas Works in New Castle now gets its chief supply from that region, and Mr. J. S. Connelly, the superintendent, informs me that it gives a better yield and makes a gas of better quality than any other obtainable coal in the county. For the quality of the Hog Hollow coal, see analysis of specimens VII and VIII.

Along the Slippery Rock valley, however, it becomes more or less pyritous and can seldom be used for smithing.

In the south-western corner of Plain Grove township, this coal is found four feet thick on the land of Mr. Lowry, and the upper half is there a genuine "*block*" coal, having been used in the raw state at the old furnace on Taylor's run.

North from New Castle, a considerable area of it is caught in the elevated ground between the Shenango and Neshanock creeks, but it is there not so pure as we find it along the Big Beaver.

At the very northern line of the county, in Washington township, we find a high knob catching a few acres of this coal near its summit. From this we learn that the coal, in question, once spread over the entire county, though subsequent erosion has so narrowed the area that it does not now occupy much more than half the surface of the same.

The following analyses represent the character of this coal at different localities in the county: (McCreath.)

- I. From upper bench of Mr. Brown's bank near the village of Plain Grove.
- II. From lower bench of same.
- III. From Mr. McConnell's bank near the head of Snake run, Shenango township.
- IV. From Mr. Armstrong's bank near Wurtemberg.
- V. From the mines of Lee & Patterson near Wampum.
- VI. From Mr. Roger's bank, two miles west of Rose Point, Slippery Rock township.
- VII. From Mr. Wooley's bank on Hog Hollow, four miles south from New Castle.
- VIII. From the mines of Mr. Granniss, on Hog Hollow, Shenango township:

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Water,	2.710	3.055	1.950	1.660	2.170	1.990	2.340	2.100
Volatile matter,	39.220	38.260	40.860	40.760	39.610	39.990	30.480	41.210
Fixed carbon,	55.693	53.585	53.531	50.008	55.591	52.286	55.774	54.163
Sulphur, . . . . .	.567	.675	1.199	2.572	.789	1.734	.741	.587
Ash,	1.310	4.425	2.460	5.000	1.840	4.000	1.665	1.940
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Coke, per cent.,	58.070	58.685	57.190	57.580	58.220	58.120	58.180	58.69
Color of ash,	Cream	Gray.	Red cr	Lilac.	Cream	R. B.	Cream	Cream

Kittanning Shale.

The interval, No. 15, of the general section, has been termed the "Kittanning Shale." To the south, in Beaver and Butler counties, it was always characterized by a dark

color, and almost invariably contained "kidney" iron ore. It is seldom seen exposed in Lawrence, but, when we do see it, the rock material seems to be less shaly and more arenaceous than in Beaver, and the iron ore also seems to be wanting. However, it is not visible often enough to determine its general character. It varies in thickness from 35 to 50 feet.

The Kittanning Coal.

Separated from the Darlington coal above by the interval of shales or flaggy sandstone just described, and from the Ferriferous Limestone below, by an interval of 20 to 40 feet we find the *Kittanning coal*.

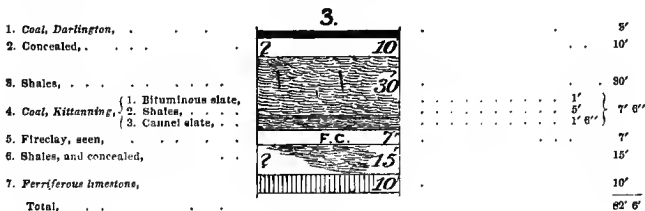
Though so constant in thickness and quality to the south in Beaver county, it proves the reverse in Lawrence; for, except over a few small areas, it never becomes of available thickness. It is, nevertheless, quite persistent as a small coal or cannel shale at its proper horizon.

We have already, in connection with the Darlington coal, alluded to the gradual thinning away of this coal, when followed up the Beaver from New Brighton.

Near Clinton it is seen directly below where the Darlington is mined, and is there separated into two layers by 8 inches of shale.

The upper portion of the bed is a slaty cannel 6 inches thick, while the lower bench is bituminous and of about the same thickness.

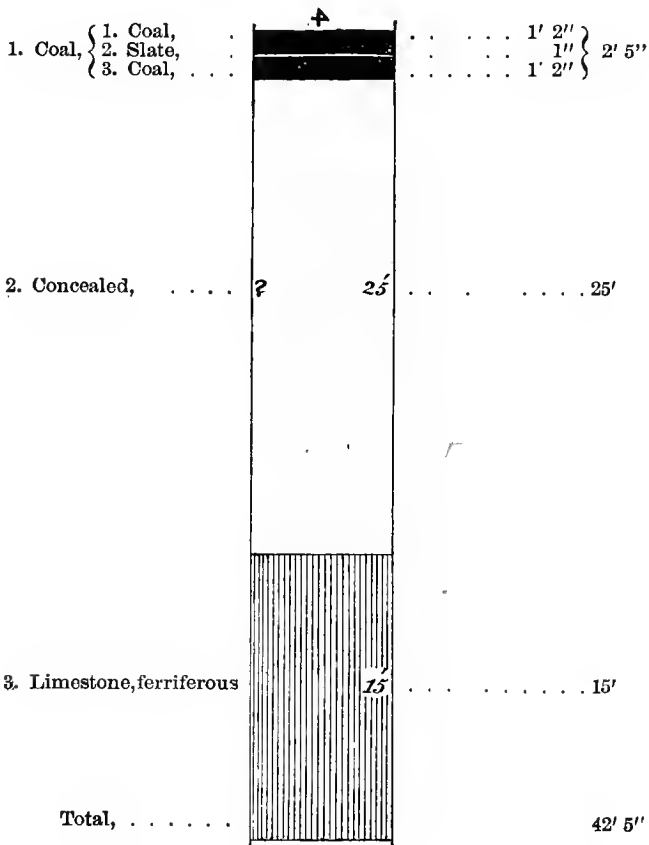
The same coal becomes a bed of cannel, 3 feet thick, a short distance above the mouth of the Connoquenessing, on the land of Mr. Ballou, who once opened it, and reports that it had a layer of slate 6 inches thick near its middle.



In Slippery Rock township, near the old Lawrence Furnace, we find it showing the following structure in the section obtained there :

The whole section is given to show the relation which this coal generally sustains to the Darlington above, and the Ferriferous Limestone below, though the latter interval is smaller here than usual.

No. 4, the representative of the Kittanning, is seen to consist merely of bituminous or cannel-like slate, with a thick layer of shale coming in the center of it.



To show that this No. 4 must represent the *Kittanning*

coal, we give the accompanying section, Fig. 4, obtained only about $3\frac{1}{2}$ miles to the north-west, on the land of Mr. Wm. Book.

By this section we see how variable and uncertain this coal has become.

A specimen obtained in Mr. Book's bank gave on analysis by McCreath:

Water,	1.930
Volatile matter,	42.445
Fixed carbon,	49.823
Sulphur,	1.832
Ash,	3.970
	<hr/>
	100.00
	<hr/>
Coke per cent.,	55.625

We have here a very fair coal, but it contains too much sulphur for many purposes.

A short distance above Croton, in the south-western corner of Hickory township, we find another small area of this coal on the lands of Mr. Emery and others. It there comes 20 feet above the limestone, and is used at the Glass-works above Croton, but is not a first class coal by a great deal.

In Plain Grove township, we find it coming in again along Taylor's run, being there $2\frac{1}{2}$ to 3 feet thick, and 20 to 25 feet above the Ferriferous Limestone, but it is sulphurous and slaty.

In the western portion of the county, along the Ohio line, the bed in question, seems to be more persistent, as it has been opened at many localities in North and Little Beaver townships, where it varies in thickness from 2 to 3 feet, but is usually too slaty and pyritous to be used by the smiths.

It may be possible that the coal area, lying north from New Castle, between the Neshannock and Shenango, really belongs to this bed, and not to the Darlington, to which it has been referred with some doubt, as well as the small area north-west from New Castle between the Shenango and Mahoning.

Kittanning Fireclay.

In striking contrast to the variable and uncertain coal just described, is the bed of fireclay which underlies it; for we never see the horizon exposed without finding it.

This, it will be remembered, was one of the important features in Beaver county, described in "Q," for there we almost invariably found a vast bed of very pure clay, immediately below the Kittanning coal.

Just south from Lawrence county, one mile below Clinton, it has been mined to a considerable extent and shipped to the blast furnaces in the valley. It is there 10 feet thick, being very white and pure.

North from Croton, where Mr. Henderson mines the Kittanning coal, we see this clay in a bed 10 feet thick, and then the bottom is not reached. It has been mined at this locality and burned into firebrick on a small scale.

But little use has been made of the clay in Lawrence, from the fact that its presence is not generally known, on account of the scarcity of exposures at this horizon.

Kittanning Sandstone.

Lying immediately below the last stratum and extending down to the Ferriferous Limestone, we frequently find a somewhat massive sandstone which has been termed in "Q" the Kittanning Sandstone.

Near Harlansburg it becomes very massive and appears to cut away the underlying limestone.

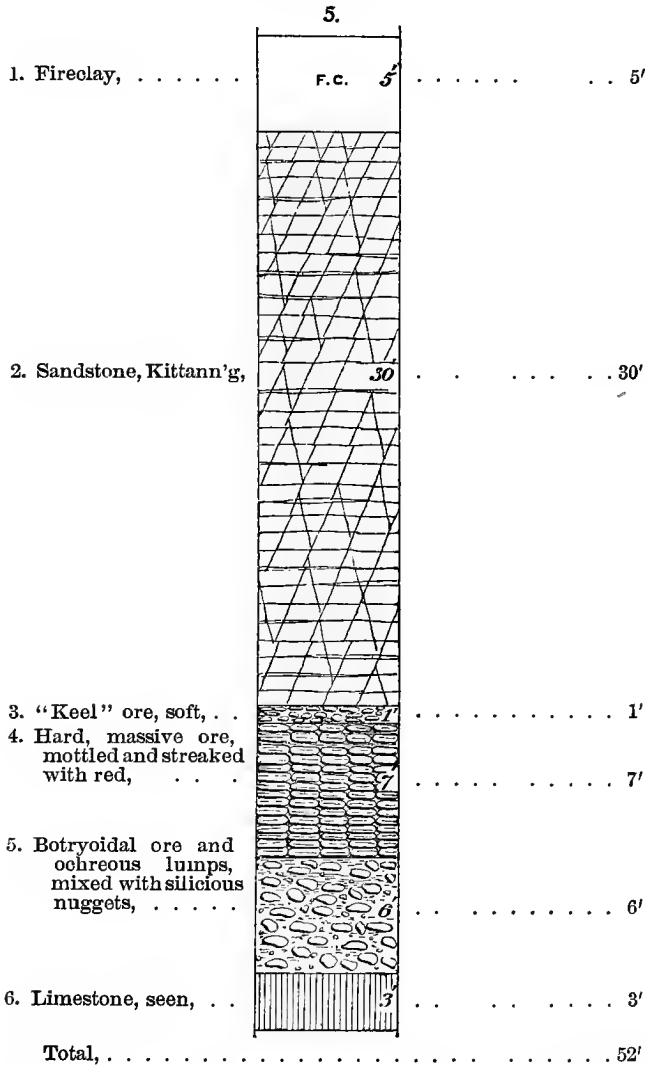
At the ore mines, near the northern line of Wayne township, it is seen above the drifts, 20 to 30 feet thick, though here it is often inclined to be flaggy. It is generally a very hard and coarse, grayish-brown rock.

Clarion Iron Ore.

Resting immediately on the Ferriferous Limestone, we find, in Lawrence, a tolerably persistent stratum of iron ore, which, from its being frequently accompanied with chert, was called by the geologists of the First survey the "*Buhrstone ore.*"

In this county it seems to be confined entirely to the portion east from the Big Beaver, in Wayne, Shenango, Slippery Rock, Scott and Plain Grove townships.

On the land of Mr. Houk, at one of the ore drifts, we see the section represented in Fig. 5:



It usually comes in a continuous layer and is then known

as "plate ore," but it is often scattered in large nodules or nuggets through the accompanying shale. It is generally a limonite ore and varies in thickness from 1 to 4 feet, though, at one locality, it attains to 20'. This maximum development occurs in the northern portion of Wayne and southern part of Shenango townships, and has been fully described in the chapter on Wayne, which, from the interest attaching to it for the general reader, we reproduce in this connection.

At the head of one branch of Hennon's run, near the center of the northern line of Wayne township, the Ferriferous ore expands wonderfully in thickness, and attains such great dimensions as almost entirely to replace the limestone itself.

This immense deposit of ore was discovered only a few years ago.

At the Houk & Grannis drift, or the "Big bank," it was found 22 feet thick at one locality, thus replacing the Ferriferous limestone entirely, since this is the thickness of the latter stratum in the vicinity.

The locality was pointed out to me where this great development was found, and there I saw still remaining the wall of Ferriferous limestone against which the ore abutted.

The face of the limestone was smooth, and the ore ceased immediately where the limestone commenced.

It is a very common thing for the limestone to come in and cut away a considerable portion of the ore, and sometimes nearly all, and again, in the midst of the ore, we often find lenticular or irregular masses of limestone wholly unchanged.

This gives a possible clue to the origin of this vast local deposit, which was most probably after the following manner :

First. It is well known that immediately above the limestone in question is a very persistent iron ore horizon over a wide area, not only in this township and county, but at many other localities in West Pennsylvania. This deposit, which is usually in the form of a calcareous "plate ore," is not generally more than 1 to 2 feet thick, and often less.

Now, it is also well known that water charged with carbonic acid very readily dissolves and carries off lime in solution. This would remove the limestone, and form the fissures and cavities in which we now find the ore. "But how," asks the miner, "did the ore get into these pockets and cavities?" Very simply and easily; water flowing over the sheet of iron ore, which so often covers this limestone, takes up the iron from it in solution and carries the same along, until being fully charged, it passes into one of these caverns, near the outcrop, and re-deposits the iron in the previously formed cavities, or the limestone may have been removed *pari passu* with the bringing in of the ore. Of course, this is merely gathering up the widely distributed ore by natural processes and heaping it more into one mass, much to the convenience of the operator and miner.

The dip is here to the south-west, and consequently the drainage would naturally follow the dip of the strata, and, as confirmatory of the local origin of this deposit, we find its greatest development along the south-west outcrop of the limestone and decreasing as we follow it into the hill, while just across on the south-west side of the stream where the dip and drainage would be away from the outcrop of the limestone, we find no ore whatever.

If this theory as to the origin of the bed be true, the ore will probably thin away very much when followed a considerable distance to the north-west.

On the side of the hill which faces directly south, at the "Joseph Honk mine," the ore is only 5 feet thick, and in the same vicinity it runs down to 2 feet.

There are only about 3 farms on which the ore is found of a thickness of 5 feet and upwards, and the whole area would probably not include more than 200 acres, which, from the causes that we have indicated, may prove much less.

A narrow gauge R. R. has been built out to it from Chewtown, by the Lawrence Ore Company, and the ore is being mined extensively and shipped to the furnaces in the Mahoning Valley.

The ores found here have lately attracted the attention,

of many iron operators in Western Pennsylvania, and besides the branch R. R. already built, it is had in contemplation to bring the Pittsburgh and North-western Narrow Gauge road through this region, so as to supply the Pittsburgh furnaces with the ore at a merely nominal cost.

In view of its promising importance, I selected a series of samples from the different portions of the bed, endeavoring to make them as nearly representative as possible. These specimens were forwarded to the Chemist of the Survey, Mr. Andrew S. McCreath, who analyzed them with the following results :

	I.	II.	III.	IV.	V.	VI.
Bisulphide of iron, . . .	.041	.123	.197	.060	.054	.038
Sesquioxide of iron, . .	85.571	76.500	83.142	71.000	49.571	69.714
Sesquioxide of manganese, . . .	.692	.950	.673	1.241	.845	1.304
Alumina,	1.775	.914	.732	1.321	1.720	1.410
Lime, . . . . .	.380	2.160	.510	6.070	19.950	5.500
Magnesia, . . . . .	.432	.940	.360	.979	.540	.945
Sulphuric acid,	trace.	trace.	.007	.007	.007	.007
Phosphoric acid, . . . .	.600	.936	.346	.625	.199	.238
Carbonic acid,	none.	1.697	none.	4.770	15.370	4.100
Water,	8.536	13.234	12.736	11.010	6.060	12.720
Insoluble residue, . . .	2.256	2.385	1.568	3.273	5.715	4.300
	100.283	99.839	100.271	100.356	100.031	100.276
Metallic iron,	59.919	53.607	58.292	49.728	34.729	48.818
Metallic manganese, . . .	.482	.663	.469	.864	.576	.908
Sulphur, . . . . .	.022	.066	.108	.035	.032	.021
Phosphorus, . . . . .	.262	.409	.151	.273	.087	.104

Average of the six specimens :

Metallic iron,	50.849
Metallic manganese, . . . . .	.644
Sulphur, . . . . .	.047
Phosphorus, . . . . .	.214

I. "Keel ore" from top of stratum at Houk & Graniss' mines (from No. 3 of section).

"The specimen consisted of a hard and tough, deep red iron ore with thin (surface) layer of brown oxide. It is generally very compact and earthy looking, and breaks with irregular fracture."

II. From No. 4 of section at the mines of Houk & Graniss.

“Limonite, brittle, full of seams of ochreous iron ore, color, dark-brown and yellowish-brown; fracture, rough, irregular.”

III. “Honey Comb” ore from No. 5 of section at the mines of Houk & Grannis.

“Limonite, honey-comb, the cells being lined with dark-brown, fibrous ore. The specimen is hard and brittle, with irregular fracture, showing kernels of iron pyrites.”

IV. From No. 4 of the section at the mines of Houk & Grannis.

“Specimen is exceedingly hard and tough with reddish-brown color, and somewhat conchoidal fracture. It is irregularly seamed with brown oxide of iron.”

V. From the mines of Mr. Ziegler.

“Specimen consisted of a hard and tough reddish-brown ore, breaking with conchoidal fracture.”

VI. From the mines of Mr. Ziegler.

“The ore is irregularly seamed with brown oxide of iron; is exceedingly hard and tough with reddish-brown color and conchoidal fracture.”

Two specimens of the ore from this same horizon, which was used at the Hope furnace, near Rose Point, on Slippery Rock creek, gave the following results: (McCreath.)

	I.	II.
Bisulphide of iron, . . . . .	.041	.056
Sesquioxide of iron,	76.428	79.000
Sesquioxide of manganese,	1.034	.517
Alumina,	1.331	2.980
Lime, . . . . .	.710	.480
Magnesia, . . . . .	.564	.396
Sulphuric acid,	trace.	trace.
Phosphoric acid, . . . . .	.831	.572
Carbonic acid,	none.	none.
Water,	13.000	13.566
Insoluble residue,	5.995	2.703
	99.934	100.275
Metallic iron,	53.519	55.326
Metallic manganese, . . . . .	.720	.360
Sulphur, . . . . .	.022	.030
Phosphorus, . . . . .	.363	.250

I. Ore from the horizon of the Ferriferous limestone used at Hope furnace, Slippery Rock township.

“Limonite, generally compact and brittle with dark color, irregular fracture and laminated structure. The surface shows light brown botryoidal iron oxide.”

II. Locality same as I.

“Limonite, ‘bombshell’ ore, the walls of the cells being lined with botryoidal dark brown ore. Hard and brittle with irregular fracture.”

The result of these analyses was quite a surprise to myself not only with regard to richness of the ores in iron, but also in the very low per cent. of Phosphorus which they show.

The samples were selected from different portions of the bed and should, in a general way, represent the constitution of the ore at these localities, and it would seem that there is no reason why a first rate quality of bar iron may not be manufactured from these ores.

At Hope furnace, the locality of the last set of samples, the iron made is said to have been of the best quality.

There is no furnace in the valley which now operates with this ore exclusively, but many of them are mixing it with Lake ore, in proportions, varying from one fourth to one third.

It seems that so far the furnaces “*gum up*” when run exclusively on the native ore, but Mr. Bergher, of the firm of Reis, Brown & Bergher, informs me that he, after various trials and experiments, found out a method of treatment by which it can be operated alone, and he made a successful run of several weeks on it at the Rosena furnace, making a superior quality of iron.

The knowledge thus gained is a secret with Mr. Bergher, however, and he does not care to impart it for the benefit of his competitors in the iron trade. But the result settles the fact that these ores can with proper treatment be used exclusively.

Wampum furnace has been using this native ore for a long time, generally mixing it with Lake ore, but it once made a “run” on the native alone. It was not satisfactory,

as the furnace did not work well with it, but this was very probably a fault of the furnace. The average amount of iron obtained during the run was 45 per cent. of the ore used.

At Hope furnace, the average of a three or four years' run was about 38 per cent.

It thus appears from these facts that the native ores of Lawrence are not to be despised, and, that with new and better methods of treatment, they may yet be brought into competition with the purer and richer Lake ores.

Besides the special localities here indicated as containing an unusual development of the ore, others will be found under the detailed report on the various townships.

The "*buhr-stone*," so characteristic of this ore, on the Allegheny river, was observed at only a single locality, viz: the Myra furnace on Taylor's run, Plain Grove township.

The Ferriferous Limestone.

Supporting the *Buhrstone ore*, when present, we find one of the most valuable and characteristic rocks in the whole column, and, from this relation which it sustains to the ore, it was early named the Ferriferous limestone.

This stratum has a great development in Lawrence and underlies nearly two thirds of its surface.

Although it exhibits sudden and great variations in thickness, yet it is much more constant in this district than we found it to the south in Beaver. Its usual thickness, in this county, is about 15 feet, but it is often much less and frequently as great as 25 feet, and occasionally it seems to disappear entirely. The stratum generally consists of two distinct portions; an upper or "gray," and a lower or "blue" limestone, with often an intervening layer of shale or clay separating them.

The rock has a peculiar physical aspect by which a mere fragment of it can be almost certainly distinguished from any other limestone with which we are acquainted. This consists of a shriveled or shrunken appearance, which manifests itself along the faces of the dividing planes, and

seems to be due to the manner of weathering, as I have explained in "Q."

The upper, or "gray" portion is largely mined along the Beaver and Mahoning and shipped as a flux to all the furnaces in the valley.

The majority of the people in these valleys are probably unaware of the immense importance of this limestone to them, but they can realize something of its value, when it is stated that had it been absent, or but poorly developed, as in Beaver county, the great iron industries which have now rendered the region famous, would, in all probability have never been heard of, for they could not have transported limestone for flux from a distance, and been able to compete with more favored districts.

This "gray" rock is usually much the larger part of the bed, and, besides making a most excellent flux, is highly prized for agricultural purposes and for plastering.

The lower, or "blue" portion varies from 3 to 5 feet in thickness, and is seldom quarried, as the furnace proprietors will have nothing whatever to do with it, since they assert that their furnaces never do well with it.

Mr. Jno. K. Shinn, one of the most extensive limestone operators in the valley, says that he thinks the rejection of it is due to prejudice based on color alone, and thinks that it arose from the fact that the furnaces were doing badly from other causes when the limestone in question was used, and it was at once ascribed to the use of "blue" limestone, since he has had several specimens of it analyzed and there was found to be but very little difference in the composition of the two portions. Whatever foundation there may be for Mr. Shinn's belief, it is certain that the "blue" portion contains much more silicious matter as a general thing than the "gray," and this is very probably the cause of its being in bad repute as a flux.

Both layers are always richly fossiliferous, and I have seen the following forms in the stratum: *Spirifer cameratus*, *S. lineatus*, *S. opimus*, *Productus Nebracensis*, *P. longispinus*, *P. semireticulatus*, *P. Prattenanus*, *Hemipronites crassus*, *Chonetes mesoloba*, *Euomphalus ru-*

gosus, *Pleurotomaria Grayvilliensis*, *P. carbonaria*, *P. turbinella*, *Bellerophon carbonarius*, *B. Montfortianus*, *B. percarinatus*, *B. Stevensanus*, *Nucula ventricosa*, *Nuculana bellistriata*, *Macrocheilus primigenius*, *M. ventricosus*, *Astartella concentrica*, *Polyphemopsis peracuta*, *Aviculopecten carbonarius*, *A. Whiteii*, *Athyris subtilita*, *Solenomya radiata*, *Macrodon obsoletus*, *Aviculopinna Americana*, *Nautilus occidentalis*, *Platyceras tortum*, *Synocladia biserialis*, *Lophophyllum proliferum*, *Orthoceras cribrosum*, *Archaeocidaris Wortheni*, *Pentremites pyriformis*, *Zeacrinus mucrospinus*, and many others besides, which could not be identified in the field.

The stems of Crinoids are especially numerous, and, in some places, make up almost half the mass of the rock.

The variations in thickness of this stratum are often quite rapid and great; for instance on the east side of the Slippery Rock it is seldom more than 2 feet thick for three or four miles along the same, but on the opposite side of the stream, and never more than a mile away, it has a constant thickness of 15 to 20 feet.

It shows the same rapid changes along the Big Beaver; for, at Wampum, we find it with a maximum thickness of 25 feet, but, only $2\frac{1}{2}$ miles above, we see it thinned away to barely a foot of impure calcareous stuff.

Another constant peculiarity of this rock when thin, is its "cone in cone" structure, since at hundreds of localities, where I have examined the stratum in Beaver and Lawrence counties, as well as in Ohio, I have never seen it thin without also finding it with this peculiar structure.

Along the Big Beaver, there are many areas where all the superior strata have been eroded, and this rock is found with only 2 to 8 feet of *débris* resting upon it, so that its mining is comparatively easy.

It is seldom a massive rock, but is generally found in thin shelving layers 2 to 6 inches thick, which split apart very readily and greatly facilitate its mining, which is done at the merely nominal price of 16 cts. per ton.

The quarries of Marquis, Green & Johnson, in the vicinity of New Castle, are the most extensive. Specimens

of this rock were analyzed with the following results by McCreath :

	I.	II.	III.	IV.
Carbonate of lime,	93.340	94.785	94.214	95.768
Carbonate of magnesia,	1.460	1.369	1.732	1.097
Oxide of iron and alumina,	1.563	1.187	.805	.632
Sulphur, . . . . .	.123	.123	.165	.088
Phosphorus, . . . . .	.047	.032	.020	.017
Insoluble residue,	3.070	2.080	2.790	1.970
	99.603	99.576	99.726	99.572

I. From quarries of Green, Marquis & Johnson near New Castle.

“The limestone sparkles with calcite, is compact and brittle, color generally bluish-gray.”

II. Two miles north from Croton, Mr. Moffit's quarry. Description same as I.

III. From the quarry of Jno. K. Shinn & Bros., near Wampum.

“The limestone sparkles with calcite, is compact, brittle, and bluish-gray.”

IV. From Mr. McCord's quarry, 3 miles north-west from Mt. Jackson.

“The limestone sparkles with calcite, is compact and brittle with pearl-gray color and irregular fracture.”

The following analyses were made for Jno. K. Shinn by Robertson Bros., Analytical Chemists of Pittsburgh, and kindly placed at my disposal by Mr. Shinn :

	I.	II.	III.
Silica,	4.50	4.14	2.31
Sulphur, . . . . .	.06	.20	.17
Alumina, . . . . .	.21	.21	.24
Phosphoric acid, . . . . .	.07	.05	.04
Sesquioxide of iron,	1.77	1.77	1.18
Oxide of manganese, . . . . .	.20	1.20	.22
Lime,	49.31	50.16	52.04
Magnesia, . . . . .	.75	.42	.43
Carbonic acid,	40.54	39.87	41.72
Water and organic matter,	2.59	2.03	1.65
	100.00	100.00	100.00

- I. From top of the stratum.
- II. From middle.
- III. From bottom or "blue" portion.

These analyses would certainly bear out the statement of Mr. Shinn previously referred to, if they did indeed represent the true constitution of the rock, since they show the "blue" portion to be much the purest. But this must have been an exceptional specimen, or else there was a mistake made somewhere; for the physical aspect alone is generally sufficient to reveal a much larger proportion of earthy matter in the "blue" portion than in the other.

Scrub Grass Coal.

Separated from the limestone by 2 to 4 feet of argillaceous or sandy shale, we find, in some portions of the county, a small coal which I have identified with the one, termed the "Scrub Grass" by the First Survey.

When first seen, I supposed it to be the *Clarion* which had approached nearer the limestone than usual by the thinning away of the intervening shales; but on Hettenbaugh run I was disabused of the idea by finding the Scrub Grass, Clarion, and Brookville, all in one section.

The coal is of no economical importance and has been mined at only two or three localities in the county.

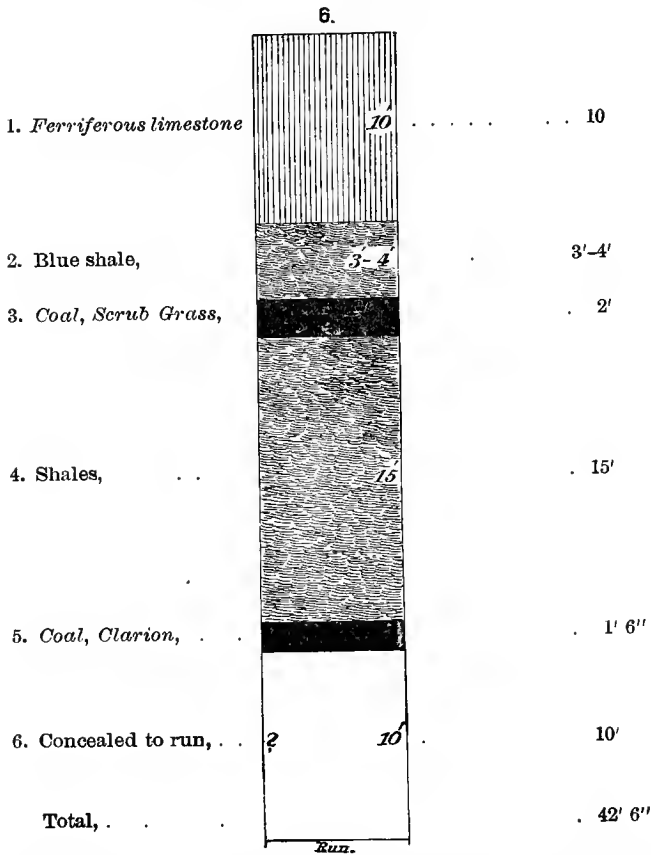
On Hettenbaugh run, in Scott township, it is mined by Mr. Reichel where it is, seen in a relation to the other strata as represented in Fig. 6.

A short distance below this, we find the *Brookville* coal coming up out of the run's bed, and see the Tionesta sandstone below; so that there is no doubt of the correctness of the identification.

The coal, in question, as seen at Mr. Reichel's bank, is a rather hard, dry, open-burning fuel, and makes considerable ash.

The same coal was once opened near Harlansburg on the land of Mr. Brown, but was there only 18 inches thick.

At the limestone quarries of Green, Marquis & Johnson, near New Castle, a small coal is reported by the miners as occurring 2 feet below the base of the limestone.



Along the Mahoning we also occasionally see a small coal at this horizon, so that the little insignificant stratum described by Rogers seems to be found over a considerable area. It is often wanting, however.

Clarion Coal.

At an interval below the Ferriferous limestone, varying from 15 to 25 feet, we nearly always find the representative of the Clarion coal.

It is seldom more than 1 to 1½ feet thick, however, and has rarely been mined, though on Hettenbaugh it was once stripped out of the run on the land of Mr. Reichel.

Near the head of Sulphur run, in Neshannock township, we find a coal mined at this horizon on the land of Mr. Crawford. It is there 20 inches thick and quite pure and clean.

Brookville Coal.

Below the Clarion, we generally find nothing but sandy shales until we come down to the Tionesta, but sometimes we get a coal resting immediately upon the latter stratum, and I have identified it with the Brookville bed of the First Survey.

It has been opened and mined above East Brook, on the land of Mr. McDowell, and is there 20 to 24 inches thick.

It is a tolerably fair coal and can be used for smithing. The bed occurs at an interval of 53 feet below the Ferriferous limestone at this locality, and it is never more than that, but sometimes less.

Two miles below New Castle, it was once opened in a hollow back from the limestone quarries of Green, Marquis & Johnson, but it was there somewhat slaty and was not pursued.

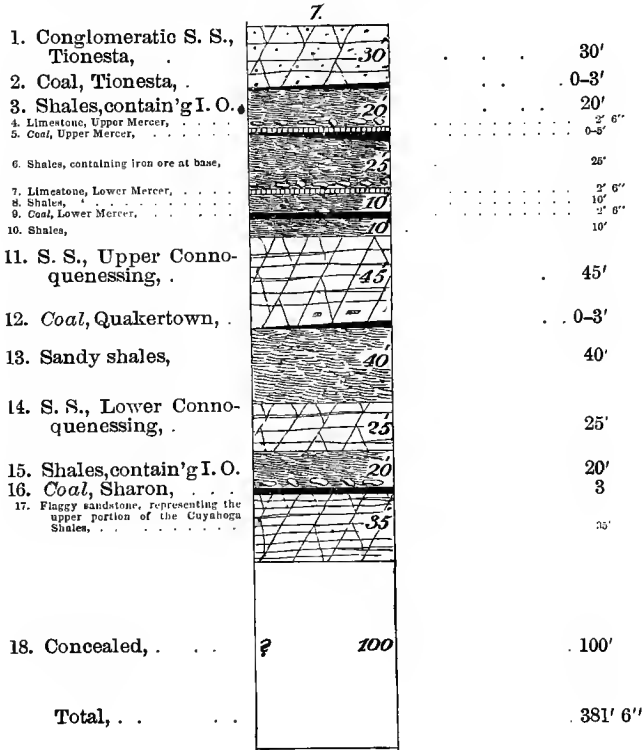
Below the coal we generally find a small bed of fireclay and this brings us down to the Tionesta sandstone, or the base of the Lower Productive Coal Series proper.

CHAPTER VI.

The Conglomerate Measures, No. XII.

The rocks which constitute the Conglomerate series in Lawrence are so changing and variable in their character that it is hardly possible to represent them in a typical section, yet the typical section, Fig. 7, may be said to convey a general idea of the strata whose variations will be pointed out in the succeeding pages :

Typical section of the Conglomerate or Inter-conglomerate Measures, together with that portion of the Cuyahoga shale exposed in Lawrence :



The Conglomerate Measures.

The section commences with the massive rock below the Brookville coal.

A glance at the column of rocks shown here, would, without a knowledge of that portion of the section which comes above, very probably lead one to place it in the Productive coal measures, instead of in the Conglomerate, since we see it containing so many coal beds, but they are not universally present in Lawrence, and are often all cut out by the rapid changes in this formation.

The Conglomerate is finely exposed along all the larger streams, Big Beaver, Mahoning, Shenango, Neshannock, Connoquenessing and Slippery Rock, since all have cut their channels down almost to its base in some portions of their courses.

This series of rocks has been very fully discussed in my Report of Work done along the Ohio Line, so that it is only necessary in this connection to describe the different members which go to make up the group, as seen in Lawrence county.

Piedmont (Tionesta) Sandstone.

Forming the top member of No. XII, we have the Tionesta sandstone. Our reasons for including this in the Conglomerate series have been fully stated elsewhere, and have been amply justified by the researches of the past year in Lawrence county.

The name "Tionesta" has, in the late publications of the survey, been replaced by "Piedmont," as the former was considered only a synonym for the Conglomerate, but I think it evident that at Tionesta, where this stratum got its name, the rock in question occupies the same relation to the other members of the series as the one at the top of our section; and that there is no valid reason why it should not retain the original name at least through this region.

The rock in question is most variable. Only three miles south from the Lawrence county line, we find it 155 feet thick in the great ledge at Homewood, but, in coming north, it gradually thins away, and where it enters the county has not more than half that thickness, while at Wampum, 4 miles above, it is still further reduced to 50 feet, and on going north along the Beaver, a few miles from that point, it disappears entirely as a massive rock, being reduced to a few feet of flaggy sandstone and shale.

On passing up the Connoquenessing, the same marked change takes place, and continues on up Slippery Rock, until we pass above Harris's Fording, when a great sand and pebble rock begins to make its appearance at this hor-

izon, and at Eckert's bridge, two miles above, attains a thickness of 110 feet in a solid mass, its top being there only 30 feet below the Ferriferous limestone.

The occurrence of these greatly expanded masses shows that the stratum in question should be included in the Conglomerate series; for it matters not how the development took place, whether from its extending down and uniting with the Upper Connoquenessing sandstone, or, its being merely an expansion of the original stratum, the fact remains that the rock in question has no place in the Productive coal series proper. And besides this, it is the only portion of the Conglomerate that in Lawrence ever contains any considerable quantity of pebbles.

After passing above Eckert's bridge, this stratum continues massive and conglomeratic until we pass above Kennedy's upper mill, when it passes below water level and is seen no more within the county in that direction.

After thinning away almost entirely on the Big Beaver near Newport, it comes in again to the north, below New Castle, and is seen at the falls of Big run where it is 30 to 40 feet thick and quite massive.

It also retains its massive character to the northward along the Neshannock, being used in the manufacture of window-glass near Croton.

Along the Mahoning, however, it continues flaggy and shaly until we pass west into Ohio.

Its usual thickness, when massive, is about 30 to 35 feet. At some localities it is very full of quartz pebbles, which are seldom larger than an acorn and generally much smaller. When not pebbly it makes an excellent building stone, and has been quarried at many places.

Inter-conglomerate, or Sharon Group.

We come now to enter upon the description of a series of coals which lie within the Conglomerate and hence I have termed them the Inter-conglomerate group, following the nomenclature of Prof. Fontaine in his description of the coals similarly situated, on New river in West Virginia. Since these beds are so fully represented along the

Mahoning river, the name of that stream would afford a perfectly acceptable geographical designation, were it not for the fact that there is an equally important stream, called also the Mahoning, flowing into the Allegheny river entirely through higher coal measures. The name Sharon group was moreover well established by the First Survey.*

We find in this series five coals which are more or less persistent in the northern part of the coal field of Western Pennsylvania.

They are, beginning at the top :

The Tionesta coal.

The Upper Mercer coal.

The Lower Mercer coal.

The Quakertown coal.

The Sharon coal.

These coals are all pretty well developed in Lawrence, except the last, which just begins to come into the section when the northern line of the county is reached, but, as we pass south into Beaver, they all, with the single exception of the first or Tionesta, thin away and disappear, from which it would seem that the conditions existing at the north were favorable for the formation of coal at an earlier period of geologic time than at the south; for here we find massive sandstone occupying the horizon of the shales at the north, in connection with which we find the coals in question.

It is possible that a more rapid subsidence was taking place toward the south, which carried everything down before enough vegetable material could be accumulated to form beds of coal.

The Tionesta Coal.

Coming immediately below the Tionesta sandstone, and at an interval of 65 to 80 feet below the Ferriferous limestone, we find in Lawrence a more or less persistent coal which I consider identical with the Tionesta bed of the First Survey. It has been mined at several localities in the

* We have thus the Freeport group, Kittanning group, Clarion Group, and Sharon group.—J. P. L.

county and sometimes attains a thickness of 3 to 4 feet, though it is never a good coal, being usually slaty and sulphurous.

In Taylor township, it was once mined by Mr. Shields, and is there known as the "Shield's coal."

In the vicinity of East Brook, this bed has been mined by Mr. McDonald, and others, and is there known as "*the 4 foot vein.*"

On Hickory creek, it has also been mined near Mt. Jackson by Mr. Wallace.

North from the Mahoning and west from the Shenango, it has been worked in numerous places, and is there suggestively called the "*Dirt vein.*" It often contains a layer of slate 2 to 6 inches thick near its center.

The coal in question, owing to its almost constantly impure character is of little economic importance in the county, except to supply many farmers with a very bad fuel when no other is at hand.

This is the bed that has been opened in so many places far up in the hill along the right bank of the Shenango between New Castle and Mahoningtown.

The following analysis shows the constitution of an extra good specimen of the coal from Mr. Miller's bank near Mahoningtown: (McCreath.)

Water,	1.190
Volatile matter,	48.140
Fixed carbon,	44.084
Sulphur,	1.951
Ash,	4.635
	<hr/>
Total,	100.000
	<hr/>
Coke per cent.,	50.670
Color of ash,	Reddish-gray.

Tionesta Iron Shales.

In the shales which underlie the Tionesta coal, we often find a considerable quantity of iron ore; sometimes it comes in the shape of huge concretions, and again is developed into a regular stratum of calcareous ore that comes immediately on top of the Upper Mercer limestone,

though this is not so persistent an ore horizon as the one which comes in connection with the *Lower Mercer* limestone below.

This shale interval is often cut entirely away when the Tionesta sandstone becomes massive, and in that case it rests upon the *Upper Mercer* limestone, or, perhaps, cuts it and much of the underlying strata out also. Its usual thickness is about 20 feet.

The Upper Mercer Limestone.

During the progress of the first Survey, a small limestone was first seen at this horizon in the neighborhood of New Castle, and afterwards more frequently along the Mahoning river, and from that circumstance was termed the Mahoning limestone by Mr. Rogers.

I have shown in my Report on the Ohio Line that this stratum is quite persistent over the northwestern portion of the coal area, both in Pennsylvania and Ohio, and have also shown that it is the *Upper Wurtemberg Limestone* of Lesley and Lesquereux's Slippery Rock section, published in Wrigley's Report on Oil.

During the present season I have found this limestone near the town of Mercer, Pa., the place after which the limestone next below was named.

Owing to the confusion that might result from the use of Roger's old name, I have thought it best to drop the term "Mahoning," and substituted in its stead Upper Mercer for this limestone, and at the same time change the "Mercer" limestone of Rogers to Lower Mercer. This change has the advantage of simplifying the nomenclature very much since each of these limestones has a coal associated with it, which would also take the name of the corresponding limestone.

The rock varies from 2 to 4 feet in thickness and is generally a very hard, compact, darkish-blue limestone, often containing iron concretions, and always very fossiliferous; the most abundant forms being *Spirifer lineatus*, *Athyris subtilita*, *Productus longispinus*, and a coral, which very much resembles *Synocladia biserialis*.

Along the Mahoning river and down the Big Beaver, it is

found in almost every section until we come to Wampum, when the increasing development of the great Tionesta sandstone cuts it away and we see it no more to the south, but, going east, we find it coming into the section again at Wurtemberg on the Slippery Rock, and along that stream we find it at several localities.

North from the Mahoning we also frequently find it in the sections made between the Shenango and Mahoning.

The Upper Mercer Coal.

Immediately below the preceding limestone, we find a very persistent coal horizon, and to harmonize with the former rock, I have termed it the *Upper Mercer coal*.

Even when the limestone is absent we still find the coal, unless both have been cut out by the massive sandstone coming down from above. Sometimes there is a small bed of coal immediately above the limestone, but when the latter stratum thins away *the two coals come together*. This is seen along the Slippery Rock, in the vicinity of the oil district. There the limestone locally thins away to a tough silicious clay, only 6 inches thick, which is found in the center of a mass of dirty coal 4 to 5 feet thick at this horizon.

The one above the limestone is not sufficiently persistent, however, to merit a separate name, and we have applied the term Upper Mercer to both.

The coal in question is always very impure and worthless, being in many localities fully one half dirt.

A few miles above Edenburg, on the Mahoning, this bed attains a thickness of 5 feet, and simulates to a small extent the physical aspect of the "*Block*" or *Sharon coal* found further up the valley, though to the competent observer, their great difference is at once revealed. This circumstance induced a New York company to expend several thousand dollars in preparations for mining the coal, since they were led to believe it the same bed as the true "*Block coal*," but the company learned too late that their coal was worthless, and could not be sold at any price.

The coal is, hence, of no economical importance, since

there are only one or two localities in the county where it has been mined and burned.

Upper Mercer Coal Underclay.

Directly below the Mahoning River coal, we often find a large bed of non-plastic fire clay.

It was once mined on the Mahoning, and manufactured into fire brick near Hilltown station. It is always filled with the roots and rootlets of *Stigmara ficoides*.

Upper Mercer Iron Shales.

The interval between the Upper and Lower Mercer limestones generally consists of dark, sandy shale, 20 to 35 feet in thickness, and occasionally we find a small coal in it, but the latter is not persistent enough to be taken into account, as it was seen in only one or two instances.

At the base of the shale, we find a very persistent iron ore, which bears the same relation to the underlying Limestone that the "*Buhrstone*" ore does to the Ferriferous limestone in the measures above. Like it, we sometimes find the ore in nodules scattered through the shale, and again aggregated into a plate like mass, resting immediately upon the limestone, and finally we occasionally find the entire limestone converted into iron ore, so that both ores, doubtless, had a similar origin.

In the past it has been mined to a considerable extent within the county. It was the principal source of supply for the Tremont furnace, near New Wilmington, and was also largely mined along the Big Beaver for use at the old Homewood furnace, as well as the old furnace that was formerly situated at Neshannock Falls.

Besides these places, it was once mined extensively, two miles above New Castle, in the vicinity of Croton, and also on the opposite side of the Neshannock, being transported to New Castle and used in the Furnaces there.

The Moffit furnace near East Brook was also operated exclusively with this ore.

Two average specimens of the ore gave on analysis, by McCreath, the following results :

	I.	II.
Iron,	37.250	35.200
Manganese, . . . . .	.655	.807
Sulphur, . . . . .	.154	.335
Phosphorus, . . . . .	.145	.178
Lime,	3.020	4.120
Magnesia,	1.747	2.223
Insoluble residue,	9.790	11.190

I. From near Neshannock falls, Wilmington township.

“Carbonate ore, crust hematite, exceedingly hard and tough, with irregular fracture and reddish gray color.”

II. Two miles north from New Castle, in Neshannock township.

“Carbonate ore, exceedingly hard and tough, with irregular fracture and dark bluish-gray color.”

The results show that the ore is in more danger from the sulphur than from the phosphorus, which it contains, though this unexpected state of affairs would probably not hold good in the analyses of a large number of specimens.

The ore varies from 6 inches to 2 feet in thickness, and there is an enormous quantity of it in the county.

Upper Mercer Limestone.

At an interval varying from 20 to 35 feet below the Upper Mercer limestone we come to another stratum which is often the almost exact counterpart of the former rock, and, from its occurrence near the town of Mercer in this State, was named by the First Survey the *Mercer limestone*. As already stated, we have changed its name to Lower Mercer.

While the *Upper Mercer limestone* is by no means persistent, this one is almost universally so, being probably the most regularly distributed of any other stratum in the county.

It comes at an interval varying from 110 to 135 feet below the Ferriferous limestone of the true lower Productive series, and was, as we have shown in the Ohio Line report, mistaken for the latter stratum on the Mahoning by the Ohio geologists. Its usual thickness is from 2 to 2½ feet, but on one or two occasions it has been seen somewhat

thicker, though sometimes it is only one foot thick. It generally has a dark blue color, flinty fracture, and in almost every case is crowded with fossils.

This is the "*Lower Wurtemberg limestone*" of Lesley and Lesquereux's Slippery Rock section, and from it Prof. Lesquereux obtained the curious marine plant, which he described in the Proceedings Amer. Phil. Society, under the name of *Caulerpites marginatus*.

Just above Wurtemberg at the bridge, the same fossil form is abundantly seen in connection with the Upper as well as the Lower Mercer limestone.

The abundant fossils of the Lower Mercer limestone are about the same as those of the Upper, viz: *Spirifer cameratus*, *S. lineatus*, *Productus longispinus*, *Athyris subtilita*, &c.

But besides these common coal measure forms, there were also seen *Athyris lamellosa*, and two other forms which could not be distinguished from *Spirifer striatiformis* and *Cardiamorpha subglobosa*, figured in the Ohio Vol. II., from the Waverly group of that State. The occurrence of so many Waverly fossils in this limestone would doubtless be regarded by some as sufficient evidence that the rock in question is of the age of the *Umbral* or *Mountain limestone*, and, indeed, these two rocks, the Upper and Lower Mercer limestones were formerly so considered by Lesley and Lesquereux, solely on stratigraphical evidence.

But I must consider this a mistake due to their identification of the overlying sandstone with the bottom mass of the Conglomerate No. XII, because I have shown that the principal part of No. XII underlies these strata, making them therefore *Inter-conglomerate* limestones.

The evidence of Paleontology is equally conclusive that they belong in the Coal measures, since their most abundant fossils are the ones that are most common in this series, and then 160 to 180 feet below them we find in connection with the *Sharon coal*, a *Flora* that is characteristically marked, and totally unlike anything that has ever been seen in any country below the *Mountain limestone*.

At a locality on Hickory creek, Mrs. Wm. M. Taylor found a very fine *Nautilus* in this stratum, which may prove to be new.

The rock also contains numerous crinoidal fragments.

The Lower Mercer Coal.

Separated from the Lower Mercer limestone by an interval of shales, varying from 0 to 18 feet, we find a very persistent bed of coal over a large portion of Lawrence county.

This is the one which was termed the "*Lower Porter*" by Mr. Rogers; but, as the coal seems always to accompany the limestone, I have thought it better to reject the old name and call it the *Lower Mercer coal* to harmonize with the limestone above, which has the advantage of simplifying the nomenclature.

This coal, although it is so persistent and often has a thickness of $2\frac{1}{2}$ to 3 feet is yet nearly always so slaty and impure as to be of very little economic importance except in a few localities.

It was once mined a short distance below Wurttemberg and used at the old woolen mill. It is there about 3 feet thick in two layers separated by shales.

It is seen at numerous localities along the Slippery Rock, sometimes with the limestone resting immediately upon it, and again with 5 to 10 feet of shales intervening. It has been burned in a few cases to run the oil engines, when nothing else could be obtained.

It is seen in the vicinity of Wampum 2 to 10 feet below the Lower Mercer limestone, and as far south as the mouth of the Connoquenessing, or southern line of the county where it seems to be cut out by the increasing development of the Tionesta sandstone.

Along the Big Beaver, above Wampum, it is found in all the sections and is known as the "*Blue limestone*" coal.

It is likewise persistent along the Mahoning river until we pass into Ohio. On the left bank of this stream, and two and a half miles below where it enters the State from Ohio, it becomes a very fair "*Block*" coal, and was once extensively mined on the land of Mr. Erskine and shipped

on the canal, when it was in operation. The interval here between it and the Limestone is 15 to 18 feet.

East from the Shenango, and near the northern line of Pulaski, a coal is mined at this horizon by Mr. Evans, and near the western line of this township, the same coal is mined by Pinkerton and Thompson. The coal has a semi-block appearance, and makes a tolerably fair fuel.

One mile west from New Wilmington, in Wilmington township, this coal is mined by Mr. Baney on the land of Mr. Detwiler. It, there, varies from $2\frac{1}{2}$ to $3\frac{1}{2}$ feet in thickness and often has a few inches of cannel at its base. It is there 9 feet below the Limestone.

The same coal has also been mined at a few localities along the Neshannock.

The Lower Mercer Iron Shales.

When the upper portion of the Massillon or Connoquenessing sandstone is massive, we usually find 5 to 10 feet of sandy shales intervening between it and the preceding coal, but when it fines down and becomes shaly, we often get a very rich layer of iron ore 20 to 30 feet below the coal.

It is seen in the ravines along the Shenango, in the vicinity of Mahoningtown, and on Hickory creek it was once mined to a small extent.

It is seldom more than 6 to 8 inches thick, however.

Connoquenessing Sandstone, (Massillon S. S. of Ohio.)

We come now to the consideration of the main mass of the Conglomerate, that termed by Dr. Newberry, in the Ohio Reports, the *Massillon sandstone*.

It includes all the massive rock between the Lower Mercer limestone and the Sharon coal.

Instead of the rock material in this interval forming a homogeneous mass of sandstone, as it does in some portions of Ohio, we find it in Lawrence county split up into an upper and a lower massive portion with a coal horizon in the center, so that, instead of calling the whole thing Massillon sandstone, it becomes necessary to give particular names to each member, and we have accordingly termed

the upper massive ledge the *Upper Connoquenessing sandstone*, from the fact that it forms the upper cliff rock along that stream between its mouth and Slippery Rock, and the lower massive member we have termed the *Lower Connoquenessing sandstone*, because it is frequently seen along the bed of the same stream.

The total thickness of rock included in this group varies from 120 to 150 feet, the different members of which we shall now proceed to describe :

Upper Connoquenessing Sandstone.

As previously stated this forms the upper massive portion of the Massillon sandstone, so finely developed along the Connoquenessing creek, contributing, in no small degree to the wildness which characterizes the scenery that has rendered that stream famous.

At the mouth of Slippery Rock, we see this rock rising in perpendicular ledges from the water to the height of 40 to 50 feet, but as we pass up that branch to Wurtemberg, we find the rock dipping rapidly down, and when we come to the village, its top has just disappeared below water level ; but, as we pass on up the creek for one and a half miles, we see the rapid rise of the strata to the north-east bringing it up and soon carrying it 10 to 20 feet above water level ; so that when we come to the new iron bridge, or Armstrong's Fording, we find its top 60 to 70 feet above the water, and the stratum forming a bold massive cliff along either side of the narrow channel.

It continues at about the same height, until we come to the vicinity of Seceeder's or Eckert's bridge, when it seems to extend up and unite with the Tionesta sandstone above, the two forming together a solid mass 110 feet thick.

Along this entire distance the rock varies but little in composition, being usually a tolerably coarse grayish-white sandstone, with no pebbles, and frequently stained with iron. Its average thickness is about 45 feet.

Along the Big Beaver this stratum is frequently seen. It forms the sharp jutting cliff at "Rocky Point," and is in constant sight from there to Wampum. Near this village, however, it seems to fine down and become shaly,

but, one mile above Newport, it thickens up again and continues massive from thence on up the Mahoning, until we follow it into Ohio.

This is the massive rock which forms "Quakertown Falls" near the station of that name at the Ohio line.

Along the Shenango it is seldom seen, since the northward rise of the strata has thrown it so far above water-level that it has suffered much from erosion and is generally buried by débris.

Along the Neshannock it is often seen in bold cliffs, and, at Neshannock Falls, it forms the vertical walls on either side of that stream.

At only one locality in the county have I ever found any pebbles of considerable size in this rock, and that is on the Mahoning river, two miles above Mahoningtown.

Quakertown Coal.

Immediately below the preceding stratum we find a quite persistent coal horizon, though we get a workable bed in only two or three instances.

At the "Falls" on Quakertown run, near the station of that name on the Mahoning, we see a coal coming immediately below the massive cliff-rock over which the stream descends. It attains a thickness of 2 feet, and was once mined at this locality, from which I have termed it the "*Quakertown coal.*"

One mile northeast from Quakertown station this coal is mined by Mr. Wright and one or two others along Coffee run.

At Mr. Wright's bank it is three feet thick and has a tendency to run into the "*block*" variety. It is somewhat slaty and sulphurous, but makes a tolerably fair fuel for domestic purposes, especially where nothing else can be commanded, as it is in this case. A specimen taken from Mr. Wright's bank gave, on analysis by McCreath, the following results:

Water,	2.030
Volatile matter,	42.147
Fixed carbon,	44.233

Sulphur,	4.087
Ash,	7.503
	<hr/>
Total,	100.000
	<hr/>
Coke per cent.,	55.823
Color of ash,	Red.

It is seen to possess a large per centum of ash.

Along the Connoquenessing we find a bituminous slate or thin coal at this horizon almost universally, and along Slippery Rock, wherever this interval is exposed, we see a bed of bituminous matter, either of shale or slate; so that, in Lawrence county at least, we have a quite persistent inter-conglomerate coal horizon here.

Quakertown Iron Shales.

In the shales immediately below the Quakertown coal, we often see a considerable deposit of iron ore in the shape of huge nodules, and sometimes it becomes a more or less regular stratum, as is the case on Hickory creek, where it was once mined by drifting.

On the Connoquenessing, just above the mouth of Slippery Rock, we see an immense quantity of iron nodules in the bed of the stream, and the same is seen near Armstrong's Fording in the Slippery Rock oil field. The nodules are usually quite rich in iron and would probably yield 50 per cent. of metallic iron.

On the small stream which puts into the Shenango opposite Harbor bridge, this ore was once extensively mined and shipped to the furnaces in the two valleys. It comes there in a regular stratum about one foot thick.

This ore is not persistent, however, and we very frequently find nothing but sandy shales in the interval from the base of the Upper Connoquenessing sandstone down to the top of the Lower Connoquenessing sandstone, and occasionally the shales themselves become massive, as in one case on the left bank of the Beaver, $1\frac{1}{2}$ miles below Wampum, where, at the mouth of Hennen's run, we see this with the Upper Connoquenessing sandstone above, forming an almost unbroken cliff 90 feet high.

Lower Connoquenessing Sandstone.

As already stated, the term *Lower Connoquenessing sandstone*, has been applied to the lower massive member of the Massillon sandstone, since, in Lawrence, that rock forms a triple deposit; having a massive top and base, with shales and frequently a coal and iron ore horizon intervening.

The stratum in question is seldom so thick as the top portion, since it rarely has a thickness of more than 25 feet, except when the upper portion becomes shaly, then the lower often attains a thickness of 50 feet, as we see in the vicinity of New Castle.

The Lower Connoquenessing sandstone is exposed at several localities along the bed of the creek of the same name between its mouth and the mouth of Smiley's run, and is seen to be a coarse brownish rock, often containing iron concretions, and being usually much stained with oxide of the same.

Along the Mahoning river, it is frequently seen in the ravines, being very finely exposed at the "*Lower Falls*" on Quakertown run, near the Ohio line.

That it is really a part of the Massillon sandstone of Newberry, and that its three members should properly be considered together is shown by the fact that further up the Mahoning valley at the Foster shaft near Youngstown, the intervening shales thicken up and the three portions unite into a massive homogeneous sandstone 130 feet thick.

In the vicinity of New Castle this rock is finely exposed along the E. & P. R. R., on the right bank of the Shenango, where it forms the cliffs along the "*Narrows*." It is here about 50 feet thick, and the upper rock seems not to be massive.

As we pass up the Neshannock the same condition of affairs seems to exist, and it is seen rising in vertical cliffs on either side of the stream for a long distance.

A short distance above Moravia, on the Big Beaver, some small pebbles are seen in this stratum, but this is about the only locality in the county where they have been observed.

Sharon Iron Shales.

In the Quakertown section near the Ohio Line, we find immediately below the Lower Connoquenessing sandstone a bed of dark-bluish, sandy shales, 20 to 25 feet thick, having much iron ore scattered through them in nodular masses, and a more or less regular stratum of it near their top.

These shales are a constant feature along the Mahoning from Quakertown station to Youngstown, and were formerly drifted upon quite extensively for iron ore, and the old dumps with their large heaps, of bluish-white shale, are still conspicuous objects along this river.

As we pass south from Quakertown station into Lawrence, the iron ore seems to become diffused through the shales, and we no longer find it in a regular stratum, though we find a great deal of iron in a dispersed condition.

These shales seem to run out when there is no representative of the *Sharon coal* below them; for on coming south from Quakertown, we find them in the vicinity of Mahoningtown and New Castle entirely changed in appearance, and to be seemingly a part of the Cuyahoga shale, since they have the same physical aspect, and the fossils of the *Waverly* are found extending up to the very base of the Lower Connoquenessing sandstone.

Sharon Coal.

This celebrated bed which attains such immense importance in the county immediately north from Lawrence, has never yet been found of workable dimensions in the area we are considering.

It comes, indeed, to within a few rods of the county line, but it there suddenly thins away to a feather edge and disappears. This occurs at the northern edge of Pulaski township, where the Sharon coal is mined in the southern edge of Mercer county, on the land of Mr. Williams, near the north-western corner of Lawrence. It there varies from 0 to 4 feet in thickness, and being near its final southern margin is not so good a coal as we find it in the neighborhood of Sharon and Youngtown, as is seen from the follow-

ing analysis by McCreath of a specimen obtained from Mr. Williams' bank :

Water,	3.790
Volatile matter,	35.300
Fixed carbon,	53.875
Sulphur, . . . . .	.675
Ash,	6.360
Total,	100.000
Coke per cent.,	60.910
Color of ash,	Gray.

The per cent. of ash is seen to be very high for this coal, which is no doubt due to its proximity to the margin of the original marsh.

There is every reason to believe that on a few farms, just south from Mr. Williams, this coal might be found in Lawrence county, if proper explorations were made with the drill. In fact, I saw a small blossom of the coal in a ravine on the land of Mr. Van Vleet.

In the vicinity of New Castle, we see thin streaks of coal and coaly shales which represent this coal, immediately below the Lower Connoquenessing sandstone.

The same thing is seen along the Neshannock, but we never see it assuming anything like a bed, being in thin and irregular strings or streaks, which come in the rock without any order.

The relative place of the Sharon coal in the series has been discussed in my report on the Ohio line, and we have there shown that it comes so near the base of the Conglomerate series that it is often practically a *sub-conglomerate* coal, when the Conglomerate rock, which immediately underlies it at Sharon, and other points to the north, is absent.

In no portion of Lawrence do we find any Conglomerate, or massive sandstone below the horizon of this coal, but the *Cuyahoga shale*, with its fossils, extends up to the very base of the lower portion of the Massillon sandstone, except at one or two localities near the Ohio line on the Mahoning ; so that, so far as Lawrence county is concerned, the Sharon coal horizon comes below all the Conglomerate.

It may be possible that the Conglomerate, which we find below it in eastern Ohio and western Pennsylvania, really belongs to the Vespertine, and that the iron-bearing shales above it represent the *Umbral* thinned away to a knife edge. But however this may be, nothing can be truer than that the Sharon coal comes near the *base* of the Great Conglomerate, and not above its *top*, where it has been placed in Ohio.

Cuyahoga Shale.

As already stated, we find this formation in the vicinity of New Castle and Mahoningtown extending up to the very base of the Lower Connoquenessing sandstone.

Just above the mouth of Hickory creek, on the right bank of the Mahoning, we find these thin flaggy argillaceous shales quite fossiliferous, and in them we see species of *Spirifer*, *Productus*, *Allorisma*, and other genera, which are peculiar to the *Sub-carboniferous*. Many fucoids are also seen, and on one slab was seen the trail of a crustacean.

Only about 40 feet of this formation is exposed within Lawrence county, so that a full discussion of its character and relations must be postponed until it has been more thoroughly studied in the lower rocks of Mercer and Crawford.

CHAPTER VII.

The Iron Furnaces of Lawrence.

As is well known, Lawrence county has long been noted for the production of pig iron.

The furnaces that have been erected within the county may be divided into two classes, according as they were intended to use charcoal or coke.

The former were nearly all erected 25 to 40 years ago, and were situated in the various portions of the county wherever a deposit of native ore happened to be discovered.

They have nearly all been out of blast for many years, and are now mostly in ruins.

Among these may be enumerated :

The Wilroy furnace on Slippery Rock,

The Hope furnace near the Wilroy,

The Lawrence furnace on Hell Hollow, Slippery Rock township,

The Myra furnace on Taylor's run,

The Powers furnace on Neshannock creek,

The Moffit furnace on Neshannock creek,

The Tremont furnace near New Wilmington.

Out of these seven furnaces none are now in blast, and all except one (the Hope) are in ruins. The causes of their decline are, of course, not difficult to see.

In the first place, they were built in out-of-the-way localities, remote from any means of transportation to market, without first hauling their products in wagons from 8 to 10 miles.

Then it cost nearly as much to mine their ore as the lake ore cost those furnaces which used it, with the additional disadvantage that their resulting iron was of not so good a quality.

With all these things against them, it is not surprising that the Charcoal furnaces have fallen into decay.

Among the furnaces which use coke, we find at New Castle,

- The Rosena,
- “ Sophia,
- “ Little Pet,
- “ Clara,
- “ Neshannock,
- “ Etna, and at Wampum,
- “ Wampum furnace.

Of these, the only ones now in blast are the Clara, Neshannock and Etna ; although the Wampum was run continuously until July, '78, and will probably be put in blast soon again, when repaired.

The Rosena, the Sophia and the Little Pet are owned by Reis, Brown & Berger, and have been out of blast for more than a year. It is uncertain when they will go in again. The Rosena is the largest furnace in New Castle. They all use Lake Superior ore, except the Wampum and Etna which sometimes mix the native ores with the Lake in the proportion of 1 of the former to 3 or 5 of the latter.

For an account of the *oil districts* of Lawrence, the reader is referred to the detailed reports of the various townships which follow.

PART III.

CHAPTER VIII.

DETAILED GEOLOGY OF THE TOWNSHIPS.

I. Perry Township.

This is situated in the south-western corner of the county, and is bounded on the south by Beaver, and east by Butler county, while Slippery Rock and Wayne townships border it on the north and west.

It is drained chiefly by Slippery Rock creek, which flows along its western border with a rapid fall, in a wild and rocky gorge carved out of the massive rocks of No. XII.

Camp run, the only other stream of any considerable size, rises on the highlands of the central portion of the township, and flowing south through it, enters the Connoqueensing in Beaver county.

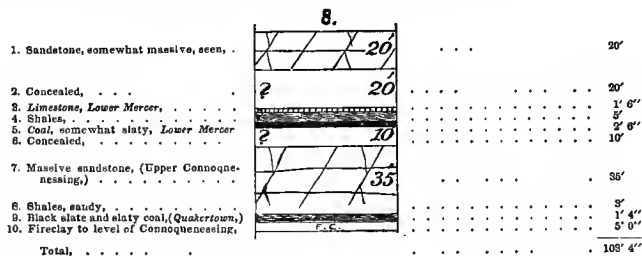
This township contains the highest rocks found in the county, since on some of its highest knobs we still find remnants of the *Buffalo sandstone*, and the underlying *Brush Creek coal*.

The section exposed in the township, extends from the Buffalo sandstone to the base of the upper Connoqueensing sandstone, or 75 feet below the Lower Mercer limestone.

This latter sandstone is finely exposed along the Connoqueensing, where it flows north-east out of Beaver county to meet the Slippery Rock. It is very massive, and the stream has cut down through the rock, excavating a narrow channel with perpendicular cliffs of sandstone on either bank. Sometimes the opposing cliffs are separated by a space of only 30 to 40 feet, and at one of these points, just before the Connoqueensing is joined by the Slippery Rock, is the locality of Capt. Brady's celebrated "Leap," which,

as history informs us, was made to escape from the bullet and scalping knife of the infuriated Indian.

On the right bank of the Connoquenessing, and one fourth of a mile above its junction with the Slippery Rock, a small ravine puts into the stream near the Beaver county line, and descending it we see the following section :



No. 1 is the *Tionesta sandstone*, and is here a tolerably fine grained rock.

Where the little stream passes over it, we see it splitting up and shelving off in vertical flakes.

The *Lower Mercer limestone*, No. 3, is a hard, dark-bluish rock, and quite fossiliferous. It breaks with a sharp angular fracture, and contains streaks of calcite.

The *Lower Mercer coal*, No. 5, was once mined by stripping out of the little bottom on the land of Mr. Hazen. It is rather slaty, however, and makes a very indifferent fuel.

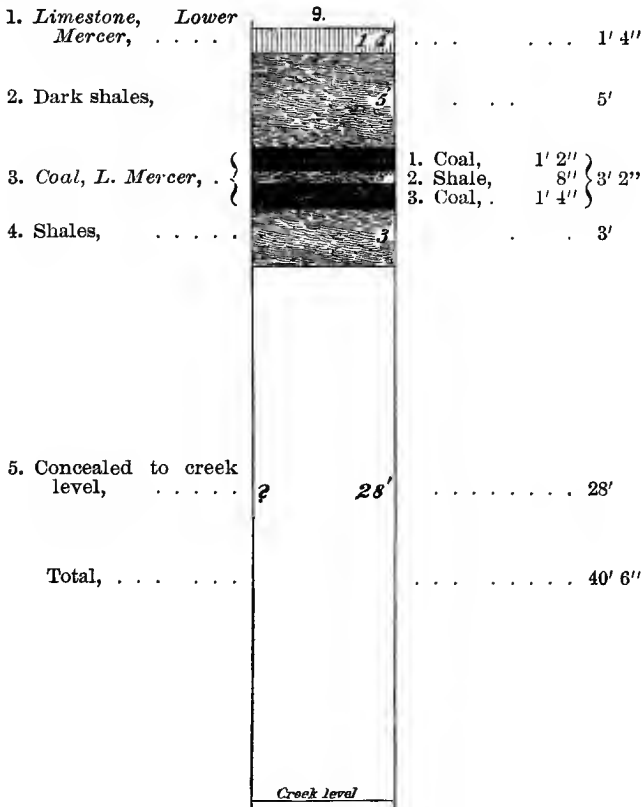
The *Upper Connoquenessing sandstone*, No. 7, is a coarse, grayish-white rock, standing out in a bold cliff along the stream, and blocking up the bed of the same with its huge fragments. It is frequently stained yellow from iron.

No. 9 is the representative of a coal which comes immediately below the Upper Connoquenessing sandstone, and attains valuable dimensions near Quakertown, on the Mahoning river, from which circumstance I have termed it the *Quakertown coal*. It here contains about 5 inches of good coal near the centre of the bituminous shale, which is, itself, interlaminated with thin streaks of coal.

There is coal or bituminous shale at this horizon from this point to the mouth of the Connoquenessing.

At the mouth of Slippery Rock, the base of the Upper Connoquenessing sandstone is 10 feet above the water, and under it we see the coaly slates which come at the horizon of the Quakertown coal ; but, as we pass up the stream from this point, we perceive the sandstone dipping rapidly below water level, and, when we come to Wurtemberg, one mile above, its top is in the bed of the creek, while the *Lower Mercer limestone*, which at the mouth of the stream is 70 feet above water level, is there only 7 feet above. This rapid dip shows that we are here on the north-west slope of the axis which crosses the Big Beaver between Clinton and Homewood.

A short distance below Wurtemberg, at the old woolen mills, we see the following :



The *Lower Mercer coal* has here been mined to a considerable extent in former times to furnish fuel for the woolen mill, but has long since been abandoned. The lower bench is not a bad looking coal, but the upper is slaty and worthless.

The high and precipitous hill at Wurtemberg affords a very fine section of the rocks from the *Mahoning sandstone* to the *Lower Mercer limestone*, and has been fully discussed by Profs. Lesley and Lesquereux in an appendix to Mr. Wrigley's Report on Oil.

10.		
1. Coal, <i>Brush Creek</i> ,		Blossom.
2. Concealed,	80'	80'
3. Coal, <i>Upper Freept</i> ,		Blossom.
4. Mostly concealed,	140'	140'
5. Coal, <i>Darlington</i> ,		2' 5"
(1. Coal,		1' 0"
2. Slate,		0' 1"
3. Coal,		1' 4"
6. Shales, and concealed	40'	40'
7. Coal, <i>Kittanning</i> ,		Blossom.
8. Fireclay,	F.C. 10'	10'
9. Shales, sandstone, and concealed,	55'	55'
10. Limestone, <i>Ferrifer</i> ,		3'
11. Concealed,	20'	20'
12. Sandstone,		4'
13. Bluish shales, sandy,		5'
14. Coal, <i>Clarion</i> ,		1' 8"
15. Fireclay,	F.C. 2'	5'
16. Concealed,	15'	15'
17. Chert,		2'
18. Sandstone, somewhat massive,	35'	35'
19. Limestone, <i>Upper Mercer</i> ,		2'
20. Coal, slaty, <i>Upper Mercer</i> ,		1' 4"
21. Bluish, sandy shales,	30'	30'
22. Limestone, <i>L. Mercer</i> ,		1'
23. Coal, slaty, <i>L. Mercer</i> ,		1' 8"
24. Bluish shales to creek level,	8'	8'
Total,		433' 1"

Along the road which descends the hill to Slippery Rock at Van Gorden's bridge, we get sec. Fig. 10.

The Blossom of No. 1, which is supposed to be the *Brush creek coal*, is seen along the road far up on the hill-top where the road passes over toward Camp run. It is not very thick, if we may judge from its blossom.

No. 3, the *Upper Freeport*, makes a considerable blossom along the road near where the Harmony road branches off, but has never been proved at this locality.

No. 5, the *Darlington coal*, is mined at the roadside by Mr. Armstrong. It makes a hot fire, but contains too much sulphur for smith's use, and is rather friable. It is separated into two benches by a parting of slate which is often pyritous.

The *Kittanning coal* is seen only by its blossom, and is evidently thin and slaty, never having been opened in this vicinity. Below it comes a large bed of fire-clay which seems to be of very fair quality, except near the bottom where it is rather silicious.

The *Ferriferous limestone* has here thinned almost entirely away, being only three feet thick, and somewhat impure, while on the opposite side of the stream (Slippery Rock), not more than half a mile away, we see it 20 feet thick, and of excellent quality. This limestone was not seen in the immediate section along the road, but is found in the steep hillside a short distance down the stream.

The *Clarion coal*, No. 14, is finely exposed in a cutting along the road, and has also been mined by stripping along the hill. It is a black, pitchy, lustrous coal, and contains a very small quantum of impurities.

No. 17 is a very white cherty stratum, and is seen at this horizon at many localities along Slippery Rock.

No. 18 represents what is left of the massive part of the *Tionesta*, or *Homewood sandstone*, which, at Homewood, attains such an astonishing development, being there 155 feet thick in a solid massive ledge.

The *Upper Mercer limestone*, No. 19, is seen at the roadside above the bridge, and is quite fossiliferous. It is dark gray in color, and breaks with a rough, irregular fracture.

Its upper surface is covered with *Caulerpites marginatus*, Lesqx.

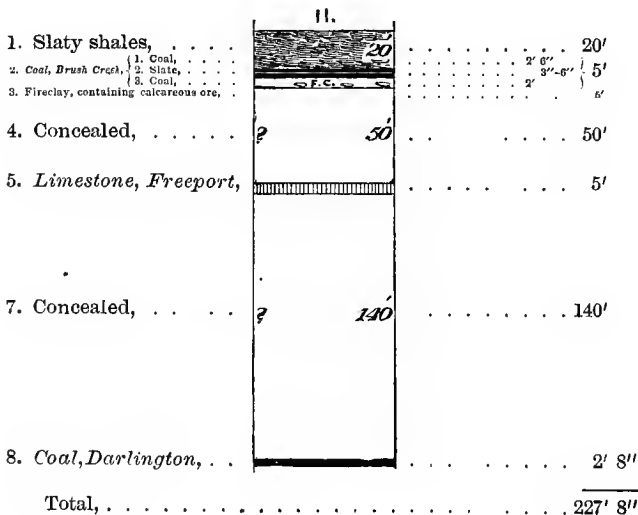
The little coal below it is quite impure and worthless.

The *Lower Mercer limestone*, No. 22, is seen finely exposed along the creek bank for a considerable distance. It is a dark-bluish, and somewhat arenaceous limestone; being crowded with fossil shells, *Productus* and *Spirifer* predominating, and on its upper surface are seen hundreds of *Caulerpites marginatus*. In it were seen *Productus longispinus*, *Spirifer cameratus*, *Athyris subtilita*, *Astartella concentrica*, and also a coral, looking very much like *Synocladia biserialis*.

The *Lower Mercer coal*, No. 23, is very impure, being filled with slate, and unfit for use.

Passing over the divide from Slippery Rock to the waters of Camp run, near the eastern margin of the township, we find the *Darlington coal* has been mined to some extent along this stream, but it is there overshadowed in purity and importance by another coal which comes in the summits of the hills, 200 feet above.

This bed has been mined for a long time in a high knob on the land of Mr. Weimer, $\frac{1}{2}$ mile east from Pyle's mill, and descending from his bank we see the following succession:



No. 2 comes at the horizon of the *Brush creek coal*, and we have identified it with that stratum. It occurs at the same horizon as the "*Cable*" coal, on Little Connoquenesing in Butler county.*

The upper part of the bed has alternate laminations of bright pitchy bitumen and mineral charcoal, so that it often presents the appearance of a true *block coal*. The upper bench is separated from the lower by a layer of dark slaty shale, which varies from 3 to 6 inches in thickness.

The lower bench is a bright, lustrous and very pure coal, containing no visible sulphur, and is in high repute as a *smithing coal*, while the whole bed is greatly esteemed as a domestic fuel, and no one will use the Darlington coal if he can obtain this.

The bed is often very much cut up by "*clay veins*" and is subject to great irregularities, frequently thinning away entirely when followed in certain directions.

It is found only in the tops of the highest knobs, and the one in which it is mined by Mr. Weimer contains about 10 to 12 acres of it.

The Fire-clay immediately below the coal contains in some places a considerable quantity of *iron ore* in large calcareous nodules.

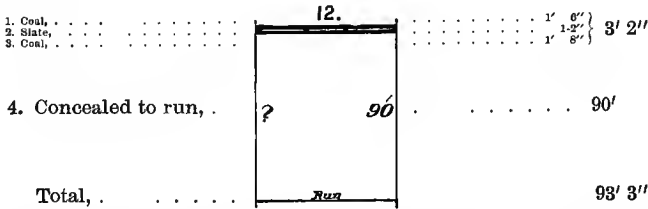
The *Freeport limestone*, No. 5, has been quarried and burned on the land of Mr. Weimer by Mr. Cuffert. It is a very hard, compact and bluish-gray rock, breaking with sharp conchoidal fracture, and having its surface frequently stained reddish with iron. It burns into a tolerably fair lime, but great care is required in the process to get it to slack well.

The *Darlington coal* is mined near the level of Camp run by Mr. Lutz. A slide had closed the mouth of the bank when I visited the locality, and the coal could not be seen, but I was informed that it was 2 feet 8 inches thick, with a parting of slate near its middle, and that it contained considerable sulphur, being much inferior to the "Weimer" coal opened in the hill-top above.

*See Report of Progress "Q."

Nothing was seen of the *Upper Freeport* in the section, and it probably does not exist, having thinned entirely away as it frequently does.

On Courtney's run, which puts into Slippery Rock a short distance above Wurtemberg, the *Darlington coal* is mined by Mr. Courtney, where it shows the following structure :



The coal is bright, pitchy, and comes out in solid rectangular blocks. It seems not to contain very much sulphur, and is reputed a good coal, though the upper portion appears rather slaty.

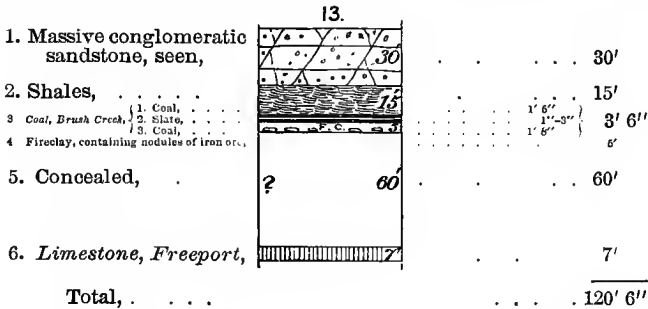
Summit Limestone.

Capping a high knob along the Portersville road, a short distance north from this, we find a slaty, slab-like limestone, dove colored, and filled with streaks of calcite, just like the one which occurs under the *Brush Creek coal* near the *Summit cut* on the *P. F. W. & C. R. R.*, in *Beaver county* (see "Q,") and there can be no doubt of their identity, since it comes 220 feet above where the *Darlington* was last seen near *White's saw-mill*, and then, below the limestone in question, we see another at 50 feet which would correspond to the *Freeport*.

On the opposite side of the hill from here, or further north along the *Portersville road*, we see a large coal blossom above the *Summit limestone*, which would correspond to the *Brush Creek coal*, and be the same as that mined at *Mr. Weimer's*.

Near the central line of the township, and north from its centre, some very high hills extend up 500 feet above the *Slippery Rock*, and take in several acres of the *Brush Creek coal* near their summits.

At Mr. Miller's opening in this coal we see the following :



The coal is very brilliant in its lower half, and pitchy black, somewhat soft, and an excellent smithing coal. The upper bench is filled with layers of mineral charcoal, and at Mr. Eckle's bank, near by, is a genuine "block coal," which could be used in the furnace in the raw state, and I am informed that it was so used at the Lawrence furnace, in Slippery Rock township. Mr. Francis also has this coal opened near Mr. Miller's.

The coal is in very high esteem for every purpose, as many people haul it a long distance in preference to using the *Darlington* which is at their doors.

The *Limestone ore*, scattered through the fire-clay in huge nuggets, represents the *Summit limestone*.

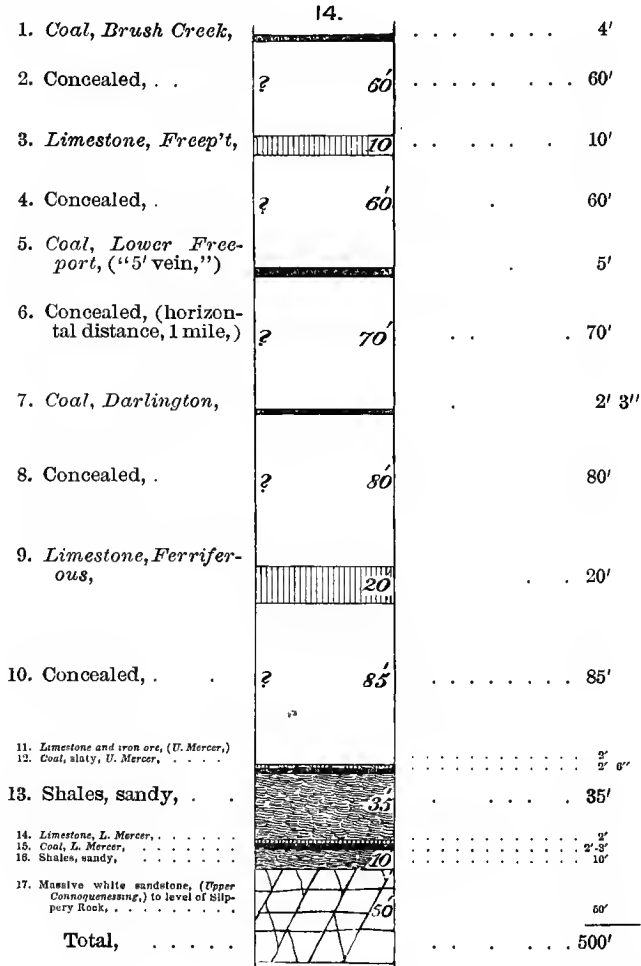
The *Freeport limestone*, No. 6, is seen at the spring-house below the old opening of Mr. Francis, and is a very massive compact rock. It has a clear ringing sound when struck, and breaks with a sharp angular fracture. It was once burned by Mr. Francis, and is said to slack well.

No appearance of the *Upper Freeport coal* was seen above it, though every thing was concealed and it could not have been seen if present, but it is doubtless absent.

Passing along the road west from Mr. Miller's bank and continuing on down to the Slippery Rock at Harris's Fording we obtain sec. Fig. 14.

The *Freeport limestone*, No. 3, occurs in the road a short distance north from Mr. Miller's coal bank, and is there seen to consist of four or five layers of limestone interstratified with fire clay. The limestone is of a grayish white

color, weathering buff on exposure, and breaks with an irregular sharp fracture. No coal was seen above it to represent the Upper Freeport.



The *Lower Freeport* is represented by No. 4, which is locally known as the "5' bed," and has been mined on the land of Mr. Thomas.

Water filling up the entrance from a choked drain, prevented my seeing the coal, but from the sulphurous appear-

ance of the water, it is most probably very impure. It is reported as burning well, however, but making considerable ash, from which it is to be inferred that the coal is slaty.

A farmer reported to me that he had seen a limestone immediately above this coal at one locality in the neighborhood, but I failed to find such a succession anywhere.

In passing over the concealed interval, No. 6, we go a horizontal distance to the west of one mile, but there is very little dip or rise of the strata in that direction here, and the interval is therefore approximately correct.

The *Darlington coal*, No. 7, is the one which we have seen mined all along the Slippery Rock at 80 to 100 feet above the Ferriferous limestone. It has here been opened in the Slippery Rock hills by Mr. Harris, and is apparently a fair coal, though a little inclined to be friable.

The *Kittanning coal* should come about midway in No. 8, but the interval is here entirely concealed and nothing was seen of it.

The *Ferriferous limestone*, No. 9, is very massive, and forms a steep bluff around the hill. It is filled with organic remains as usual.

The *U. Mercer limestone*, No. 11, is at this locality very ferruginous, and the upper part of it is an iron ore, in an irregular, nodular stratum. The lower part is dark, fetid and fossiliferous.

The coal below it, is very impure and slaty, and totally worthless.

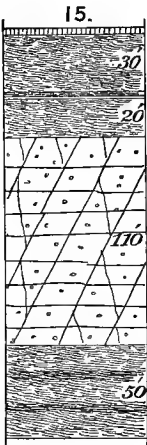
The *Lower Mercer limestone* is separated from this coal by 35 feet of dark sandy shales, and is seen finely exposed in a ravine, a short distance below the fording, where the lower part of this section was obtained. It is very hard and compact, of a dark blue color, and very full of fossils, principally *Productus*, *Spirifer*, and *Corals*.

The coal below it is likewise very slaty and impure.

No. 17 is very massive and is seen in perpendicular cliffs along the stream. It is a rather coarse, grayish-white, and very hard sandstone. It represents the upper portion of the Massillon sandstone of Dr. Newberry, and is the same

one which forms the cliff-rock or wall along the Connoque-
nessing between its mouth and that of Slippery Rock. No
pebbles were seen in it here. As we pass up Slippery Rock
from this point we find a great conglomerate sandstone
coming in and cutting out the *U. and L. Mercer lime-*
stones of the preceding section, and near Eckert's bridge
we get the following:

1. Limestone, <i>Ferriferous</i> , seen,	4'
2. Sandy shales,	30'
3. Black fissile slate, (<i>Clarion coal</i>)	1' 6"
4. Fireclay,	1' 6"
5. Sandy shales,	20'
6. Massive conglomerate sandstone,	110'
7. Bluish shales, contain- ing coaly shales at top down to level of creek,	50'
Total,	217'



The *Ferriferous limestone*, No. 1, is seen along the Portersville road, a short distance above where the new bridge crosses the deep gorge of Glenn's run. Only 4 feet of it was seen, and it does not appear to be much thicker.

No. 3 is exposed at a cutting in the road below, and is a very bituminous shale, which, in all probability, represents the *Clarion coal*, as it comes at the horizon where we generally find that stratum.

No. 6 attains an immense development at this locality, and Glenn's run, cutting down through its top, makes a perpendicular plunge of 50 feet over its most massive portion, amid a scene of the wildest grandeur.

The thickening up of a massive conglomerate rock at this horizon is analogous to what occurs at Homewood on the Beaver, except that there the massive portion extends up and cuts away the *Ferriferous limestone*, while here it ends at 50 feet below that stratum.

The *Upper and Lower Mercer limestones* and their accompanying *coals* are entirely absent, since this immense sandstone mass occupies the horizon where they should be found, as shown in the previous section, made only one and a half miles below.

The rock is quite coarse, and many portions are conglomeratic.

Just above Eckert's bridge a *coaly shale* is seen immediately below the sandstone, and then bluish sandy shales succeed to the level of the stream.

Near the center of the mass occurs a *plant bed*, in which were seen fragments of *Lepidodendron*, *Cordaites*, and *Pecopteris nervosa*.

About half way between Eckert's bridge and Wurtemberg, on the Slippery Rock, we come to the "Slippery Rock oil district," and descending from the "Summit," or Brush creek coal, at Mr. McCrackin's, to the creek at the iron bridge, or central portion of the oil district, we obtain section Fig. 16.

The *Brush Creek coal*, No. 1, was once opened by Mr. McCrackin, but it was so near the summit of the hill that there was a very poor roof above, and the coal was inferior.

Mr. McCrackin also states that he once opened a coal at the horizon of No. 5, and mined it for some time. He reports it as being 3 feet thick, and a tolerably fair coal, though somewhat slaty.

Mr. McCrackin is very positive that the coal is *below* the *limestone*, yet this is such an unusual feature in the section that it is more probable that the coal comes immediately above the limestone, as it ought to do, when it would be the *Upper Freeport*.

At the locality where Mr. McCrackin showed me his old drift in this coal everything else was concealed, and it was not possible to decide whether the coal should be placed *above* or *below* the *limestone*. It is possible that there may be a local coal at the horizon indicated, but the probabilities are in favor of its being above the limestone.

No. 7 is the *Lower Freeport coal*, and was once dug into by Mr. Armstrong, who reports it as impure and only one

foot eight inches thick. Its blossom is seen at the roadside as we descend the hill to Slippery Rock.

16.		
1. Coal, <i>Brush Creek</i> ,		3' to 4'
2. Concealed, .	? 60'	. . 60'
3. Limestone, <i>Freeport</i> ,	10'	. . . . . 5'
4. Shales, . . . . .		. . . . . 10'
5. Coal, (1) reported, . . . . .		. . . . . 8'
6. Concealed, .	? 70'	. . 70'
7. Coal, <i>Lower Freeport</i> ,		1' 8"
8. Concealed, .	? 60'	60'
9. Coal, <i>Darlington</i> ,		3'
10. Concealed, .	? 45'	. . 45'
11. Coal, <i>Kittanning</i> ,		. Blossom.
12. Concealed, .	? 125'	. 125'
13. Coal, <i>Upper Mercer</i> ,		. . . 2'
14. Shales,	35'	. . . . . 35'
15. Limestone, <i>Lower Mercer</i>, . . . . .		. . . . . 2'
16. Coal, <i>Lower Mercer</i>, . . . . .		. . . . . 2'
17. Shales,	15'	. . . . . 15'
18. Massive sandstone, (Upper Connoquenessing,)	40'	. . . . . 40'
19. Concealed to level of Slippery Rock, .	10'	. . . . . 10'
Total,		492' 8"

The *Darlington* coal, No. 9, is mined at the roadside by Mr. Armstrong, and is a very good coal for steam purposes, but contains considerable sulphur—enough to unfit it for smelting.

The *Kittanning* coal has not been proven here, but its blossom is seen in the road, and it is probably 2 feet thick.

The *Ferriferous limestone* is concealed in No. 12, since, on the opposite side of the stream, it is seen 10 to 15 feet thick at this horizon.

No. 13 is a very impure, slaty coal, which comes at the horizon of the one usually found beneath the *Upper Mercer limestone*. It was once opened here, but was found to be too impure for use.

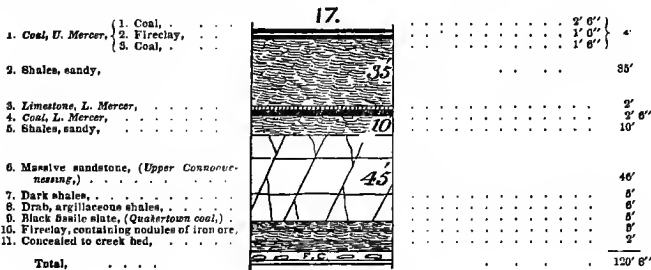
The *Lower Mercer limestone*, No. 15, is a dark-bluish, very hard and compact rock, which is crowded with fossils, and has the characteristic features of that stratum wherever seen along the Slippery Rock.

Immediately below it comes the *Lower Mercer coal*, which, though somewhat slaty, is still much better than the *Upper Mercer* above, and has been mined for use in running the engines at the oil wells in some instances.

No. 18 is the upper part of the *Massillon sandstone* of Newberry, and is here a very hard, massive, grayish-white rock, tolerably coarse, stained with iron, and stands out in perpendicular cliffs along the stream.

At Wurtemberg, three miles below, its top is in the bed of the stream, but on ascending the creek it rises to the northeast much faster than the stream, and carries the *Lower Mercer limestone*, which at that village is only 10' above water level, up to 65' above the same at this locality.

A short distance above the iron bridge we see the following in descending a ravine to Slippery Rock :



The *U. Mercer coal*, No. 1, is here seen to be double bedded, with a very hard silicious stratum of fire clay separating the upper and lower benches. The coal is slaty

and well nigh worthless, and has seldom been used except in a few cases when nothing else could be had.

Nothing was seen of the *U. Mercer limestone* above this coal, and it is probably absent, though two miles below, it occurs in the section, as well as one and a half miles above this locality.

No. 4, the *L. Mercer coal*, has been mined at this locality, and is reported as varying in thickness from 20 to 36 inches. It is rather slaty and impure.

No. 9 represents the coaly shale which is seen under the *Upper Connoq. sandstone* at the mouth of Slippery Rock and along the Connoquenessing, and comes at the same horizon as the *Quakertown coal*, seen on the Mahoning river.

The bed of fire-clay below it contains many nodular masses of calcareous iron ore.

No. 6 is very massive here, and is seen in immense cliffs where the ravine cuts through it.

Slippery Rock Oil Field.

About midway between Eckert's bridge and the mouth of Slippery Rock occurs the Slippery Rock oil territory. The first oil was obtained here soon after petroleum was discovered in such immense quantities on the Allegheny river and its tributaries. About the first well to obtain it in paying quantities was the Lawrence, and the amount that it has produced up to the present time is variously estimated at from 25,000–40,000 barrels. It still produces a small quantity when another well near it is also pumped, but if the Lawrence alone is pumped nothing but water is obtained.

Soon after the first oil strike at the old Lawrence well others were rapidly put down in every direction, and as rapidly abandoned to their fate when not productive. By this injudicious boring and abandonment of wells the territory was almost ruined from the access of water driving the oil back, and "water-logging" the oil rocks, as it is termed, thus preventing the accumulation of the oil.

The most of the wells commence 10 to 20 feet above the

Three Oil Well borings in Lawrence Co. compared.

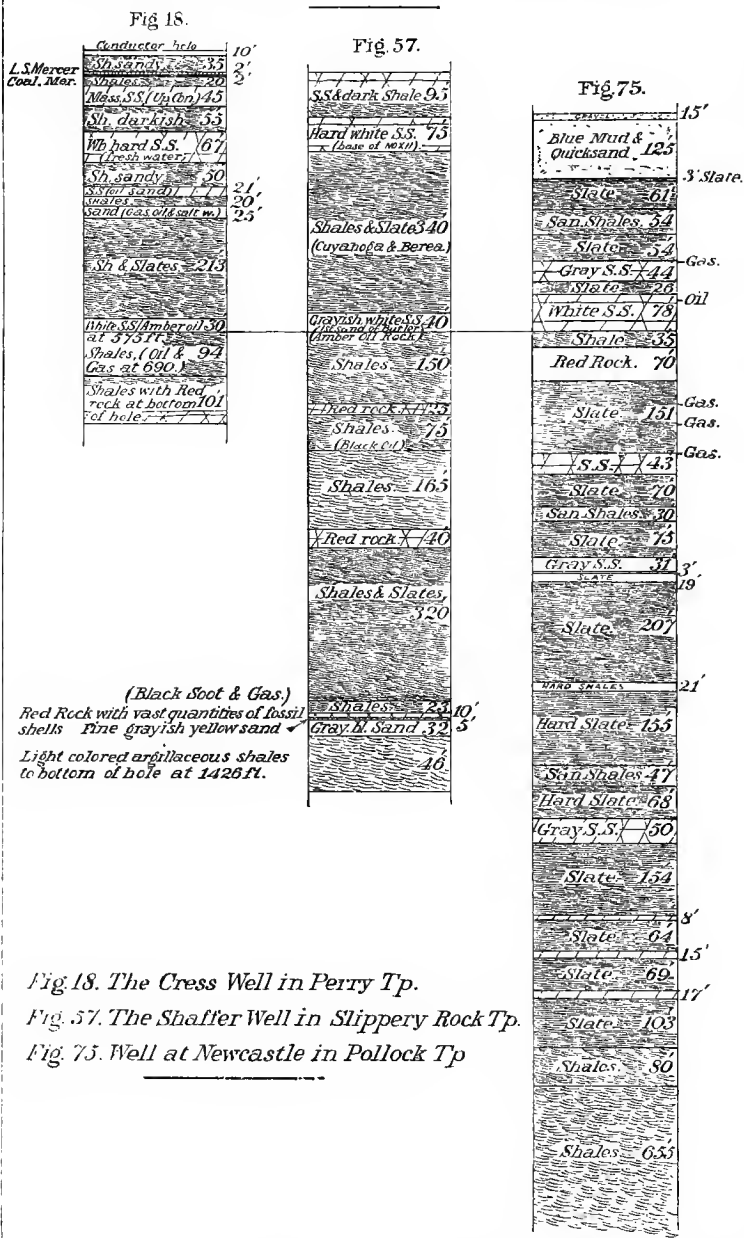


Fig. 18. The Cress Well in Perry Tp.

Fig. 57. The Shaffer Well in Slippery Rock Tp.

Fig. 75. Well at Newcastle in Pollock Tp

level of Slippery Rock, and obtain the oil at 190 to 200 feet. When the price of oil took so great a fall, after the discovery of the Butler oil fields, nothing more of any consequence was done here until 1876 and 1877, when a company under the superintendency of Mr. George Dimmick, an experienced oil operator, undertook to reclaim the territory by pumping on a large scale so as to exhaust the water, at the same time having cleaned out and plugged up many of the old holes in the vicinity.

Mr. Dimmick drilled two wells, of which he kept systematic records, and kindly placed them at my disposal.

The Chew well was drilled at the turn of the road below the iron bridge, and commenced at the top of the *U. Mercer coal*, 40 feet above the *Lower Mercer limestone*. The following is a record of the strata passed through in this well:

1. Conductor hole,	10'
2. Shales, sandy,	35'
3. <i>Limestone, L. Mercer,</i>	2'
4. <i>Coal, L. Mercer,</i>	2'
5. Shales,	20'
6. Massive, hard sandstone, (Upper Connoquenessing,)	45'
7. Shales, darkish,	55'
8. White, hard sandstone, (fresh water,)	67'
9. Shales, sandy,	50'
10. Sandstone, (oil sand,)	21'
11. Shales,	20'
12. Sand, (gas, oil, and salt water,)	25'
13. Shales and slates,	213'
14. White sandstone, (Amber oil at 575,) (first S. S.,)	30'
15. Shales, (with oil and gas at 690,)	94'
16. Shales, with red rock, at bottom of hole,	101'
Total,	790'

No oil of any consequence was obtained from this well.

No. 10 is the representative of the oil sand in which the Slippery Rock oil is obtained, and is seen, in this record, to come 239 feet below the *Lower Mercer limestone*, which puts it in the "Cuyahoga shale."

No. 8 is the base of the Conglomerate series proper, since the bottom of this stratum comes 190 feet below the *Lower Mercer limestone*.

The oil obtained at this horizon is a heavy lubricating oil of 30 to 36 gravity, and has never been found in greater

quantities than a fifty barrel well, while the most of them now in operation yield only 2 to 10 barrels per day, though in June, 1877, Mr. Wallace of New Castle struck what was at first a 30 barrel well, and which has since been doing 15 to 20 barrels per day.

The oil is hauled in wagons to New Castle, a distance of 10 miles.

The Lawrence well has yielded about 40,000 barrels of oil, all told, but is now not yielding any, owing to access of water from a well a short distance above it.

When both these wells are pumped the Lawrence well obtains oil, and the other one gets nothing but water, so the owner of the upper well very soon tires of producing oil at his own expense for his neighbor; and, on ceasing to pump, the water again drowns out the former, the one pump not being capable of exhausting the water from the well.

The owner of the upper well acting the part of the "Dog in the Manger" refuses to pump his well, and will make no arrangements with the Lawrence men whereby they might pump it, so that both wells are now valueless.

The trend of the oil-bearing rock seems to follow pretty nearly the course of the stream, as no successful wells have ever been found away from it, though very few have been drilled. The course of the stream is about S. 35 W.

2. *Wayne Township.*

This lies west from Perry, south from Slippery Rock and Shenango townships, and borders Beaver county on the south.

Its principal draining streams are the Slippery Rock, Connoquenessing, and Big Beaver

The Slippery Rock flows along its eastern border, and receives no tributaries whatever from this township except small streams which plunge down its rocky sides, or cut deep ravines through the same. Near the southern margin, however, it meets the Connoquenessing, which, from that point, flows west to the Big Beaver, reaching it at the Beaver county line.

The Big Beaver flows along the western border of the township and forms its boundary.

The tributaries of these principal streams are all small, and have a very rapid descent from the highlands on the north to the Connoquenessing and Big Beaver on the south and west.

This township is the most highly favored, in regard to its mineral wealth, of any in the county, since it contains inexhaustible stores of coal, limestone and iron ore.

The *Darlington coal* is accessible over nearly its entire area, while the great *Ferriferous limestone* spreads over it in a continuous sheet 15 to 25 feet thick.

Resting immediately upon this last stratum, we find at numerous localities in the township vast deposits of iron ore, which attain at one locality a maximum thickness of 22 feet!

The highest stratum exposed in this township is the *Brush creek coal*, and the lowest is the horizon of the *Sharon coal*, there being an interval of more than 600 feet of rock between the two.

In the northeastern portion of the township a very high knob extends up 550 feet above the level of the Slippery Rock, and in its summit takes in two or three acres of the *Brush creek coal*, which is the only area of that stratum in the township.

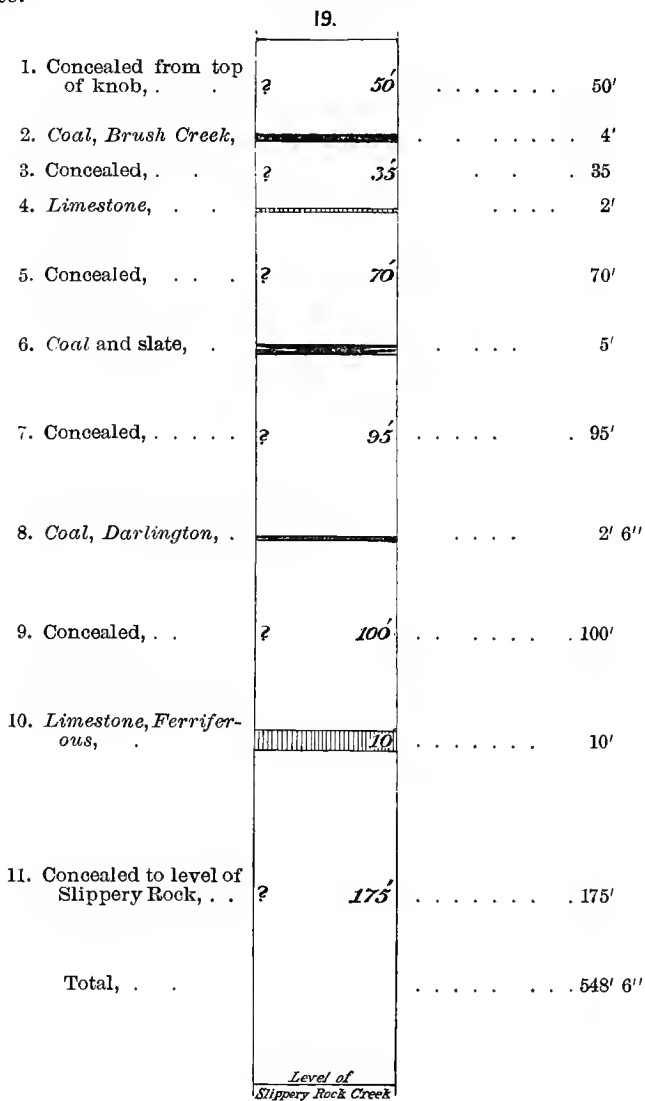
The coal has been mined on the land of Mr. Foy, and descending from his opening to Slippery Rock, we get section, Fig. 19.

The *Brush creek coal*, as will be seen from the section, is here nearly 500 feet above the creek. It is mined occasionally by Mr. Foy, but being near the surface has, of course, deteriorated greatly, so that it is quite slaty now, and probably never was a good coal at this locality. It contains a band of slate near its middle.

No. 4 is seen along the road near Mr. Foy's, and he informs me that in sinking a well he once passed through it and found it to be 2 feet thick.

It is a light gray limestone, and tolerably compact. This stratum comes at a very perplexing horizon, since it could

hardly be the *Freeport limestone*, which was seen on the opposite side of the creek only two miles away, at an interval of twice this below the same coal. It is very probably a new element in the series, coming in locally at this horizon, though, of course, it is possibly the *Freeport limestone*.



The *Upper Freeport* coal is concealed in interval No. 5, if the former limestone be not the *Freeport*.

No. 6 comes at the horizon of what is called the "5 foot vein" in this neighborhood, and is, very probably, the *Lower Freeport coal*. It was once opened on the land of Mr. Foy, but was entirely worthless on account of its impurities of slate, &c.

No. 8, the *Darlington coal*, has been mined here by stripping on a little stream which passes through the land of Mr. McQuiston. It is a very good coal, and is used by the smiths of the vicinity.

The *Ferriferous limestone* is seen extending along the hill in a line of cliffs.

The *Darlington coal* is also mined on a small scale near *Glasser's Fording* by Mr. Freshcorn, but it is there only one and a half feet thick, and very impure at that.

Near the northeastern part of this township we come to the Slippery Rock oil region, and the Wallace well, to which we referred in the description of Perry, was struck on this side of the stream.

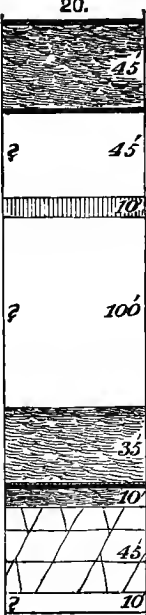
Descending the hill from Mr. Frew's coal bank to the creek at the iron bridge, we get sec., Fig. 20.

The *Darlington coal* is mined here quite extensively to supply the oil engines along the creek below. It is a rather soft, pitchy-black and lustrous coal, containing very little pyrites, and is in excellent repute.

Below it we pass over 45 feet of shales and flaggy sandstone, when we come to the *Kittanning coal*, which makes its appearance in a broad band of smut across the road. It has never been mined here, so that nothing is known of it except that Mr. Frew once dug into it and reports it as 2 feet thick, but somewhat slaty. It should be further tested, as it is often a valuable coal.

The *Ferriferous limestone*, No. 10, is well exposed in its upper part, along the ravine which here puts into Slippery Rock. It is the same bluish-gray, shriveled, and shelly limestone which we so often find it when of considerable thickness. The bottom of the stratum was not seen, and

it is probably much thicker than the exposed part would indicate. It is filled with fossil remains.

	20.	
1. Coal, <i>Darlington</i> ,		2' 6"
2. Shales,	45'	45'
3. Coal, <i>Kittanning</i> ,	2'	2'
4. Concealed, .	45'	45'
5. Limestone, <i>Ferriferous</i> ,	10'	10'
6. Concealed, .	100'	100'
7. <i>Coaly shales, U. Mercer</i> ,	5'	5'
8. Sandy shales,	35'	35'
9. Limestone, <i>L. Mercer</i> ,	1'	1'
10. Coal, <i>L. Mercer</i> ,	2'	2'
11. Shales,	10'	10'
12. Sandstone, massive (<i>Upper Connoque- nessing</i> ,) . . .	45'	45'
13. Concealed to cree level,	10'	10'
Total,		312' 6"

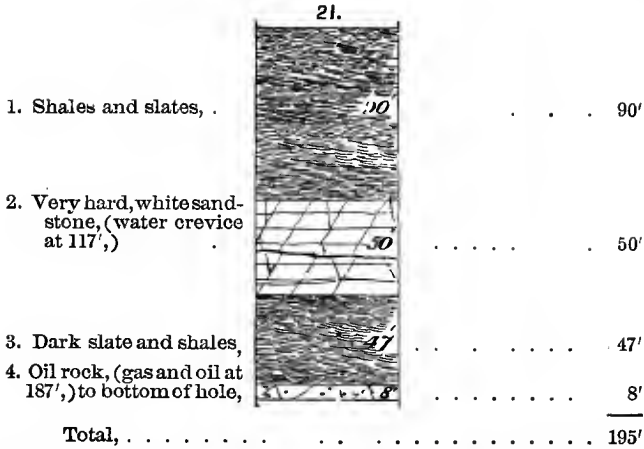
No. 7 represents the *U. Mercer coal*, and is here a mere mass of coaly shale and bituminous slate.

The *U. Mercer limestone*, which should appear with it, seems to be absent both here and on the opposite side of the creek, in Perry township.

The *Lower Mercer limestone* is a dark blue, richly fossiliferous stratum, and the coal below it is so slaty and impure as to be entirely worthless.

The *Upper Connoqueenessing sandstone*, No. 12, is very heavy bedded, and extends along the creek in huge cliffs; no pebbles were seen in it, however.

At the base of this sandstone, 50' below the *Lower Mercer limestone*, the "Wallace well" commences and attains its oil at 190 feet. The driller gave me the following record of the boring, which he had kept very carefully, as he stated, sec., Fig. 21:



This shows that the oil very probably comes in some portion of the Cuyahoga shale, probably in the *ferriferous sandstone*, which is exposed 50 feet below the base of the Conglomerate at Sharon, and northward, and is often massive, very coarse, and contains, where exposed at the surface, a great many cavities, occupied by iron balls and other concretions.

No. 2 is doubtless the base of the Conglomerate. It is called the "Mountain Sand" by the oil men here, and is represented to be very hard and white, and also contains pebbles.

The well drilled by Mr. Wallace, of New Castle, was at first thought to be a fifty barrel well, but its greatest run was only about thirty barrels per day, and it very soon ran down to 20, and then 15, and finally settled at 10. The oil is 30 gravity, and is a fine lubricating oil.

This well was struck in June, 1877, and gave a great stimulus to the oil industry of the region, which had been languishing for a considerable time.

There is undoubtedly plenty of oil here, if the territory could only be developed carefully and scientifically by skillful operators.

As we pass down Slippery Rock from this point the strata dip down faster than the stream falls, and when we come to Wurtemberg the *Upper Connoquenessing sandstone*

has got below water-level and the *Lower Mercer limestone* is only 8 feet above, but as we pass down to the mouth of Slippery Rock from this point the strata rise very rapidly to the southwest, and at the mouth of Slippery Rock, one mile below, the base of this sandstone has emerged from the water, and the *Lower Mercer limestone* is thrown 70 feet above the same.

From this point, as we go down the Connoquenessing, the same sandstone gradually rises until near the mouth of Smiley's run its base is 40 feet above the creek, and keeps from 40 to 60 feet above the stream until we come to its mouth at the Big Beaver.

All along this line it is 45 to 50 feet thick, and immensely massive; huge blocks of it larger than a common house cover the steep bluffs, or block up the channel of the stream.

On either bank may be seen a long line of cliffs, which hem in with narrow walls the wild and rapid Connoquenessing.

About one and a half miles below the mouth of Slippery Rock a sharp roll in the strata brings to-day the lowest rocks seen in the township, and at this point we obtain sec., Fig. 22.

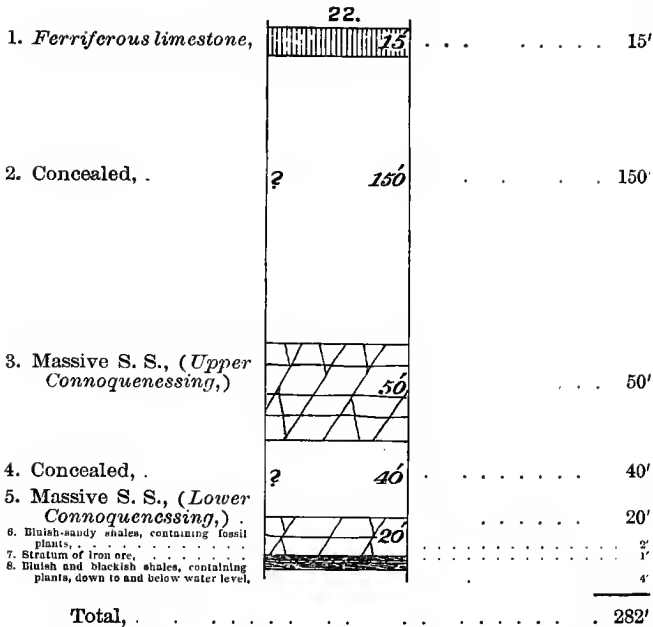
No. 1 occurs in the high hills which border the Connoquenessing on the north, and $\frac{3}{4}$ mile back from this locality. It is very massive, and makes a cliff around the hill.

No. 3 is the same massive rock which is seen at the mouth of Slippery Rock, and which forms the massive top-wall rock all along the Connoquenessing. Immense blocks of the same are here scattered over the slopes of the hillside, many of them being 30 feet long, 20 wide, and 15 thick. The rock is rather coarse but not conglomeratic.

No. 4 consists mostly of sandy shale, with a coaly slate at top, as is seen a short distance below this locality. This bituminous slate represents the *Quakertown coal*.

No. 5 is a coarse, brownish, iron-stained rock, which represents the lower part of the Massillon sandstone of Newberry.

No. 6 contains many vegetable fragments, and in it occur *Cordaites*, *Cardiocarpus*, and *Trigonocarpus*.



In No. 8 were seen *Alethopteris grandifolia*, *A lonchitica*, *Odontopteris neuropteroides*, *Sphenopteris macilentia*, and other forms characteristic of the *Sharon coal*, and near water-level the shale contains streaks of coal interlaminated with it, so that here there may possibly be a small area of the *Sharon coal*, which might be of available thickness. The coal bed, if present, would probably come 20 feet below the creek at this locality. The section itself, as well as the fossil plants found in this stratum, shows that these are the roof shales of the *Sharon coal*.

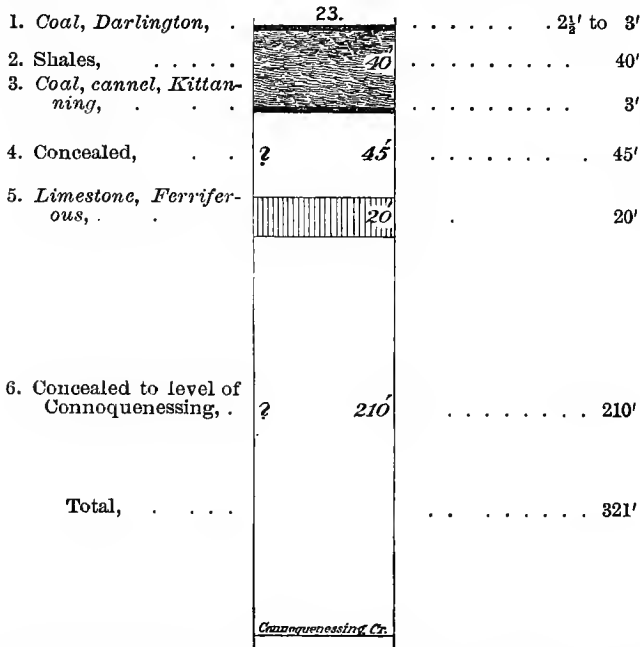
No. 7 is a stratum of calcareous ore, and comes at the same horizon as that which has been so extensively mined in the past along the waters of the Mahoning river, above the "*Block coal*."

About one mile below this we come to Jones' bridge across the Connoquenessing, and north from it in the bordering hills the *iron ore*, which comes immediately on top of the *Ferriferous limestone*, has been extensively mined, and taken to old Homewood furnace, as well as to

Wampum furnace. The ore varies in thickness from 1 to 3 feet, and is quite good.

The *Kittanning sandstone* is seen in a massive ledge immediately above the ore. This is on the land of Mrs. McClain.

Below this about one mile we get sec., Fig. 23 in descending to the Connoquenessing from the land of Mr. Ballou :



The *Darlington coal* is mined by Mr. Ballou, and is reported to be a very good coal, and used by the smiths. There is a parting of slate a few inches above its bottom.

The *Kittanning coal* has here locally changed to a bed of *cannel*, which Mr. Ballou once opened and reports to be 3 feet thick, with a parting of slate 6 inches thick near its middle. He also reports it as burning quite well, but making considerable ash.

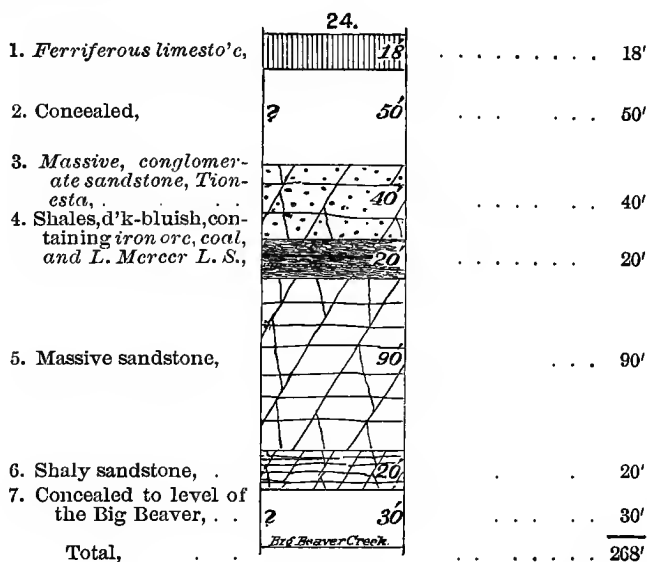
The *Ferriferous ore* also occurs on the land of Mr. Ballou, and he says that it is most persistent around the outcrops of the *limestone*.

A short distance southwest from this, at the mouth of the Connoquenessing, occurs what is known as "Rock Point." It is the narrow neck of land between the Connoquenessing and Big Beaver, which is capped at top by the massive Connoquenessing sandstone, and which rises in a bold vertical cliff forming the "Point."

The wild and attractive scenery in the vicinity is greatly admired, and the "Rock Point Hotel," at the foot of the hill, was built to accommodate the summer tourists to this locality.

About one and a half miles above "Rock Point" a considerable stream, which we shall call Hennen's run, puts into the left bank of the Big Beaver, and passing over No. XII in a series of falls exposes the same very finely.

Descending from the hill above we get section, Fig. 24 at this locality :



No. 3 is the Tionesta sandstone, and is here very conglomeratic, many of the pebbles being as large as hickory nuts. This is the same rock which, by developing upward from its top, reaches such an immense thickness at Home-wood, five miles below.

The shales below this rock contain the carbonate ore which was so largely used at the old Homewood furnace, and also at Wampum in former times. The ore comes immediately upon the *L. Mercer limestone*, and this latter rock is at times converted into an ore itself.

The limestone is very fossiliferous, and in the blocks of it which lie on the dump at the mouth of the old drift were seen *Spirifer cameratus*, *Productus longispinus*, multitudes of *Crinoidal fragments*, and some *Bryozoan corals*.

Neither the ore, the limestone, nor the coal were seen by me in bed, but fragments of all are scattered over the dump at the mouth of the drift, and a miner who had worked in the drifts at one time gave me their succession. He stated that the coal came immediately below the limestone, and was very slaty, seldom more than one foot thick, and often less.

This represents the *L. Mercer coal*, and is the same as the small bed seen below the *L. Mercer limestone* at Wampum station.

The shales which contain the ore, limestone, &c., are of a dark blue color, and coming with the ore are many calcareous nodules which possess the "cone-in-cone" structure.

No. 5 is the *Upper Connoquenessing sandstone*, or part of the Massillon of Newberry. It forms a vertical cliff along the Beaver at this locality, and the whole 90 feet is broken by only a small layer of shale near its center, and the rest is a very massive, grayish-white and tolerably coarse sandstone, but no pebbles were seen in it.

No. 6 is a shaly sandstone with layers of argillaceous shale coming in it.

At Chewtown, one mile above this last locality, we find a very broad and handsome terrace, 160 feet above the level of the Beaver. Its top and slopes are covered with rounded and angular boulders of sandstone, granite, gneiss, and other crystalline rocks.

No intermediate terraces can be seen here, except the one which comes 30 to 40 feet above the river, and forms its flood plain.

Passing up Hennen's run, we find the Ferriferous lime-

stone jutting out along the hills on either side of the stream in a long line of huge blocks, or bold cliffs, and immediately above it comes the *iron ore* which has been stripped out and largely used at Wampum furnace. On the land of Mrs. McCallum, $1\frac{1}{4}$ miles east from Chewtown, this ore attains a thickness of 3 feet, and is now mined and taken to Wampum.

Great Development of the Ferriferous Ore.

At the head of one branch of Hennen's run, near the center of the northern line of the township, the *Ferriferous ore* expands wonderfully in thickness, and attains such enormous dimensions as to replace the limestone itself.

On the land of Mr. Houk, at one of these ore drifts, we get sec., Fig. 25.

This immense deposit of ore was discovered a few years ago.

At the Houk & Grannis drift, or, the "Big bank," it was found 22 feet thick at one locality, replacing the *Ferriferous limestone* entirely, as this is the thickness of the latter stratum in the vicinity.

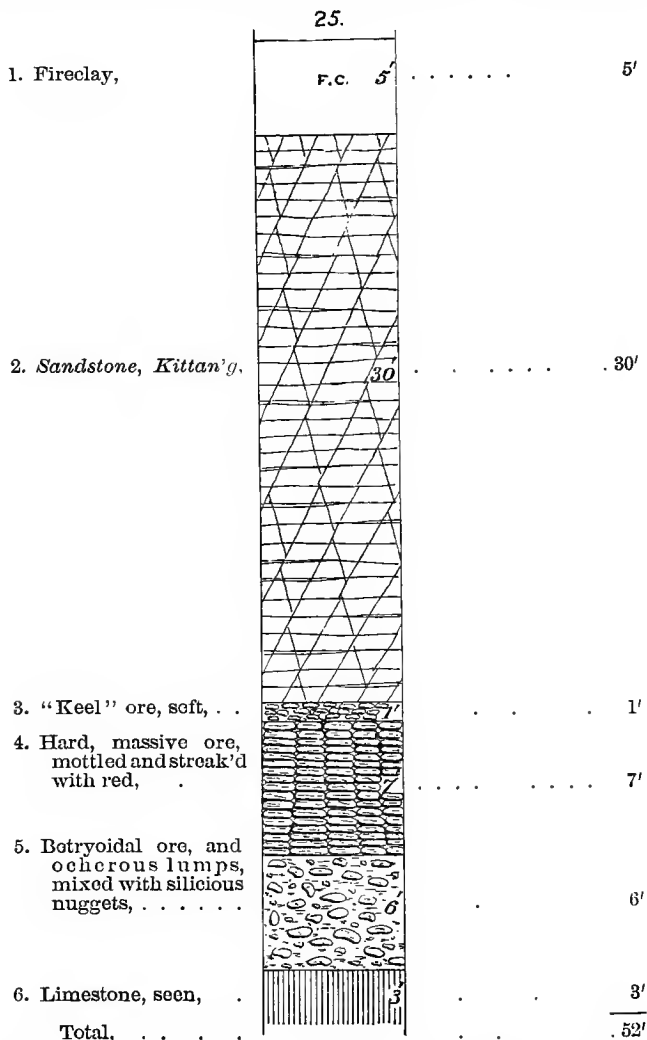
The locality was pointed out to me where this immense development was found, and there I saw still remaining the wall of *Ferriferous limestone* against which the ore abutted. The face of the limestone was smooth, and the ore ceased immediately where the limestone commenced.

It is a very common thing for the limestone to come in and cut away a considerable portion of the ore, and sometimes nearly all; and again in the midst of the ore we often find lenticular or irregular masses of limestone wholly unchanged.

This gives a possible clue to the origin of this vast local development, which was most probably after the following manner:

First. It is well known that immediately above the limestone in question is a very persistent iron ore horizon over a wide area, not only in this township and county, but at many other localities in West Pennsylvania. This deposit

which is usually in the form of nodules, or "plate ore," is not generally more than 1 to 2 feet thick, and often less.



Now it is well known that water charged with carbonic acid very readily dissolves and carries off lime in solution. This would remove the limestone and form the fissures and cavities in which we now find the ore. "But how," asks

the miner, "did the ore get into these pockets and cavities?" Very simply and easily; water flowing over the sheet of iron ore, which so often covers this limestone, takes up the iron from it in solution, and carries the same along, until being fully charged it passes into one of these caverns near the outcrop, and deposits the iron in the previously formed cavities, or the limestone may have been removed *pari passu* with the bringing in of the ore.

Of course, this is merely gathering up the widely distributed ore by natural processes and heaping it more into one mass, much to the convenience of the operator and miner.

The dip is here to the south-west, and consequently the drainage would naturally follow the dip of the strata, and as confirmatory of the local origin of this deposit, we find its greatest development along the south-west outcrop of the limestone, and decreasing as we follow it into the hill, while just across on the south-west side of the stream, where the dip and drainage would be away from the outcrop of the limestone, we find no ore whatever.

If this theory, as to the origin of the bed be true, the ore will probably thin away very much when followed a considerable distance to the north-west.

On the side of the hill, which faces directly south at the "Joseph Houk mine," the ore is only 5 feet thick, and in the same vicinity it runs down to 2 feet.

There are only about three farms on which the ore is found of a thickness of 5 feet and upwards, and the whole area would probably not include more than 200 acres, which from the causes that we have indicated may prove much less.

A narrow gauge railroad has been built out to it from Chewtown by the Lawrence Ore Company, and the ore is being mined extensively, and shipped to the furnaces in the Mahoning valley.

Along Smiley's run, the great *Ferriferous limestone* is seen outcropping on either side of the stream in a bed 20 to 25 feet thick, and above it 80 to 90 feet comes the *Darlington coal*, which has frequently been opened by the farmers,

and is from $2\frac{1}{2}$ to 3 feet thick. It contains considerable sulphur in these localities however, and is rather inferior.

This township is very rich in mineral wealth, as the Ferriferous limestone, 15 to 25 feet thick, extends over the most of its surface, while the valuable deposits of iron ore at this horizon seem to be quite persistent in the township, and, no doubt, many more rich deposits like the Huok bank will be found when the country is properly explored. We would advise the farmer to explore always the outcrops which face the west and south, as being more likely to contain these deposits from causes which we have already suggested.

3. *Big Beaver Township.*

This lies west from Wayne, and also adjoins the Beaver county line.

The Big Beaver river flows along its eastern boundary, and cuts far down into No. XII, in fact nearly to its base.

This is the only stream of any importance, since the only tributaries of the Beaver in this township are two small runs putting into it at Wampum.

The north fork of Little Beaver passes through its southwest corner.

Back from the Beaver the hills rise very high, and in some of their summits take in the *Upper Freeport coal*, so that the section extends from the base of No. XII up into the base of the *Barrens*, a distance of 600 feet.

This township is also very rich in mineral resources, for while it has not the iron ore deposits of Wayne, it has the great *Ferriferous limestone* spreading over its entire northern half, and the *Darlington coal* attains a purity and thickness unknown to that bed in Wayne.

And, in addition, this district has the E. and P. R. R. running along the outcrops of these deposits from north to south, thus affording a ready and convenient outlet for the products of the mines.

The *Darlington coal* is more extensively mined here than in any other area of equal extent in the county. It was formerly supposed to be the *Kittanning coal*, but, as I have shown in "Q," the latter coal thins away in coming up the

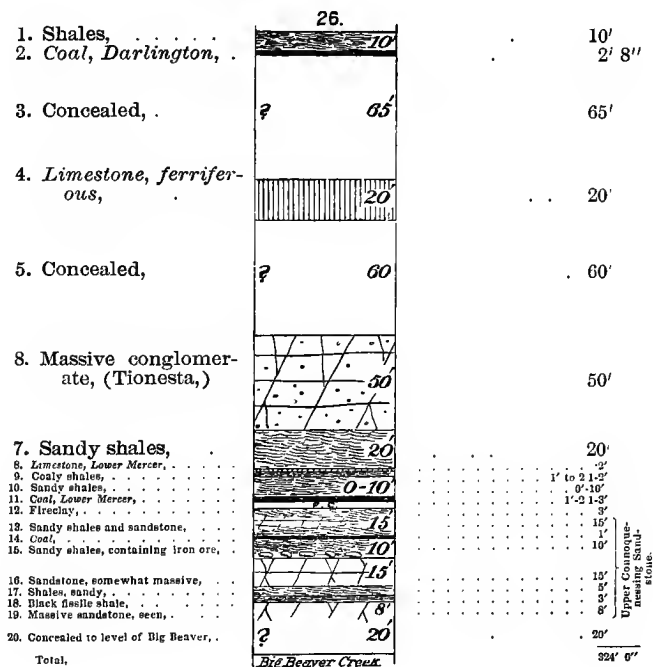
Beaver from New Brighton, and appears here as a slaty coal, only 12 to 18 inches thick, while the *Darlington*, which at New Brighton, is too thin to mine, thickens up and becomes the very pure coal at Clinton, and all along the Beaver in this township.

A short distance above Wampum the *Tionesta sandstone* commences to thicken up as we pass down the Beaver, and is seen in vast cliffs along this stream between Wampum and Clinton, making the scenery on the Big Beaver very picturesque and attractive.

On its top, about 160 to 200 feet above the river, is a broad level area along which the R. R. passes, and extends nearly one mile back from the stream in many places.

The Tionesta sandstone is an excellent building stone, at many points along this line, though often very conglomeratic.

At Wampum, we get section, Fig. 26, in descending from the coal works of Jno. K. Shinn & Bros. :



The *Darlington coal* has been mined to a considerable extent at Mr. Shinn's bank, and was formerly shipped extensively on the E. & P. R. R. The coal is very black and pitchy in luster and contains very little pyrites.

The interval, next below the coal, is here entirely concealed, though I was informed by a miner that he had once seen a small coal near its center, where a slip occurred a short distance south. This would be the *Kittanning coal*, which is here thin and has never been opened.

No. 4, the *Ferriferous limestone*, has been very extensively quarried at this locality, and shipped as a flux to the furnaces in the valley, but the quarries are not now in operation.

The limestone varies from 15 to 25 feet in thickness, and the upper two-thirds is a light gray, fragile rock, and very brittle, coming off in shelving layers.

The lower part is blue and somewhat earthy, and was not taken out, as the furnace men reject it.

Both portions are very fossiliferous, and many of the fossils have weathered out of their limestone matrix, and lie loose among the piles of débris, and limestone chips of the quarries. I recognized the following species at this locality: *Spirifer opimus*, *S. cameratus*, *S. lineatus*, *Productus longispinus*, *P. Nebrascensis*, *P. semireticulatus*, *Athyris subtilita*, *Euomphalus rugosus*, *Hemipronites crassus*, *Chonetes mesoloba*, *Nucula ventricosa*, *Pleurotomaria carbonaria*, *P. Grayvilleiensis*, *P. turbinella*, *Platyceras tortum*, *Bellerophon carbonarius*, *B. percarinatus*, *Macrocheilus primigenius*, *M. ventricosus*, *Polyphemopsis peracuta*, *Lophophyllum proliferum*, *Synocladia biserialis*, *Zacrinus mucrospinus*, besides innumerable *Crinoidal stems*, and many fossil molluscs, which I could not determine in the field.

The limestone has been used at the works of the "*Wampum Cement Company, Limited*," operated by Jno. K. Shinn & Bros., in the manufacture of a superior article of cement.

The company is now erecting large works and intend to carry on the business quite extensively.

The limestone is burned and pulverized, and then undergoes a mixing process with a clay which is obtained on the terrace deposits of the vicinity.

The proportions of clay and limestone and the various manipulations required in the process are the result of many experiments of the Shinn Bros., and are, of course, secrets of the firm.

Their object was to take two substances, and so combine them as to form a mixture of the same composition as the Portland cement. To this end they had thorough analyses made of their limestone and of the clay, and by mixing the two in a certain proportion they claim to get a cement even superior to the Portland.

The firm received an award for their products at the U. S. Centennial Exhibition.

The cement weighs 132 lbs. to the loose bushel, or 164 to the *struck* bushel—shaken.

The firm has many letters commending the cement, from those that have used it, among whom is Gen. Gilmore of the Engineer corps.

Mr. Jno. K. Shinn kindly placed at my disposal, the following analyses of the *Ferriferous limestone*, which were made for him by Robertson Bros., Analytical Chemists, of Pittsburg, Pa. :

I. Specimen from top of the stratum.

II. " " middle " " "

III. " " bottom " " "

	I.	II.	III.
Silica,	4.50	4.14	2.31
Sulphur,	0.06	0.20	0.17
Alumina, . . . . .	.20	0.21	0.24
Phosphoric acid, . . . . .	.07		0.04
Sesquioxide of iron,	1.77	1.77	1.18
Oxide of manganese, . . . . .	.20	1.20	0.22
Lime,	49.31	50.16	52.04
Magnesia, . . . . .	.75	.42	.43
Carbonic acid,	40.54	39.87	41.72
Water and organic matter,	2.59	2.03	1.65
Totals,	100.00	100.00	100.00

From the analyses, it will be seen that the limestone from

the different parts of the bed is quite uniform in composition, if it were truly represented by the specimens analyzed.

The per cent. of phosphorus is seen to be very small.

These analyses do not disclose any reason why the lower or blue (III) portion of the limestone should be rejected by the furnace men, and Mr. Shinn, who has had much experience in the matter of fluxes is inclined to impute it to prejudice, it having happened that the furnaces were working badly from other causes, when this stone was being used, it was at once ascribed to the blue limestone.

It is possible that there is some foundation for the reason which Mr. Shinn assigns, though some parts of this blue portion undoubtedly contain much more silica and alumina than the top portion, judged by the physical aspect alone.

No. 6 is the *Piedmont* or *Tionesta sandstone*, and is here seen in immense cliffs as we descend along the road from the cement works.

Many large masses have become detached, and now lie scattered over the hill, and in them we see numerous quartz pebbles, varying from the size of a pea to that of a hazel nut.

On the opposite side of the hill we see only 30 feet of this stratum, and when we come to the northern line of the township, two miles above here, it has thinned away to a shaly sandstone, but as we pass south from this point it continually thickens, until at Homewood, seven miles below, it attains a maximum of 155 feet.

No. 8 is the *Lower Mercer limestone*, and the numerous R. R. cuttings in the vicinity of Wampum expose it very finely. It is a dark bluish, compact rock, having an arenaceous aspect on its weathered surface, and is here, as always, richly fossiliferous.

It is seen in the little cut on the E. & P. R. R., 4 rods south of Wampum station, and is also finely exposed in the cuttings along the coal and limestone R. R. which passes up Wampum run from the furnace.

Passing along this we see its outcrop almost constantly exposed for $\frac{1}{2}$ mile, and are afforded an excellent opportunity to study its changes. It is seen to vary greatly in thickness, sometimes running up to $2\frac{1}{2}'$, and again down

to $\frac{1}{2}'$, while on two occasions it is observed to disappear entirely, but reappears again at the proper horizon within a few rods in both cases.

Its companion, the *Upper Mercer*, which is seen at Wurttemberg, and is so constant a feature a few miles north, has here been displaced by the *Tionesta sandstone*, No. 6, which comes down below the limestone's proper horizon, as it is usually about 30 to 35 feet above the *Lower Mercer*.

The *L. Mercer coal*, No. 11, is also splendidly exposed along the same road which passes up Wampum run, and is seen to vary even more than the limestone above. At times it comes 10 feet below the limestone, and again the intervening shales thin away and the limestone rests immediately upon it. Sometimes the coal thickens up to $2\frac{1}{2}'$ and is tolerably good, and then it as rapidly thins down to one foot of very slaty, worthless coal, or an impure cannel.

It has not been mined in this vicinity, except by some local stripping in one of the cuts.

The *Massillon sandstone*, or that part of it which is here exposed, is represented by Nos. 13-20. It will be seen to differ widely from the constitution of the same stratum, as seen in the section from Wayne township, given in sec., Fig. 24, and which was obtained only $1\frac{1}{2}$ miles below this locality; there it is a very massive rock, 90 feet thick, while here it is split up into several layers, and some beds of coal and bituminous slate occur in the same; thus affording a striking example of the rapid change which may, at any time, take place in the character of No. XII.

Wampum furnace is located at the mouth of the run of the same name, near where the preceding section terminates. It is owned and operated by Messrs. Matherly, Bingham, Kimberly and Kay, the latter of whom gave me the following statistics:

Wampum furnace, erected, 1856.

Height of stack,	50'
Diameter of boshes,	12'
Batter per foot,	0' 3''
Diameter of hearth,	5' 6''

Six twyers, 4 inches in diameter, uses "Pollock's" hot blast.

The furnace has been run for short intervals on native ore alone, but Mr. Kay informs me that when so used, "it works gummy," and they consequently mix the native ore with Lake Superior, in the proportion of one of the former to two of the latter.

The native ore used is that which comes immediately above the Ferriferous limestone, and is obtained on the east side of the river in Wayne township, at the Houk mines, and others along Hennen's run. When used raw and alone it yielded 40 per cent. of iron, and was highly prized for foundry purposes.

The native ore is generally roasted, previous to mixing with the Lake ore.

The *Ferriferous limestone* is used as a flux, and the company makes use of a composition fuel in smelting the ores, viz: $\frac{1}{4}$ Connelville coke, $\frac{1}{4}$ coke from the Darlington coal, $\frac{1}{4}$ Block coal, and $\frac{1}{4}$ Darlington coal, which is obtained at their own mine, the "Welsh bank," a short distance away. It will thus be readily seen that the Wampum furnace is fortunately situated with respect to its raw material, since most of the fuel, all the limestone, and $\frac{1}{3}$ the ore are in its immediate vicinity.

The furnace is now, September, 1877, out of blast for repairs.


Above Wampum, $\frac{1}{4}$ mile, are the coal works of Davisson, Greene & Co. The mouth of the pit is $\frac{1}{2}$ mile back from the coal tipple at the E. and P. R. R., and it is the *Darlington coal* that is mined.

Mr. Davisson gave me the section, seen in Fig. 27, which he said their firm had found by leveling.

No. 1 is known as the "*Six foot bed*" in this region, and from the section it is seen to be the *Upper Freeport*. It has not been opened on the land of Mr. Davisson, but it occurs near the summit of a high knob where the section was made, and was recognized from its blossom.

No. 3, the *Lower Freeport*, is locally termed the "*Four*

foot bed," but it is here a mere mass of bituminous slate, with streaks of coal interlaminated.

1. Coal, (<i>Upper Freep't</i>) "Six-foot bed,"	27. —
2. Concealed,	? 77'	..... 77'
3. Coal, (<i>Lower Freep't</i>) "Four-foot bed,"		..... 3'
4. Concealed,	? 65'	..... 65'
5. Coal, (<i>Darlington</i>), "Three-foot bed,"		..... 2' 9"
6. Concealed,	? 65	. 65'
7. Ferrifer's limestone,	 20'	. . . . 20'
8. Concealed to level of E. & P. R. R.,	? 155'	. . . . 155'
	<i>Level E. & P. R. R.</i>	
9. Concealed to level of Big Beaver,	? 80'	..... 80'
Total,	<i>Big Beaver Cr.</i>	..... 467 9'

No. 5, the *Darlington coal*, is the one which is operated by this company, and is an excellent coal. It varies in thickness from 34 to 36 inches, and is a pitchy, shining black coal, which contains a very small per cent. of impurities. It is shipped to New Castle, at the rate of 150 tons a day, and is largely used by the *Ætna* iron works, as well as the other mills in that town. It has also been used

at the gas works in New Castle, and yielded excellent results.

The "*bearing in*" band of slate comes 4 to 5 inches above the bottom, and is 1 to 1½ inches thick.

Many "*horse-backs*" occur in the bed, and it has a slight dip to the south-west, while the "face" runs nearly north and south.

No. 7, the *Ferriferous limestone*, is seen a short distance south from the mouth of the coal mine, and is there quarried by Mr. Shinn, on the land of Mr. Davisson. Only the upper half is quarried, since the lower is "blue," and is consequently rejected by the furnaces.

At the point where the limestone is quarried the *Drift* is seen covering the slopes of the hill to the height of 30 feet above the limestone. It is unstratified, and bowlders of granite, gneiss, limestone, sandstone, conglomerate, &c., of all sizes, from 1 inch to 15 inches in diameter, mostly rounded and water worn, are scattered through the clay and silt. The top of the portion seen is here 285 feet above the Beaver, and it is possible that this may be the remnant of a terrace deposit, which once spread entirely across the valley at this level, but the supposition in favor of its being true *Glacial Drift* and not the secondary result of subsequent transportation is much to be preferred, since at no point along the river hills below this do we find any remnants of a terrace deposit at a higher altitude than 160 feet above the level of the stream, a result which is incompatible with its supposed terrace or Champlain origin.

We learn then from this deposit that the old Glacial rivers flowed as far south as Wampum, and as I have suggested in a previous part of this report very probably extended as far south as the Ohio river.

North from Wampum, in the vicinity of Newport, we find a broad terrace 120 feet above the level of the Beaver, and scattered over it are immense quantities of large bowlders, some 3 to 4 feet in diameter. Many of them are of metamorphic rock, while some are sandstone and conglomerate.

In descending to the Beaver at Newport, we go over a

very steep escarpment of the *Massillon sandstone*, which has here again become massive, after leaving Wampum, but the rock at no point forms cliffs, and the steep escarpments present a rounded outline.

A short distance below Newport the *Tionesta sandstone* is seen along and above the E. & P. R. R., thickening up into a massive conglomerate.

Returning to Wampum, and passing up Wampum run, we find the stream's bed rising quite rapidly and the strata passing under it successively, and $\frac{3}{4}$ mile up the same we come to the limestone quarry of Mr. Williamson, operated on the land of Mr. O'Neil of Pittsburgh. The limestone is here not so good as usual, the *blue* and *silicious* portions of the stratum extending even to the upper part of the rock at many places in the quarry.

A lime kiln has lately been erected here, and preparations made for burning lime for shipment on an extensive scale. A R. R. track extends from this point down to the E. & P. R. R. at the furnace.

At the head of one branch of Wampum run, called Smoky Hollow, about one mile south-west from the village, the Wampum Oil Company is now (July, 1877,) drilling a test well. It commences a few feet above the base of the *Ferriferous limestone*, and when I visited them they had attained a depth of 379' made up, according to the driller's log book, of the succession seen in sec., Fig. 28.

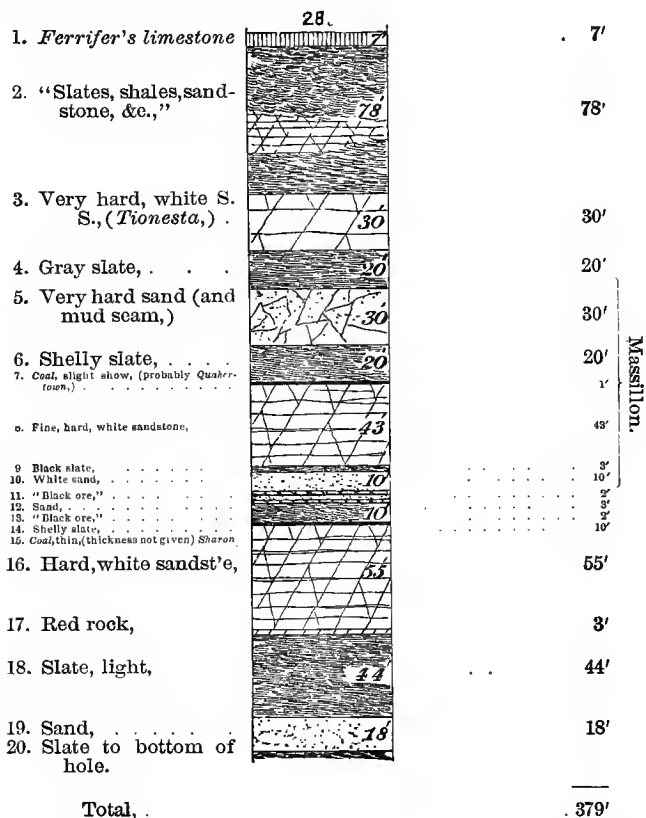
The drill hole is 8 inches in diameter, and had not yet been cased when I visited the well.

A well was bored near this several years ago, and some oil and gas were obtained at a depth of 600', or thereabouts, which would place it in the *First sand* or "124' rock" of the deep well at Beaver falls, which is also the *Smith's ferry oil rock*.

Nos. 3 to 16 represent the Great Conglomerate, which is here 229 feet thick. No. 15 is probably the representative of the *Sharon coal*, while No. 16 may represent the Ohio Conglomerate, or the lowest member of the Conglomerate series.

Nos. 11 and 13, given as "black ore" in the driller's nomenclature, are described as very tough and difficult to

drill through, and may represent the iron ore strata which often overlie the Sharon coal. The driller says they looked like iron ore when brought up in the sand pump.

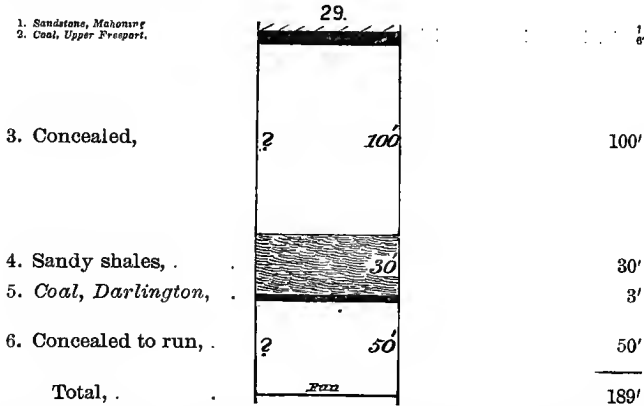


A short distance above where the oil well is located some very high land occurs on the farm of Mr. Whan, and near the summits of the hills the *Upper Freeport coal* is caught.

Descending from an old opening in this bed we get sec., Fig. 29 :

The coal, No. 2, was once mined here by Mr. Whan, and is reported to be 6 feet thick, but it occurs so near the surface of the ground that it is very friable and almost worthless. Immediately above it are seen the remnants of

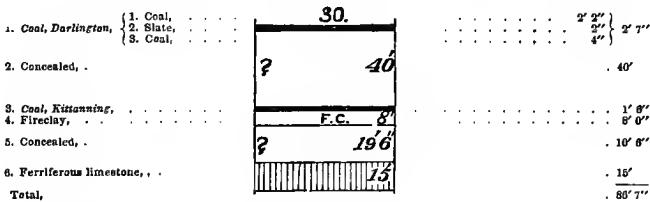
a once massive sandstone, which is the Mahoning. It is now scattered in fragments over the hill.



The *Darlington coal* has also been mined by Mr. Whan, who reports it as varying in thickness from 2½ to 3 feet.

One and a half miles below Wampum the *Darlington coal* is extensively mined at what is known as the "Welsh Bank," by Kay, Kimberly & Co. of the Wampum furnace. Two hundred tons are shipped daily to Erie, Ashtabula, and other points to the north as a gas coal.

This bed and its associated strata are shown in sec., Fig. 30:



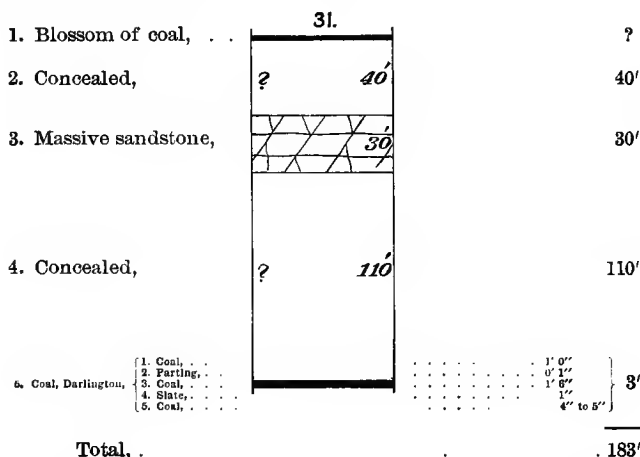
The *Darlington* is pitchy, brilliant, and an excellent coal in every respect. It is used at the Wampum furnace, being coked and mixed with the Connellsville coke.

The rest of the section below No. 1 at this locality is given on the authority of the superintendent of the "Welsh Bank," who says that he once had the interval leveled between the coal and the limestone.

No. 3, he states, was once exposed by a land slide near the mine. It was separated into two parts by a parting of slate, the upper of which looked like cannel, while below the coal was a very large bed of fireclay.

No. 6 is seen forming a line of cliffs a short distance south from the "Welsh bank."

About two miles below this, and a short distance above Clinton, the *Darlington coal* is extensively mined by Lee, Patterson, Harbison & Co., and, being nearly opposite to Rock Point on the Beaver, is known as "Rock Point coal." In descending from the summit of the hill to these mines, we get sec., Fig. 31 :



It is not certain whether No. 1 is the *Brush creek* or *Upper Freeport*, most probably the *Brush creek*, however, as in the Whan section on page 62 we find an interval of only 130 feet between the *Upper Freeport* and the *Darlington*. It makes a conspicuous blossom in the road near the top of the hill.

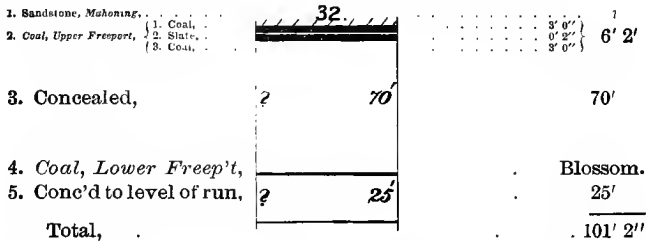
No. 3 is a very massive sandstone, and is seen in a huge cliff extending around the hill. If No. 1 be the *Brush Creek coal*, this would be the *Mahoning sandstone*, but if the former be the *Upper Freeport coal*, this would be the *Butler*, or *Lower Freeport sandstone*.

The *Darlington coal* has here an extra parting one foot

below the top, but there is seldom any slate comes in the parting. The coal at this bank is very excellent in every way, and is especially valued as a gas and steam coal, being preferred by the locomotive engineers to any other coal ever used on the Erie and Pittsburgh R. R. It is extensively shipped on the E. & P. R. R.

The superintendent, Mr. Davis, told me that, on the opposite side of the hill from this opening, he once had to cut a very deep drain on account of the dip to the south-west, and that, 30 feet below this coal, he cut through another about 18 inches thick, which was underlaid by a large bed of excellent fireclay. This latter coal is the Kittanning, and has degenerated into a thin and worthless bed in coming north from Homewood, in Beaver county.

Near the central line of the township, and one mile north from its southern boundary, we find a small area of the *Upper Freeport coal* in the summit of a knob on the land of Mrs. Gilkey, and there we get sec., Fig. 32 :



No. 2, the *Upper Freeport*, varies much in thickness, and is also somewhat slaty and sulphurous.

Above the coal is seen a massive sandstone, which would represent the Mahoning.

The blossom of No. 4 is seen along the road, 70 feet below the Upper Freeport, and is, hence, the Lower Freeport. It has never been opened here, though, from the size of the blossom it makes, it is evidently of workable thickness.

Passing north one mile, and descending the hill, we come down to the *Darlington coal*, 130 feet below the Upper Freeport, as seen at Mrs. Gilkey's. The Darlington has here been mined at the roadside by Mr. Carey, and also a short distance below by Mr. Weatherspoon. The coal is

only 2 feet thick, but is quite pure, and highly valued as a domestic fuel.

An old projected railroad, called the New Castle and Darlington line, was once surveyed and located through the central portion of this township, and much of the cutting and grading was completed before the route was abandoned. In one of these old cuts, a short distance north from Mr. Weatherspoon's, we get sec., Fig. 33:

33.	
1. Shaly and flaggy sandstone, (<i>Freeport</i>),	50'
2. Coal, <i>Darlington</i> ,	2' 4"
Total,	52' 4"

The coal occurs at the bottom of the cut, and nothing is seen below it. The coal has been exposed many years to the elements, but it still retains a sharp, clean face, with no tendency to crumble, and very little appearance of copperas.

The *Freeport sandstone* above is very shaly, and is in striking contrast to its character at the south in Beaver county, where it is frequently 75 to 100 feet thick in a massive bed.

4. *Little Beaver Township.*

This lies directly west from Big Beaver township, and is bounded on the south by Beaver county, west by the Ohio State line, and north by North Beaver township.

It is drained entirely by the numerous branches of the north fork of Little Beaver, several of which take their rise near its northern and western borders, while the main branch of this stream entering it from the north-west flows with a very tortuous course across to the south-east corner of the township, and there passes into Beaver county.

The surface of this township shows pretty clear evidence of former *glaciation*, for all the valleys are filled with *Glacial drift*, and in the northern portion of the township a continuous sheet of pebbles, bowlders, clay and glacial débris overspreads the entire surface, except where sub-

sequent erosion has removed the same. The general surface is also planed down, and the hills lack the abruptness and elevation of those to the east in Big Beaver township.

This lower level is plainly indicated by the fact that in Big Beaver many of the highest knobs catch the *Upper Freeport coal*, yet notwithstanding that there is a general dip to the west the same coal is caught in but a single hill in the township.

There is probably less of geological interest or value to be seen in this township than any other in this county. The section extends from the Upper Freeport coal down to within 20 feet of the Ferriferous limestone, but the Darlington and Kittanning coals have both thinned away so much as to be practically worthless, while the Lower Freeport becomes workable at only one locality, and the Upper Freeport, as previously stated, is caught in only a single hill, and is there too thin to be of any economic value.

At Enon Valley station, on the P. F. W. & C. R. R., near the southern line of the township, the *Darlington coal* was once mined on the Lynerman property, but, although 26 to 28 inches thick, it was so slaty and impure that it was soon abandoned. Above it there is seen the *Freeport sandstone*, which forms a steep bluff around the hill. The coal comes about 25 feet above R. R. level at Enon.

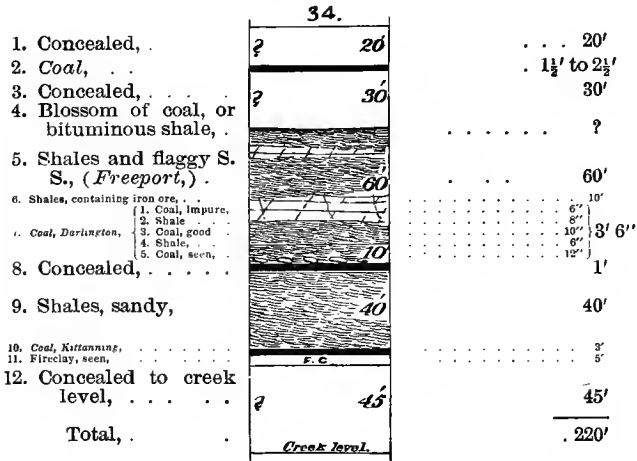
Immediately below where the Darlington was opened, the *Kittanning coal* was passed through, in digging a well on the property of Mr. Cole. It comes 35 feet below the Darlington at this locality, and is reported as being 2 feet thick, with a large bed of fireclay below.

Two miles west from Enon, the *Kittanning coal* is 5 feet below the level of the west branch of the North Fork. A shaft was once sunk to it at this locality, on the land of Mr. Fischer. The shaft is 16 feet deep, and passes through débris, or drift. Mr. Fischer tells me that the coal was 3 feet thick, and somewhat sulphurous, and slaty.

Above the coal on the opposite side of the creek, are seen 15 feet of sandy shales, and flaggy sandstone.

As we pass further west toward the State line, everything becomes buried with Drift and no exposures can be seen.

Returning to Enon and going up the main branch of the North Fork, we find the strata rising to the north-west at about the same rate as the stream's bed, and $2\frac{1}{2}$ miles above Enon, near the northern line of the township, we get sec., Fig. 34 in descending a gulch on the right bank of the stream :



This is the locality to which reference has been made as containing the *Upper Freeport coal* in the summit of the hill, but the section throws some doubt upon the correctness of identifying No. 2 with the *Upper Freeport*, since we find it here only 100 feet above the *Darlington*, while that interval has been observed as 140 feet in the township immediately east from this.

The coal in question was once mined on the land of Mr. McGeehan, but the bank has long been abandoned. He reports it as varying from $1\frac{1}{2}$ to $2\frac{1}{2}$ feet in thickness, and a tolerably fair coal.

At the horizon of No. 4 was seen a dark coaly blossom, only partially exposed, and it may be merely black slate. If No. 2 be the *Upper Freeport*, this would be the *Lower Freeport's* representative.

No. 7, the *Darlington coal*, is here split up into three

layers by shales. It has been stripped along the little ravine on the land of Mr. Hutchinson. The uppermost division of the bed is quite slaty and worthless, but the next lower ones are rather good coal. The entire thickness of the lowest layer was not seen, as it was partially covered up, but it cannot be much thicker than I have given it.

The *Kittanning coal*, No. 10, has also been mined by Mr. Hutchinson on the bank of the stream. It has a parting of slate near its middle, and is rather impure, containing considerable pyrites in thin lamellar plates.

Below this coal we see 5 feet of very good looking fire-clay in the drain, and then all is concealed to the creek.

Near the northern line of the township, and one mile east from Newburg, the *Lower Freeport coal* thickens up, and has been mined on the land of Mr. Robinson. A large amount of coal has been taken out there, but the bank is not now in operation; the coal having thinned away so as to make mining unprofitable in the direction of the present drift. The coal was 3' to 4' thick and said to be quite good. Above the mouth of the old drift we see 20 feet of sandy shales, and then a black slate makes its appearance, which passes up into the concealed portion.

In digging a well on the opposite side of the run the same coal was passed through by Mr. Winthrow, where it was 4 feet thick.

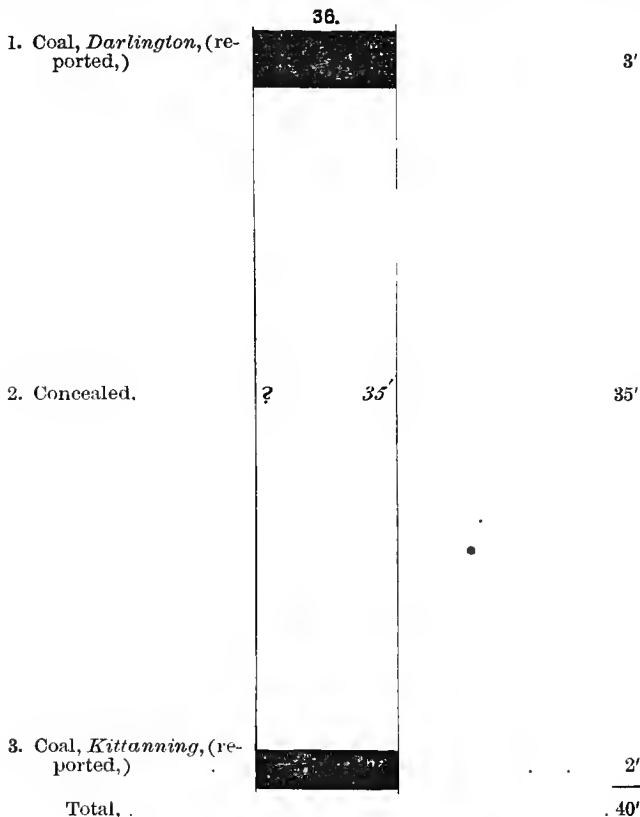
One fourth mile east from Mr. Robinson's the same coal is mined by Mr. Mitchell near the old steam saw-mill, and there we get sec., Fig. 35:

35.		
1. Concealed from top of hill,		40'
2. Coal, <i>Lower Freeport</i> ,		4'-6"
3. Concealed,		50'
4. Flaggy sandstone and shales,		25'
5. Coal, <i>Darlington</i> ,		2' 6"
Total,		123' 6"

The coal, No. 2, which the section shows to be the *Lower Freeport*, is here 225 feet above the R. R. level of Enon station. It attains a great development, since at many places in Mr. Mitchell's bank it is 6 feet thick, with no slate partings intervening. The coal is lustrous, pitchy-black, and quite pure, since it is highly valued as a smithing coal, and many of the farmers say they prefer it to any other coal in the county.

The bed has a local dip to the north-east, and is, hence, very difficult to drain, and on this account it is not kept in operation all the year.

The proper way to work it would be to sink a shaft on top of the hill, where it could be reached at 45 feet, and then the pump would drain it without any further trouble.



No. 5 was once mined a short distance south of the saw-mill on the land of Mr. Faddis, and is reported to have been $2\frac{1}{2}$ feet thick, and not very pure. The bank is now fallen in, and the coal could not be seen.

A short distance east from the saw-mill, the *Lower Freeport coal* occurs on the land of Mr. Weatherspoon. It comes near the summit of the hill, and its area is limited.

Beaver Dam run rises near Newburg, and flows south into the Little Beaver near the south-east corner of the township. Along this stream some openings have been made in the Kittanning and Darlington coals, but all are now abandoned, as the coals in question were in every case too thin and impure to work.

Leaving Beaver Dam run near Mr. Taylor's and passing south-east toward Enon, we get sec., Fig. 36 on the land of Mr. Young.

Both banks had fallen in when the locality was visited, and the coal could not be seen, but it was reported to be quite good in both, and could be used for smithing purposes.

5. North Beaver Township.

This is the largest township in the county. It lies directly north from Little and Big Beaver townships; is bounded on the west by the Ohio State line, and east by the Mahoning and Big Beaver rivers.

Besides these last mentioned streams which flow along its border, the only other stream of any importance is Hickory creek, which, rising in the north-west corner of the township, flows south of east and empties into the Mahoning river, near the junction of the latter stream with the Big Beaver. Some of the branches of Little Beaver take their rise on its southern slope, while one branch of that stream flows across its south-west corner from Ohio.

The *Glacial drift* spreads over this township in almost a continuous sheet, except where it has been removed along the streams by subsequent erosion. Covering the summits of even the highest hills, we find a coating of gravel, bowlders, clay, and sand to the depth of 30 to 60 feet.

The land is well adapted to farming and grazing, and here we see some of the finest farms in the county.

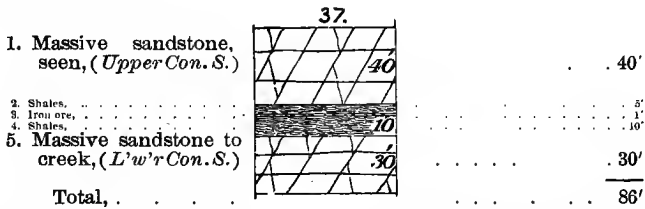
In making the examinations in this township, I was accompanied by Rev. Wm. M. Taylor of Mt. Jackson, who, on account of his intimate knowledge of the local geology, rendered me very valuable service.

The section exposed in this township extends from the base of No. XII to the Lower Freeport coal.

Hickory creek is a very bold and rapid stream, and along its precipitous banks, very fine exposures occur, thus affording an excellent opportunity to study the geology of the township in a continuous cross section from east to west, so we shall begin at the mouth of this stream, and pass up the same to its source. At the mouth of Hickory, we find ourselves at a geological horizon 20 to 25 feet below the base of the great Conglomerate, or No. XII; for here, a short distance above the mouth of the creek, we see exposed along the right bank of the Mahoning river, 20 feet of brownish and bluish flaggy sandstone, which contains fossil shells characteristic of the Waverly of Ohio, or the member of that group, termed by Dr. Newberry, the *Cuyahoga shale*. The shale also contains considerable iron ore in lenticular calcareous nodules, and is immediately overlaid by the very massive Massillon sandstone. Besides species of *Spirifer*, *Productus*, *Allorisma*, and others, characteristic of the Waverly, the shale contains many *fucoïds*, and on one of the flags was seen the trail made by some ancient animal, as it crawled along the beach or muddy flat, and left its "foot-prints on the sands of time," in a very literal sense.

It might be asked here if the massive sandstone, immediately above these shaly flags, be the Massillon, what has become of the Ohio Conglomerate, or the one which we find underlying the Sharon coal near Sharon. To this we reply that in coming south from Sharon, along the Shenango, as well as south from Youngstown along the Mahoning, that lowest member of the Conglomerate series thins away and disappears, so that the Waverly shales extend up to the base of the Massillon sandstone.

As we pass up Hickory creek, these Waverly flags soon disappear below the stream owing to the rapid rise of its bed. For two and one half miles above the mouth of the stream we find its channel hemmed in between cañon-like walls of massive sandstone, which occurs in two beds separated by shales containing iron ore. The whole mass is about 120 feet thick, and represents the Massillon sandstone of Newberry. The iron ore, which occurs in the intervening shales, was once mined on the right bank of the creek, about one mile above its mouth, and at an old ore drift we get sec., Fig. 37.



No. 1 is a very hard, coarse, and grayish-white sandstone. It forms a line of cliffs along the bluffs above the stream, while huge masses of the same obstruct its channel below. It is the upper part of the Massillon.

No. 3 is a calcareous ore, and the specimens seen lying on the dump had passed by oxidation to the limonite state. The ore was taken to New Castle, and used at one time. It contains near 40 per cent. of metallic iron.

Below the shales which contain the iron ore, we see another bed of massive sandstone continuing on down to water level. This is also coarse and massive, and represents the lower member of the Massillon sandstone, which we have elsewhere termed the Lower Connoquenessing, while No. 1 has been called the Upper Connoquenessing. A short distance above this point we see the shales and ore thin away and disappear, while the two previously separated beds of sandstone unite to form a single mass 100 feet thick. Descending the hill near this point from Mr. Winthrow's, we get sec., Fig. 37.

No. 1 is the fireclay which comes under the Tionesta coal. It is non-plastic, almost as hard as flint, and is seen scat-

tered in rough and forbidding blocks, over the fields on Mr. Winthrow's land.

	38.	
1. Fireclay, non-plastic,	f. c.	5'
2. Concealed, ?	45'	45'
3. Limestone, Lower Mercer,	2	2'
4. Concealed,	10	10'
5. Shales, dark,	10	10'
6. Iron ore,	10	5'
7. Shales,	10	5'
8. Massive sandstone to level of Hickory creek,	95'	95'
Total,	77' 8"	77' 8"

The *Upper Mercer limestone* is in the concealed interval, No. 2, and was not seen.

The *Lower Mercer limestone*, No. 3, is seen along the hill above the sandstone cliff, and numerous blocks of the same lie scattered over the hill. It is a dark blue, and very compact rock, being richly fossiliferous. Below the limestone, 20 feet, we find another iron ore horizon, which is rather constant throughout this region. The ore is a proto-carbonate, and comes mostly in a single layer, which would probably yield 35 to 45 per cent. of iron.

No. 8, the *Massillon sandstone*, has here thickened up enormously, and forms perpendicular cliffs on either side of the stream, at the base of which Hickory creek rushes along with a rapid fall.

As we pass up the stream from this point, the scenery becomes very wild, for the creek is constantly flowing in the Conglomerate, which rises in lofty ledges, on either side, while immense masses of the same have broken away from the parent bed, and are now scattered along the base of the cliffs, or obstruct the channel of the stream.

About one mile above Mr. Winthrow's occurs what is locally known as the "*Devil's Backbone*."

At this point, a considerable little stream cuts down through the Conglomerate, and, instead of entering Hickory creek in a direct line, it comes up to within a few feet of it, and then thwarted in its course by the very hard wall of

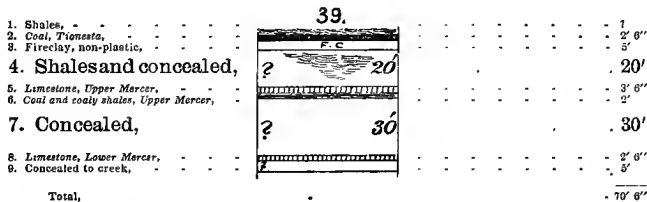
sandstone, turns abruptly southward and flows along parallel with the main creek for nearly one half mile, being often separated from it by only a few feet. Along this narrow separating space the Conglomerate rises in a high sharp ridge, which has been honored with the name of his Satanic majesty.

Going on up the creek from this locality its bed rises very rapidly, and finally, one mile above, reaches the top of the massive portion of the Conglomerate, over which it makes a vertical plunge of 10 feet.

No pebbles larger than a pea are seen in the Massillon sandstone, which forms the massive portion of the Conglomerate along Hickory creek, but it is generally a coarse, hard, and grayish-white sandstone.

After the Conglomerate, or massive sandstone of No. XII has passed below the level of the stream, a wonderful change takes place in the topography; the valley gradually widens out as we ascend the creek; the hills become less precipitous, and, as we approach the northern line of the township, we find vast level reaches on either side of the water-course. This marked change is due entirely to the change in the nature of the rock material through which the stream has carved its channel, since after the Conglomerate passes under, we go up into the easily disintegrating shales of the Lower Coal measures, which here contain no massive sandstones.

About three-fourths of a mile below Mt. Jackson, we get sec., Fig. 39 on the land of Mr. Wallace, descending a ravine to the right bank of Hickory creek.



No. 2, the *Tionesta coal* of Rogers, is mined by Mr. Wallace at this locality. It is somewhat slaty, and sulphurous, and is burned only when nothing else can be ob-

tained. This is the coal which we find quite persistent through Lawrence county at an interval of 60 to 75 feet below the *Ferriferous limestone*.

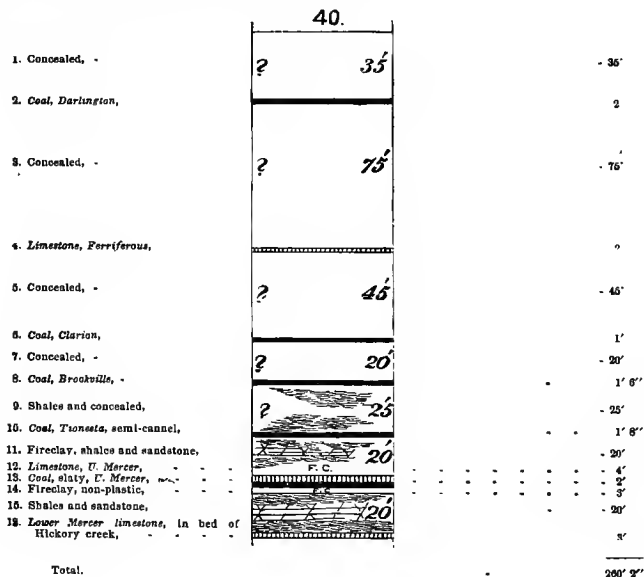
No. 5, the *Upper Mercer limestone* is seen finely exposed in the ravine below where the coal is mined, and large masses of it have broken away from the parent bed and lie scattered over the ground, and along the creek's bed. It is very fossiliferous, and of a dark-bluish color.

Under it we see 2 feet of coaly shales with a small amount of coal, scattered through the mass, and entirely too impure to mine.

The *Lower Mercer limestone*, No. 8, occurs down near the bed of the creek, and looks very much like its companion, the *U. Mercer*, above.

Passing on up Hickory creek, we come to the village of Mt. Jackson, about one mile above the last locality, and here the hills rise 450 feet above the level of the Mahoning river, taking in the *Darlington coal* near their summits.

Mt. Jackson is situated on the hill above the stream, and descending from the summit of the same down the little ravine which passes near the residence of Rev. Wm. M. Taylor, we get sec., Fig. 40.



The blossom of No. 2, the Darlington coal, is seen in the road near the M. E. church, and a short distance north from the village it was once mined on the land of Mr. Kennedy, where it was reported as varying from 2' to 2½' in thickness, and being quite a good coal. It lies near the surface, and the mine is now abandoned.

The interval, No. 3, is entirely concealed at every point, and the Kittanning coal, which should occur in it, was consequently not seen.

No. 4, the *Ferriferous limestone*, is seen only partially exposed in the ravine below Mr. Taylor's. It is very probably not much thicker than what we see of it (2'), since it is somewhat impure, and then there is no bluff at this horizon like we always find when this limestone is thick. It has here locally thinned away, as it frequently does, though only 3 miles north it is 15' to 20' thick.

No. 6 represents the *Clarion coal*, and was once dug into at this locality. It was slaty, however, and too thin to mine. No. 8 comes at the horizon of the *Brookville coal*, and, like all other coals in the section, has also been drifted upon. It proved slaty and worthless, however, and was abandoned.

No. 10 represents the *Tionesta coal* of Rogers. It is here a semi-cannel coal, and burns tolerably well, though it contains considerable ash. This is the same coal as that shown in the previous section, and mined on the land of Mr. Wallace, one mile down the creek. Below this coal comes a large bed of non-plastic fire-clay.

No. 12, the *Upper Mercer limestone*, is seen in the bed of Hickory creek, and the stream makes a fall of five feet over it. The limestone is seen stretching across the creek's bed in huge blocks like a pavement. It is a very compact, hard, and very dark-blue rock, being crowded with fossil remains, among which are *Spirifer*, *Productus*, *Athyris*, *Nautilus*, *Crinoids*, *Corals*, &c. Mrs. Wm. M. Taylor found a very fine *Nautilus* in this rock, which is most probably new to science.

Immediately below this limestone is seen a bed of slaty

coal 2 feet thick, but it has not been mined at any locality here.

No. 14 is a bed of non-plastic fire-clay, which is perfectly filled with *Stigmariæ* and its rootlets.

Passing down Hickory creek, a short distance from this point it falls very rapidly, and soon cuts down to the *Lower Mercer limestone*, No. 16, near where the Mt. Jackson road crosses the stream. It is a dark-bluish, compact rock, like the *U. Mercer* above it, and is likewise filled with fossils. The stream also makes an abrupt plunge over this rock.

As we pass up Hickory from Mt. Jackson the hitherto steep bluffs of this stream become gentle slopes, and everything is deeply buried by *Drift* and débris, but about four miles up this stream the *Ferriferous limestone* comes down to its level, and is finely exposed on the land of Mr. McCord, near the school house. Here the stream makes a vertical plunge of 20 feet over the limestone, and it forms a wall-like cliff on either side of the creek for some distance. It is quarried and burned by Mr. Paden, and makes very white and pure lime, being hauled for a long distance into the interior. The limestone is about 15 feet thick, and is crowded with organic remains. It is also quarried by Mr. McCord, and a specimen from the top layer at his quarry gave, on analysis by McCreath, the following:

Carbonate of lime, . . . . .	.95.768
Carbonate of magnesia,	1.097
Oxide of iron and alumina, . . . . .	.632
Sulphur, . . . . .	.088
Phosphorus, . . . . .	.017
Insoluble residue,	1.970
Total,	<u>99.572</u>

This immense mass of limestone underlies all the country between this and the Mahoning river, coming near the surface, which has been planed off above it by Glacial action.

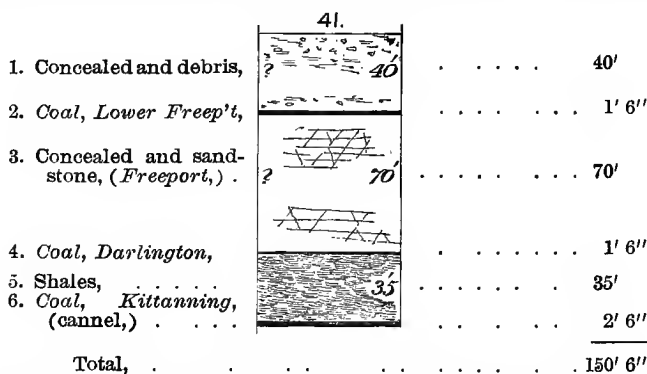
Going west from McCord's to the State line, and passing south along the same, we come to some high knobs which have been spared the Glacial erosion, and now rise 160' to 175' above the Ferriferous limestone. In one of these a

coal is mined on the land of Mr. Davisson, at an elevation of 80 feet above the *Ferriferous limestone*, which would make it the *Darlington*.

Petersburgh, Ohio, lies only a short distance west from the State line, and 2 miles south from the northern boundary of this township. Near this village, Mr. Rock has a quarry in the *Freeport sandstone*, and in the bottom of his quarry is seen the *Darlington coal* 1½ feet thick, and quite pure. It is taken out by stripping after the flags have been removed from above. The rock makes excellent flags, splitting out in nice smooth layers, 2 to 6 inches thick, and of most any desirable size.

Thirty-five feet below the *Darlington coal*, at this locality, occurs the *Kittanning coal* in a bed of cannel 2½ feet thick, and mined in Ohio by Messrs. Livingstone and Shrenk.

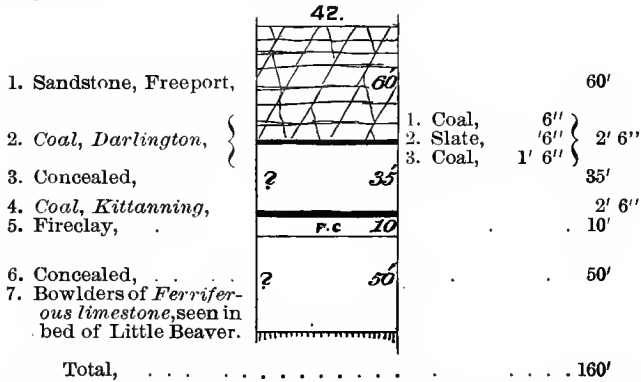
Above the *Darlington coal*, 70 feet, Mr. Rock states that in sinking a well he passed through a bed of coal 18 inches thick, which would be the *Lower Freeport*, and placed in the form of a section these coals would come as in Fig. 41.



Below Petersburg, on the north branch of Little Beaver, ½ mile east from the State line, and the same distance north from the southern boundary of this township, we get sec., Fig. 42 on the land of Mr. Saur, in descending from the summit of the hill to the bed of Little Beaver.

No. 1, the *Freeport sandstone*, is extensively quarried at this locality by Mr. Saur. This is the only rock suitable for building purposes found in all this region, since none of

the hills extend up far enough to take in the Mahoning sandstone. The lower part of the rock is shelving, irregularly bedded, very hard and micaceous, but the upper is softer, and many of its layers made a very fair building stone. It is much streaked and specked with sesquioxide of iron. Many vegetable impressions are seen in the stratum, principally worn and broken fragments of *Lepidodendron* and *Sigillaria*.



Immediately below the sandstone occurs the *Darlington coal*, and it was once drifted upon here by Mr. Saur, but the thick bed of slate, separating the two benches, rendered its mining unprofitable, though the lower bench is a very good coal. No. 4, the *Kittanning coal*, is mined by Mr. Saur quite extensively for local supply. It is a tolerably fair coal for domestic purposes, though containing too much sulphur for smithing.

At the level of Little Beaver, which is here 60 feet below the coal, we find many blocks of the *Ferriferous limestone*, and that stratum very probably exists here, as it should come at about this horizon. The blocks are quite massive, and would indicate a considerable thickness for the parent bed, so that the matter should be explored, since this region is comparatively destitute of lime, and a good bed of it would be a valuable discovery.

A short distance below Mr. Saur's, the *Kittanning coal* is mined by Mr. Phillip Phlug, where it is 2½ feet thick.

On the branch of Little Beaver, which puts into the Pe-

tersburg fork, near the south-west margin of the township, a shaft was once sunk for coal. The intention was to shaft for the *Sharon coal*, or "*Block*" coal of the Mahoning valley, and it was supposed, by the managers, that they would strike it at 75 to 100 feet below the mouth of the shaft. The shaft commences 40 feet below the Kittanning coal, and, at a depth of 75 feet, a coal of some kind was struck, and the managers then took charge of the shaft, and would allow no one to see the thickness of the coal. They reported it as 4 feet thick, and a superior quality of "*Block*," and then tried to effect a sale of their franchises, but their statements were very properly distrusted, and nothing came of their venture.

It is very safe to say that no four feet bed of "*Block*," or any other variety of good coal, exists at this horizon; for to reach the *Block coal* of the Mahoning valley, the shaft would have to be continued down at least 200 feet lower. The coal they found comes at the horizon of the *Tionesta*, and is probably here, like we find it on Hickory creek, $1\frac{1}{2}$ to 2 feet thick, and very slaty and impure.

A short distance east from this, both the *Kittanning* and *Darlington coals* have been opened on the lands of Mr. Henderson and Mr. Fullerton. There is an interval of 30 feet separating them, and the coals are reported to be 2 feet thick each, but the banks being temporarily closed, I could not verify the statement. The *Darlington* is said to be the better coal.

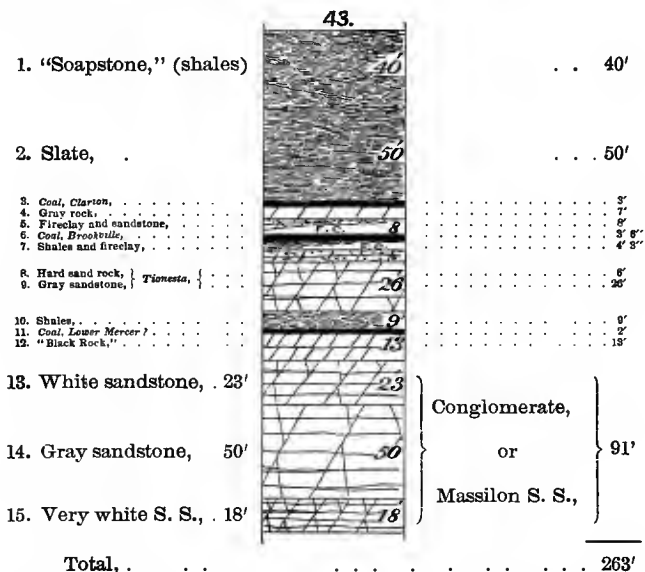
About one mile north from Henderson's, both coals are also mined on the land of Mr. Rob't Fullerton, and there they are 40 feet apart.

Near here a drill hole was put down by Mr. Hays, in search of coal, commencing 10 feet below the Kittanning, and the record he presented of the boring is given in sec., Fig. 43.

The coal represented by No. 3 comes at the horizon of the *Clarion*, and it is most probably that coal, and No. 6 would then represent the *Brookville*.

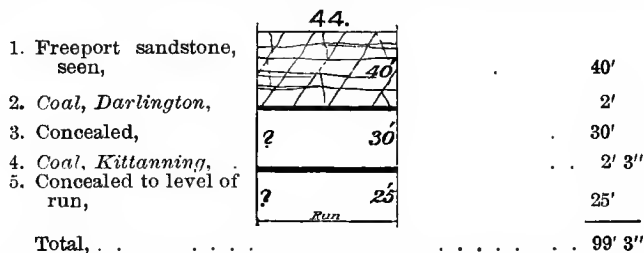
Nos. 9 and 10 represent the *Tionesta sandstone*, or top member of the Conglomerate, while No. 11 represents the

Lower Mercer coal, or the one termed *Lower Porter* by Rogers, and which is so often seen in Lawrence county below the *Tionesta sandstone*.



Nos. 13, 14, and 15 represent the Conglomerate proper, or *Massillon sandstone* of Dr. Newberry, which here appears to be quite massive.

On the land of Mr. Woods, $2\frac{1}{2}$ miles south-west from Mt. Jackson, the *Kittanning coal* is mined quite extensively for local supply, and there we see the following succession:



The *Darlington coal* was once opened here, and an attempt made to mine it, but a thick layer of slate was found near the center of the coal, which rendered it valueless.

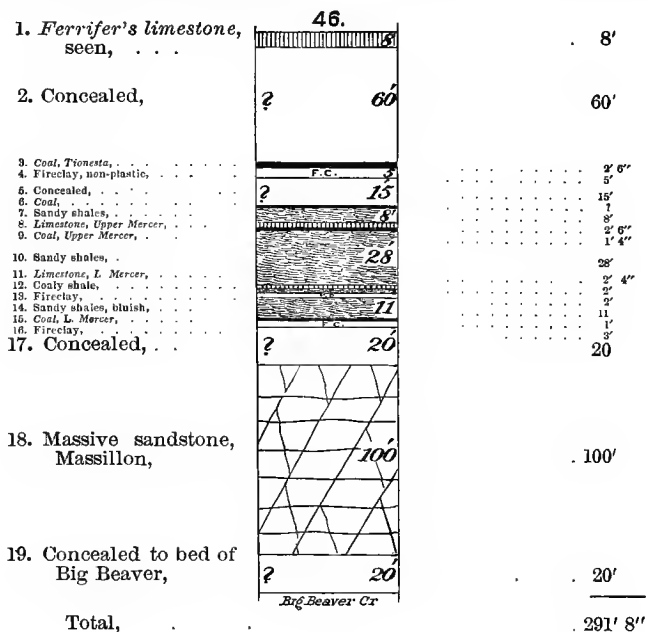
The *Kittanning*, No. 4, is a tolerably good coal, though

Hickory creek, by Mr. Wallace, and is the *Tionesta* of Rogers.

The two limestones in the lower part of the section are crowded with fossils, and both are finely exposed along the run.

Near this locality is quite a noted resort for curiosity seekers, to what is known as "Moss Cliff." A stream of water descending from the *Ferriferous limestone* is highly charged with a solution of carbonate of lime, and flowing over a cliff covered with a species of moss, deposits its surplus load of lime, and thus the moss is gradually enclosed, and converted into carbonate of lime, forming a beautiful petrification. As the old plant is petrified, the new grows out on top of it, and thus the moss is extending outwards, and increasing in thickness from year to year until now there is a considerable cliff of the "Rock Moss," as it is called.

On the main branch of Leonard's run, which puts into the Big Beaver a short distance below Moravia, we get the succession seen in Fig. 46.



The entire thickness of No. 1 could not here be seen, as it was partially concealed by débris, at the head of the side hollow where the upper portion of this section was made.

No. 3, which comes at the horizon of the *Tionesta coal*, has been opened and mined at this locality on a small scale, by Mr. Beacom. It has a clay parting near its middle, and the upper portion of the bed is slaty and apparently worthless, while the lower bench is a tolerably fair looking coal. Under it comes a bed of non-plastic fireclay, which is here filled with *Stigmariæ* rootlets.

At the horizon of No. 6, we get a small coal coming between the *Tionesta coal* and the *U. Mercer limestone*, which constitutes a new feature in the series. It was once stripped out of the run at this locality, but the coal is now covered up by débris, and I could learn nothing concerning its thickness.

No. 8, the *U. Mercer limestone*, is here found in two layers; the upper 6 inches thick, and the lower 2 feet. The small bed of coal, below it, is quite slaty and impure.

No. 11, the *L. Mercer limestone*, like the *U. Mercer* above it, is crowded with organic remains; it is of a dark blue color, and very compact.

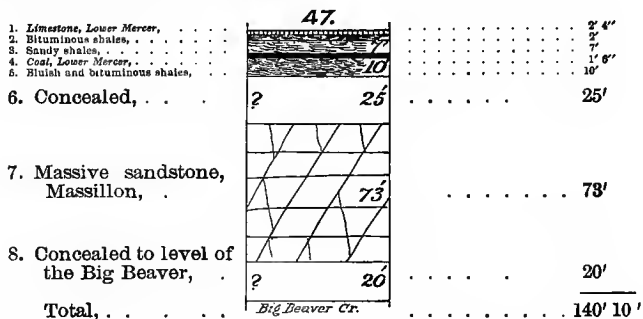
No. 15 is the representative of the old Lower Porter coal of Rogers, which we so often find a few feet below the *L. Mercer limestone*, and which we have termed the *Lower Mercer coal*, to have it correspond with the accompanying limestone of the same name. It is only one foot thick, and has been stripped to some extent along Leonard's run.

No. 18 is the immense sandstone mass, which, in the Mahoning valley, overlies *Coal* No. 1, or the *Sharon*, and which has been termed the *Massillon sandstone* by Dr. Newberry. It is quite massive, especially toward its top and bottom, with a slight tendency to become shaly near its center. It contains many fragments of *Sigillaria* and *Lepidodendron*, and near its base was seen a streak of coal, $1\frac{1}{2}$ to 2 inches thick.

At one locality, we see 3 feet of bluish shales under this sandstone mass, and then comes a layer of iron ore, which very probably represents that so often found above the

horizon of the Sharon coal on the Mahoning river, and which here passes below water level on the Beaver.

Near the south-eastern margin of this township, and about one mile above Newport, Jenkin's run puts into the Big Beaver, and descending it from $\frac{3}{4}$ mile above its mouth, we get the section, seen in Fig. 47.



The *U. Mercer limestone* was not seen in bed at this locality, but above where the *Lower Mercer* had passed under the stream, were seen many scattered blocks that had been washed out of the stream from the former bed which is now concealed by débris.

No. 4 has been mined here by stripping, and is reputed a very good coal.

The upper portion of the *Massillon sandstone* is very massive, and the stream descends over it in a series of cascades, falling 40 feet in as many yards. Near the base of the exposed portion of this stratum, we see a very coarse layer, composed of rounded nodules of iron ore, quartz-pebbles, pieces of sandstone, and fragments of vegetable remains. The lower portion of this sandstone is not so massive as the upper, and is inclined to split up into layers.

About one mile above Moravia, the *Ferriferous limestone* is extensively quarried on the land of Mr. Shinn, and descending a ravine from this point to the Big Beaver, we get the section seen in Fig. 48.

The *Ferriferous limestone* is here quarried by Mr. Dayton, and shipped on the E. & P. R. R. to the furnaces in the Mahoning and Shenango valleys.

	4 B.	
1. Limestone, Ferriferous,	20'	20'
2. Concealed,	60'	60'
3. Coal, Tionesta,		Blossom.
4. Concealed,	30'	30'
5. Limest'ne, U. Mercer		1' 8"
6. Concealed,	25'	25'
7. Limestone, L. Mercer		2'
8. Shales,		5'
9. Coal, Lower Mercer,		?
10. Concealed,	100'	100'
11. Massive sandstone, (L. Connoquen'g,)	35'	35'
12. Concealed to level of Big Beaver,	36'	36'
Total,	Big Beaver Cr.	314' 8"

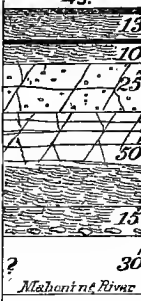
The upper or "gray" limestone, which is the part quarried, varies greatly in thickness at this locality, running as high as 18 feet, and as low as 5 feet.

At the horizons of Nos. 3 and 9, coals have been opened at some time, but the banks are fallen in and nothing could be learned of their quality or thickness.

No. 11 is the lower part of the *Massillon sandstone* and is seen in cliffs along the ravine, where it passes under the E. & P. R. R. The rock has here been quarried, and used in building the culvert across the gulch. It is a coarse, bluish-white rock, and many of its layers contain small quartz pebbles.

About one half mile south of the northern line of this township, a small run puts into the Mahoning river, and descending it to the same, we see sec., Fig. 49.

No. 3 is a coal which comes 45 feet below the *L. Mercer limestone*, and may be the equivalent of the *Quakertown coal*. It was once mined here by stripping, and is said to have been quite good.

	49.		
1. Bituminous shales,			
2. Sandy shale,	13	. . . . .	13'
3. Coal,	10	. . . . .	1' 6"
4. Dark sandy shales,	25	. . . . .	10'
5. Massive, conglomerate sandstone,	50	. . . . .	25'
6. Flaggy sandstone, and sandy shales,	15	. . . . .	50'
7. Blue, sandy shales, containing iron ore	30	. . . . .	15'
8. Concealed to level of the Mahon'g river,	?	. . . . .	30'
Total, . . . . .		. . . . .	146' 6"

No. 5 is a very hard, coarse, white sandstone, and is quite conglomeratic at this locality, containing, in some of its layers, many pebbles of quartz. They are both rounded and angular, and vary in size from a pea to a hickory nut. This is a part of the *Massillon sandstone*, and, on the opposite side of the stream, it is seen extending in a long line of cliffs far up the river.

No. 6 is the lower portion of the *Massillon sandstone*, which is here not massive.

No. 7 represents the iron bearing shales which occur immediately above the *Sharon coal*, along the Mahoning river.

6. Taylor Township.

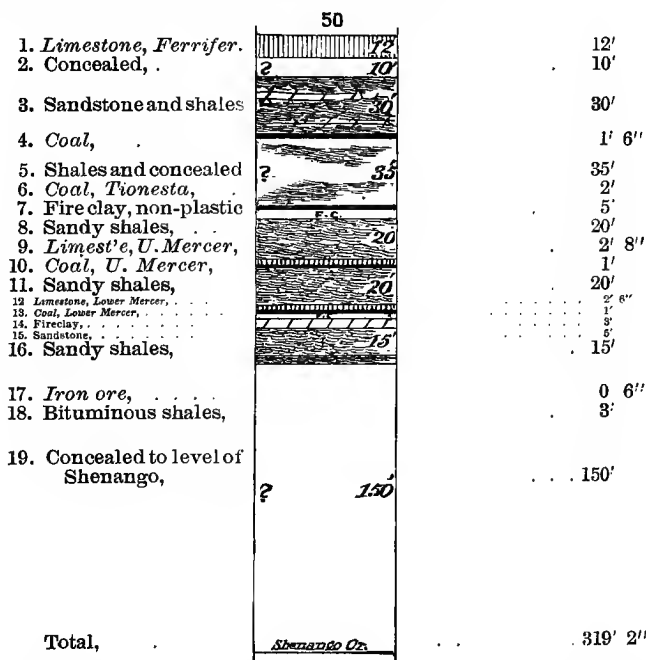
This is a long and narrow strip of territory which lies immediately east from North Beaver, along the waters of the Big Beaver and Mahoning rivers, and its northern portion occupies the triangular area formed by the junction of the Mahoning and Shenango.

The township has a maximum width of only two miles, while it is often much less, so that it frequently occupies only the alluvial plain of the river, and is consequently rather barren of geological data.

There are some very broad and level terraces bordering the Beaver along its entire course through this township. The lowest comes 30 to 40 feet above the river, and is the one along which the old Erie and Pittsburgh canal formerly passed. It is in many places more than a mile broad. The next higher one comes usually at 60 to 80 feet, and then

another at 160 feet. It is very probable that there was one at 120 feet, like we find it near the mouth of the Beaver, but no traces of it are seen along this line, and it very probably has disappeared through erosion, since we find a sloping plain in passing from the second terrace up to the third. Numerous rounded boulders of granite, gneiss and other metamorphic rock, together with rounded masses of sandstone, conglomerate, limestone, &c., occur on each terrace.

Near the eastern line of this township, and about two miles below New Castle, some high ground extends up from the Shenango and takes in a considerable area of the *Ferriferous limestone*. This stratum is extensively quarried at this locality by Messrs. Green, Marquis & Johnson, and descending a ravine from their quarry to the Shenango the section seen in Fig. 50 is exposed.



No. 1, the *Ferriferous limestone*, is here quarried, and shipped to the furnaces at New Castle and other points in the two valleys at the rate of 200 tons daily. There is only

a thin coating of *débris* resting on the stratum, as everything above and probably part of the rock itself has been torn away in the past by Glacial action. The upper or "gray" portion only is mined, being about 9 feet thick, while the lower or "blue" part is left in the quarry, as the furnace men reject it. Six and a half feet below the top of the rock is seen a layer of fire-clay, which varies from 4 to 6 inches in thickness, and sometimes it is merely a calcareous shale. The limestone is not massive, but splits off easily into irregular shelving layers which glisten with calcite and are crowded with organic remains, *mollusks*, *crinoids*, and *corals* being equally numerous. A beautiful specimen of *Pentremites pyriformis* was seen at this locality.

The limestone is transported down the hill in cars on an inclined plane, the loaded one drawing the empty one up as it descends. It is shipped on the E. & P. R. R.

The quarrymen say that one to two feet below the base of the limestone there occurs a coal 1 to $1\frac{1}{2}$ feet thick, but this horizon was concealed at every locality I could find and I did not get to see the coal. The statement is doubtless correct, however, as we often find a coal at that horizon, and Rogers named it the *Scrub-grass coal*.

No. 4 represents either the *Clarion* or *Brookville coal*, but which it is would be impossible to state; however the probabilities are in favor of the Brookville, since this is a much larger interval (40') than we find between the *Ferriferous limestone* and *Clarion coal* in the surrounding region. At Lowell, on the Mahoning, the interval is only 15 feet.

No. 6, the *Tionesta coal*, was once opened here in the ravine, on the land of Mr. Cooper, but it proved too thin and slaty to mine. This bed is known throughout the region as the *Shield's coal* or " $\frac{1}{4}$ foot vein." It is the same coal as that mined in North Beaver township, below Mt. Jackson, by Mr. Wallace, and which is there characterized, as well as here, by having a large bed of non-plastic fire-clay below it. This peculiarity seems to accompany the coal in question over a wide area in Lawrence county.

No. 8, the *U. Mercer limestone*, is quite hard and mas-

sive, and the stream makes a vertical plunge of 8 feet, where it passes over the same. The coal below the limestone is very impure and worthless.

No. 11, the *L. Mercer limestone*, also causes a fall of 8 to 10 feet in the little stream, and it stretches in a broad projecting shelf clear across its bed. The limestone is found in two layers, the lower being only 6 inches thick. The whole mass like its companion, the *U. Mercer* above, is filled with fossils, and is of a dark blue color. The coal under this limestone is also very slaty and bad generally.

No. 17 is a quite persistent stratum of iron ore, it being the same one which we saw in North Beaver township, at this horizon on Hickory creek. The ore is a limonite, and would probably make 50 per cent. of metallic iron. On the under side of the layer are seen many curiously shaped markings and cavities, which probably represent casts of fucoids.

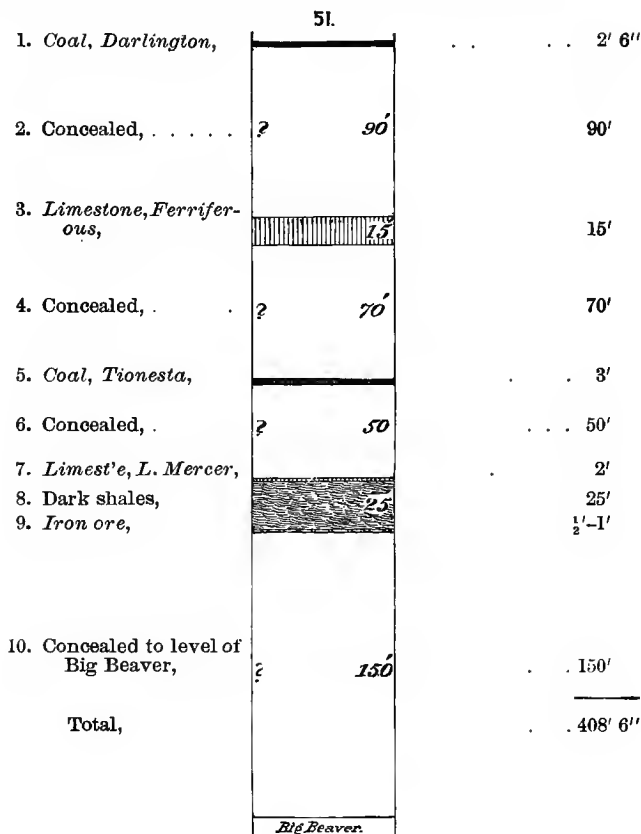
Below this everything is covered up by débris, until we come down 150 feet to the Shenango.

About one mile and a half below here, and nearly opposite the junction of the Shenango with the Mahoning, to form the Big Beaver, the *Darlington coal* comes into the hill tops nearly a mile east from the river, and descending from that point we get section, Fig. 51.

The *Darlington coal* is here mined on the land of Mr. Cunningham, in what is called "Sheep hill." The land rises about 50 feet above the coal.

The *Tionesta coal*, No. 5, was once mined a short distance below this locality by Mr. Shields, and is hence often called through this region, the "Shields coal." It was 3 feet thick, but contained many impurities in the shape of slate and sulphur.

No. 9 is the same little layer of calcareous ore which we saw below the *Lower Mercer limestone*, in the previous section. It was once mined here quite extensively by drifting, and taken to the furnaces at New Castle. It made an excellent foundry iron, but contained too much phosphorous for many purposes. It is said to have averaged 45 per cent. of metallic iron.



About one mile north from Mahoningtown, the *Tionesta coal* is mined on the land of Mr. Miller. It comes 40 feet above the *Lower Mercer limestone*, and 280 feet above the level of the Shenango. The coal is 22'' to 24'' thick, and is represented to be quite good. It has been gouged out of the hill at a great many places between this and New Castle.

The *Ferriferous limestone* comes 80 feet above the coal, near the summit of the hill, but is thin and impure, while immediately on the opposite side of the Shenango, one and a half miles away, it is 12 to 15 feet thick. Mahoningtown is situated on a beautiful terrace between the Shenango

and Mahoning rivers. The Terrace has an elevation of 30 feet above water level, and is a mere boulder bed.

7. *Shenango Township.*

This lies directly east from Taylor, being bounded on the north by Pollock and Hickory, south by Wayne, and east by Slippery Rock township.

Its drainage is all to the west, into the waters of the Shenango and Big Beaver, except a small area in its south-eastern corner, which passes off by way of Smiley's run into the Connoquenessing at the south.

Its streams are consequently all small, and the principal ones are Big run, Hog Hollow, Snake, and Smiley's runs.

The hill-slopes along the streams are generally quite steep and rugged, but, near the heads of the same, we find wide reaches of elevated land, which has a comparatively gentle slope, and much of it almost level.

The township is very rich in mineral wealth, as the *Darlington coal* spreads over a large portion of its surface, while the *Ferriferous limestone* extends in an almost unbroken mass 10 to 20 feet thick over its entire extent, except where it has been eroded by the water-ways of the streams. The immense deposits of iron ore at the horizon of this latter stratum, and which was described in connection with the chapter on Wayne, also occurs in the southern portion of this area.

On Hog Hollow, in this township, the *Darlington coal* attains a purity and richness found at no other point in the county, and is known as the "*Hog Hollow coal.*" At the gas-works in New Castle it yields a better quality of gas, and 8 to 10 per cent. more of it than any other attainable coal.

The section of this township extends from about 100 feet above the *Darlington coal* down to the base of the *Conglomerate series.*

Snake run rises in its southern part, and flows southwest into the Big Beaver at Chewton, in Wayne. Along either bank of this stream, the *Ferriferous limestone* is seen exposed in a constant line of outcrop until we come to

the head of the same, near the cross roads at Reed's school-house, and here it passes below water-level. It is from 15 to 20 feet thick all along this line, and is often seen in huge cliffs.

The *Darlington coal* comes about 75 feet above the limestone, and has frequently been opened along the hills by the farmers. At the very head of Snake run, we come to some extensive workings on this coal. Here, within sight of each other, are the mines of McConnell, Granniss, McKee, Crowl and others. The coal is 2 feet thick, and has a thin slate parting near its top, and another, $\frac{1}{2}$ inch thick, 2 inches above the bottom. It is of an excellent quality, being pitchy black, very free from slate and sulphur, and very rich in bituminous matter. Layers of pitchy black bitumen are interlaminated with mineral charcoal, and the coal is in very high repute for smithing purposes. The coal has the same structure, and nearly the same appearance, in all the mines. They supply the surrounding country for a long distance, and a considerable quantity is sent to New Castle, 6 miles north. It has only a slight dip to the south at this locality, and lies almost level.

Many abandoned openings are seen in the vicinity, which were carelessly constructed, and then allowed to fall in, by the thoughtless operators.

Passing north from here, across the "divide," we come down on to Hog Hollow, a stream which rises near the center of the township and puts into the Big Beaver opposite Moravia. About $2\frac{1}{2}$ miles above its mouth, the *Darlington coal* is extensively mined on the right bank of the same, by Mr. Woolley, and descending from his coal opening, we get the section, seen in Fig. 63.

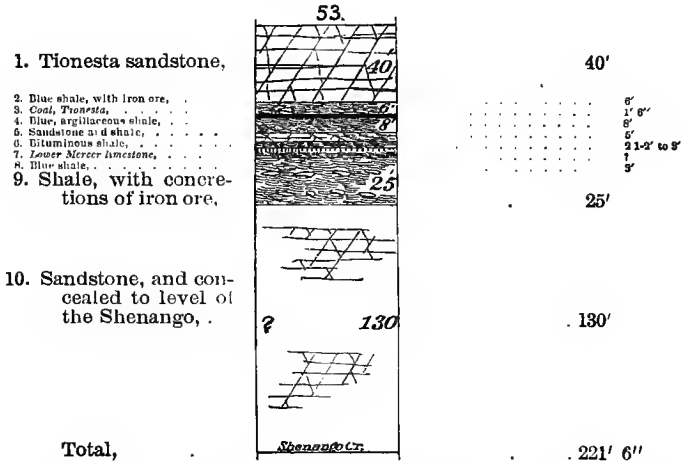
The coal is of a very superior quality, containing no visible pyrites nor slate, and is a very rich gas coal. The smiths hold it in very high esteem, and a large amount of it is hauled in wagons to New Castle, 4 miles north.

No. 3, the *Ferriferous limestone*, is seen finely exposed in a side ravine, which puts into Hog Hollow at this locality. The little stream makes a vertical plunge of 30 feet over the stratum, which extends in a cliff-like wall around the

of a better quality, and the yield is 8 to 10 per cent. greater than that obtained from any other coal in the county, notwithstanding the fact that the "Clinton" coal has a great reputation as a gas coal.

Along this branch of Hog Hollow the *Tionesta coal*, or as it is here called the "*4 foot vein*," has been opened at several localities, but no banks are in operation on it now. The coal is represented to have been $2\frac{1}{2}$ to 3 feet thick, but not very good, being slaty and impure. It comes 70 to 75 feet below the *Ferriferous limestone*.

The *L. Mercer coal*, or what is locally termed the "*Blue Limestone coal*," has also been mined along this stream, but its openings are likewise abandoned now, and the coal could not be seen. It comes 8 to 10 feet below the *Lower Mercer limestone*, which is here 125 feet below the *Ferriferous*, and is reported to have been 2 to $2\frac{1}{2}$ feet thick, but it was slaty and worthless, according to the most reliable accounts.

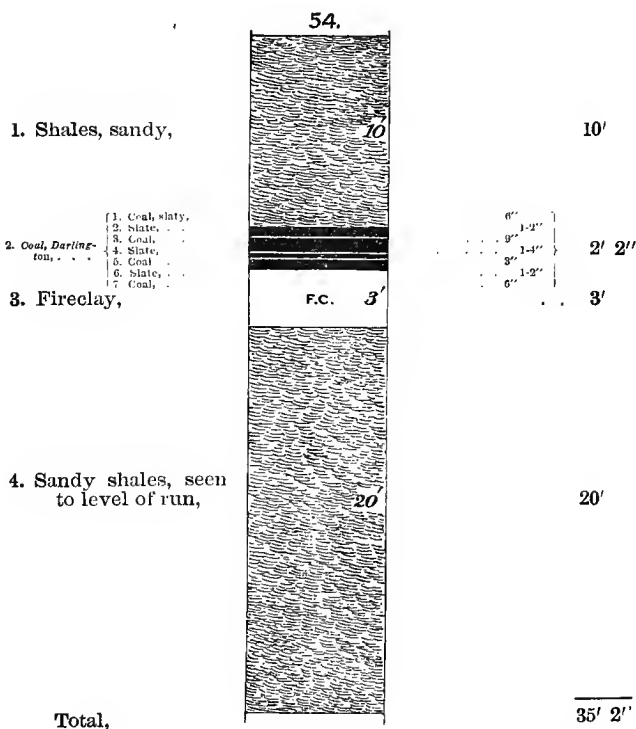


Big run flows across the northern part of the township and enters the Shenango below New Castle. Where the New Castle and New Brighton road crosses this stream it cuts down to the *Tionesta sandstone*, and passes over the massive part of the same in a vertical fall of 35 feet, and from this point to the Shenango descends a distance of 230

feet in 2 miles. At this locality, known as "Big Run Falls," we see the *Tionesta sandstone* in a very massive ledge 40 feet thick, and the stream descending through the narrow gorge which it has cut for itself after rushing over the falls makes a very wild scene. The place is much frequented by picnic parties during the summer.

Everything below the massive sandstone is now concealed by the débris and talus from the rock above, but at this same locality Rogers reports the succession, seen in Fig. 53 exposed at the time of the first survey: Vol. II, page 566, Fig. 410.

I was at first inclined to regard the massive sandstone at the top of this section as the *Upper Connoquenessing*, but if the *Lower Mercer limestone* was seen below it, that fixes it as the *Tionesta*. As previously stated, I could find no exposures at all below it now.



As we pass up Big run from this point it becomes a sluggish stream with gentle slopes on either bank, and everything is covered up with *Drift*.

At the south-eastern edge of Shenango township, near the head of Smiley's run, the *Darlington coal* is mined on the land of Mr. Van Emon, and there we get section, Fig. 54.

The coal is here very much split up by bands of slate, and also contains considerable pyrites, being a pretty bad coal generally. The uppermost 6 inches is a slaty cannel at the mouth of the drift, and further back in the mine is said to become much purer and to burn very well, leaving a not very abundant white ash.

Further down the stream the *Ferriferous limestone* rises from the bed of the same at an interval of 75 to 80 feet below the Darlington coal, and is seen in cliffs and immense detached masses on either slope of the hill.

8. *Slippery Rock Township.*

This area lies directly east from Shenango township, and is bordered on the north by Scott, south by Wayne and Perry, and adjoins Butler county on the east.

Slippery Rock creek flows in a very irregular and winding course south through its eastern portion, and reaching its southern border, turns south-west and forms the boundary of the township, until we come to its extreme southern margin. Throughout the most of this distance the stream flows in a narrow gorge, cut down almost perpendicularly through the massive rocks of No. XII, and in consequence possesses many very wild and picturesque localities, which are much frequented by the lovers of such scenery. The most attractive of these localities are Eckert's bridge, Muddy Creek falls, Kennedy's lower mills and Kennedy's upper mills.

Slippery Rock receives not a single tributary from the west, of any consequence, throughout the ten miles of its course through and along this township. What drainage does come into it from that direction is carried by insignificant streams, which rise on the highlands only one to two miles back, and pour down with rapid fall to the main

stream. From the east, it receives but one of any importance, viz: Muddy creek, which puts into it from Butler county, between Rose Point and Kennedy's lower mills. This is a considerable stream, and drains a large area in the northern part of Butler.

The great ice sheet, which came down from the north during the *Glacial Period*, stretched in a narrow stream clear across the northern part of this township to the Beaver Valley at New Castle; for we find an old eroded valley about 200 feet below the surrounding hills, extending across between the valley of the Slippery Rock and that of the Beaver. Big run flows west in this valley of erosion, and we pass by an almost imperceptible divide (only a few feet high) to the source of a small stream that heads up against Big run, and passes into the Slippery Rock. In fact we can scarcely tell by the eye where the one stream ends and the other begins. This valley however may have been mostly eroded by the former course of Slippery Rock, (as suggested in chap. II) before it was filled with Drift.

This township, like Shenango, also possesses extensive deposits of iron ore, coal and limestone, but its coals although extensive in area cannot begin to compare in purity with those found in Shenango. The *Darlington coal*, which is the principal one in this township, seems to become somewhat slaty, and contains more pyrites, when traced eastward from Shenango.

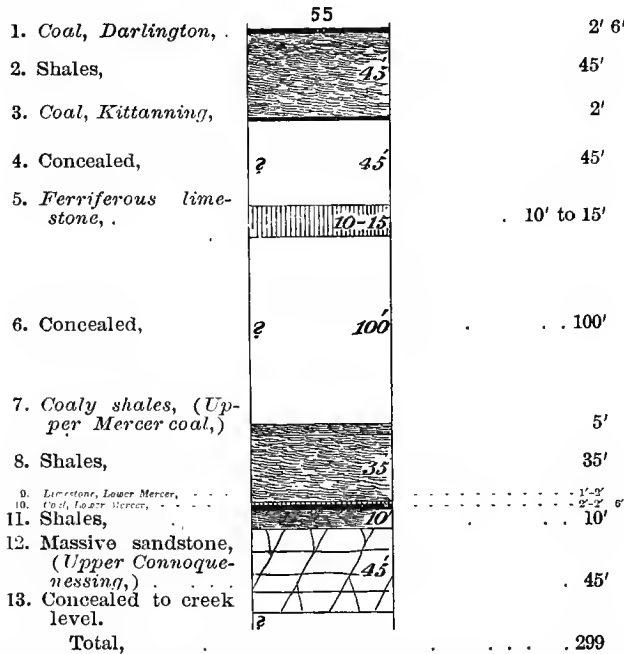
The *Kittanning coal*, which was absent as a workable bed in Shenango, thickens up again in Slippery Rock, and is of valuable dimensions at many localities.

The great *Ferriferous limestone* and its accompanying iron ore also stretch over a wide area.

The Slippery Rock Oil Territory extends into this township from Wayne and Perry at the south, and two wells are now getting oil along the creek.

The section of the rocks extends from 60 feet below the *Lower Mercer limestone* up to 150 feet above the *Darlington coal*, but owing to the meagerness of exposures in the upper portion of the rocks, we seldom see anything uncovered above the Darlington coal. Beginning at the most

southern limit of the township, on Slippery Rock creek, and passing up the same, we find substantially the succession given in Fig. 55.

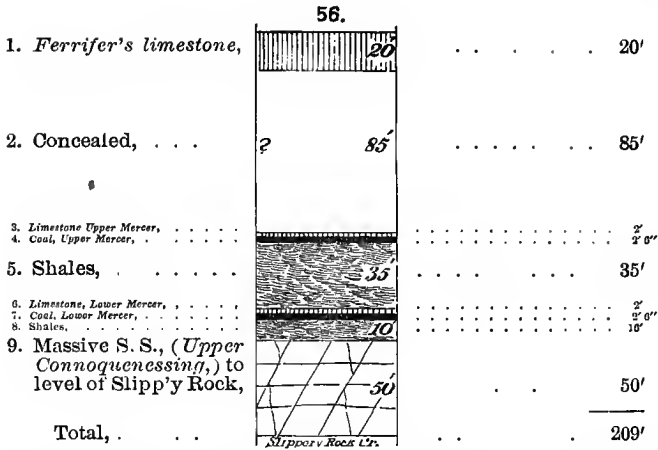


This section is the one made on the land of Mr. Frew, near the Wayne township line, and described in connection with that township on a previous page.

No. 5 forms frequent lines of cliffs along the hills, and is quite persistent, but on the opposite side of the stream, in Perry township, it is either absent entirely or found to be only 2 to 5 feet thick, which is a very good illustration of what is continually occurring with this stratum, when followed to any considerable distance.

The *Upper Mercer limestone*, which should come at the horizon of No. 7, is absent from this section, but, as we go up the creek, it comes in at its proper place.

No. 12 is a very hard, grayish-white rock and forms bold cliffs along the stream. One mile north from the township line, we come to Harris's Fording, and descending a ravine at this locality, we get section, Fig. 56.



Here the *Ferriferous limestone* attains an enormous development, and huge blocks of it, as large as an ordinary house, lie scattered over the hill, along and below its bed. It has also thickened up to the same size on the opposite side of the creek.

At this locality we see the *U. Mercer limestone* coming into the section again as No. 2, which is partly limestone and partly iron ore.

The coal below it is slaty and worthless as we always find it along the stream. Some one has attempted to open it near the Fording, but the coal was so bad that the attempt was given up. It probably contains 40 per cent. of ash.

The *Lower Mercer limestone*, No. 6, is a compact, dark-bluish rock, breaking with sharp angular fracture, and perfectly filled with organic remains. The coal below it is better here than we usually see it, and looks as though it would burn quite well.

The *Upper Connoquenessing sandstone* is a very massive stratum, and stands out in perpendicular cliffs on the east bank of the stream.

Just at the Fording, an oil well is now being operated by Mr. Lukens. It commences 10 feet above the creek, and obtains the oil at about 190 feet, which makes it at the same horizon as the oil obtained in the vicinity of Arm-

strong's Fording, in Wayne and Perry townships, since the oil is found there 237 feet below the *Lower Mercer limestone*, and, at this locality, comes 240 feet below the same rock. The yield is small, only 3 to 4 barrels daily, but the oil is of the heavy or lubricating variety, and thus it pays to pump it. It ranges in gravity from 32 to 36. No regular record of the strata, passed through in the boring, was kept.

About one mile above this, a test well was drilled by Mr. Geo. Dimmick, an experienced oil operator, on the Shaffer farm, and the well is known as the "Shaffer well." Mr. D. keeps a careful record of all wells drilled under his supervision, and from his book of records, he gave me the following succession passed through by the Shaffer well. It commences about 15 feet below the *Lower Mercer limestone* and 50 feet above the level of Slippery Rock :

1. Sandstone and dark shales,	95'
2. Hard, whitish sandstone, (base of No. XII,)	75'
3. Shales and slates, (Cuyahoga and Berea,)	340'
4. Grayish-white sand, "Amber Oil Rock," first sand of Butler,	40'
5. Shales,	150'
6. Red Rock,	25'
7. Shales, (black oil at bottom,)	75'
8. Shales,	165'
9. Red Rock,	40'
10. Shales, slates, &c., (black soot and gas at bottom,)	320'
11. Shales,	23'
12. Red rock, containing vast quantities of fossil shells,	10'
13. Fine, grayish-yellow sand,	5'
14. Grayish-black sand,	32'
15. Light-colored, argillaceous shales, to bottom of hole, at 1,411 feet,	116'
Total,	1411'

"Well cased at 247 feet, no water veins found below that, and no salt water." Mr. Dimmick put down this well not only to test the Slippery Rock oil horizon, but to make a satisfactory test of the presence or absence of the lower or Butler oil sands in this region. The Slippery Rock oil sand should have been found about 50 feet below the base of No. 2, since the *Lower Mercer limestone* comes 15 feet above where the well commenced, and we have else-

where shown that this oil horizon generally comes 230 to 240 feet below that limestone. No sand was obtained at that horizon in the well, and consequently no oil. But at 510 feet a tolerably coarse, white sand, which is known among the oil men of this region as the "Amber oil rock," was found 40 feet thick. In it was obtained some light amber oil, in such small quantity, however, that no attention was given it.

I have shown in Report "Q," on the Beaver district, that the *Smith's Ferry oil rock* lies about 700 to 730 feet below the horizon of the *Kittanning coal*, and to show that No. 4 of this boring is the same rock we have only to add the interval occurring here between the *Kittanning coal* and *Lower Mercer limestone* to the distance below the latter stratum at which this oil rock comes. According to the 1st section given in this township, on page 152, and made $1\frac{1}{2}$ miles below here, we have 185 feet as the interval between the *limestone* and *coal*, and as the well commences 15 feet below the *Lower Mercer limestone* we have $185+15+510=710$ feet as the interval at which the "Amber oil rock" or No. 4 of this boring lies below the *Kittanning coal*, which demonstrates the identity of the Smith's Ferry oil horizon with that of the "Amber oil rock." This is also the same as the "124 foot" rock struck in the deep boring at Beaver Falls, and at the other localities along the Big Beaver where borings have been put down. This is the "78 foot rock" in the New Castle boring, the "75 foot rock" at Sharon, and the oil rock on the Mahoning river, near Edinburg, at the Ohio State line. It is noted as always containing "Amber oil" in greater or less quantity, and is doubtless the representative of the 1st Oil Sand of Butler.

As will be perceived by the record, there were found no representatives whatever of the 2d and 3d Oil Sands, but the strata passed through, as described by Mr. Dimmick, were mostly hard, sandy layers, or "shells" of the drillers, alternating with soft or argillaceous ones.

A small quantity of Black oil was found at a depth of 800 feet, however, and this may represent some one of the

other oil sand horizons of the Butler, or Oil creek district. The record of this well taken in connection with those bored at New Brighton, Beaver Falls, Smith's Ferry, New Castle, Sharon, and other points along the western line of the State, may be considered as definitely settling the fact that all the oil sands of Butler are absent here, except the First, and it is hence a useless waste of capital to seek further for any oil in this region, below the base of No. 4, or the 1st Sand. All the lower sands of Butler appear to have fined down and split up into mere sandy shales, and fine, close, flaggy layers incapable of acting as reservoirs for oil. This conclusion is not based on meager data, for there is now a line of borings extending from Sharon to the Ohio river, a distance of 45 miles, and none of these deep borings have found any good sands below the horizon of No. 4, though several have been drilled 1500 feet below it. So that, unless the sands should run in a very narrow belt, there is no chance for their having escaped the drill.

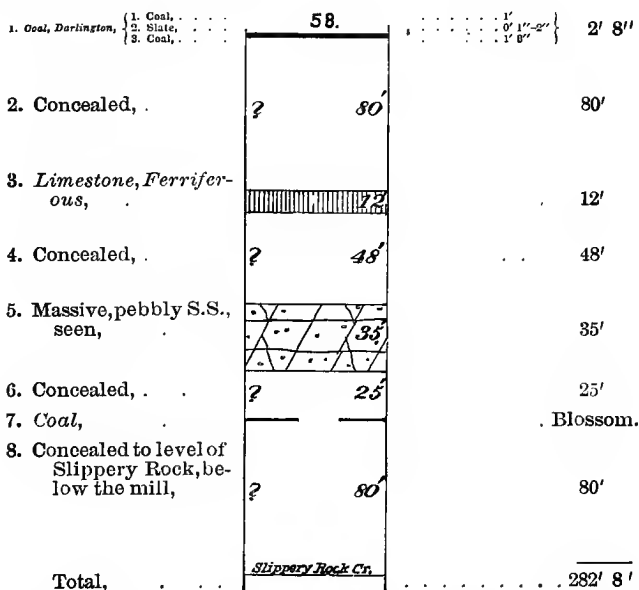
As we pass up the Slippery Rock from the Shaffer well, a great change takes place in the rock interval between the *Ferriferous limestone* and the *Lower Mercer limestone*, below. Hitherto, along this stream, we have seen no massive sandstone in this interval, but instead shales, several small coals and two limestones, the *Lower Mercer* and *Upper Mercer*. But as stated in our description of Perry township, we find, on going up the stream to Eckert's or Seceder's bridge, that an immense sand and pebble rock has come into the series at this same horizon, cutting out both limestones and their associated coals, and forming a solid sandstone mass, 110 feet thick.

Just how this great development of massive rock takes place could not be seen, but it is probably caused by the *Tionesta sandstone* coming in and cutting away the underlying coals, limestones, shales, &c., until it extends down to and unites with the upper portion of the *Massillon*; or the whole mass may represent the *Tionesta sandstone* which has here developed both upwards and downwards, as it does on the Beaver river, in the vicinity of Homewood. There it extends above the horizon of the *Ferrifer-*

ous limestone, and is altogether 155 feet thick, and we see from the section on page 83, Perry township, that, if it should extend up to the same horizon here, it would have an equal thickness.

The channel of Slippery Rock is in the vicinity of Eckert's bridge, and for a long distance above, only a mere gorge cut down through this massive sandstone, thus making the hillsides very precipitous, but above the line of the sandstone they slope gradually away and carry the *Kittanning* and *Darlington* coals in their summits.

On going above Eckert's bridge, the boundary of this township crosses the stream and extends out to the Butler county line. The area between the stream and the Butler line is quite narrow, being here only $\frac{1}{2}$ to $\frac{3}{4}$ mile wide, but the hills extend up to a considerable height, and on the land of Mr. Kelty, one mile above the Eckert bridge, take in a small area of the *Darlington coal*, and descending from this locality along the road to Kennedy's lower mill, we see the section, Fig. 58.



The Darlington coal has here been extensively mined for local supply by Mr. Kelty, near to Butler county. The

coal is quite good for grate and steam purposes, but contains too much sulphur for smithing.

At a distance of 45 feet below the Darlington coal occurs the *Kittanning* in the concealed interval No. 2. It was not seen at the immediate locality of the section, but a short distance away, and just over in Butler it is mined on the New Castle and Portersville road by Mr. Oliver, where it is 40 inches thick and quite a fine coal. It is there 35 feet above the *Ferriferous limestone*, and the *Darlington coal* has also been opened above it at the same horizon that we find it in this section.

No. 3, the *Ferriferous limestone*, has been mined and burned along the Portersville road by Mr. Kiddou. It is a light gray rock, quite compact, and exhibits the shriveled or wavy aspect along its cleavage faces, which is so common a characteristic of this stratum. It makes a beautiful white lime, which is highly prized for plastering and for agricultural purposes.

No. 5 is the *Tionesta sandstone*, and it extends down through the concealed interval of 25 feet below, which makes its thickness here about 60 feet. It is a mere mass of quartz pebbles, and is seen extending around the hills in the vicinity of the mill in very massive, perpendicular cliffs, from which monstrous blocks have broken away and now obstruct and fill up the channel of the stream which here falls at the rate of 50 feet per mile. The scenery produced by the overhanging cliffs and rushing torrent below is wild and grand in the extreme, so that this locality is a noted resort for pleasure parties during the summer.

About two miles above Kennedy's lower mills, we come to Rose Point, and here is situated the old Will Roy furnace. It was run with charcoal, and was built 25 years ago. The ore used was that occurring in connection with the *Ferriferous limestone*, and the iron was hauled to New Castle for shipment. It went out of blast about 12 years ago, and has not been in operation since.

A short distance west from Rose Point we find the Hope furnace, also a charcoal one, which was built 10 years ago by Mr. Brown of Pittsburgh. It was operated from that

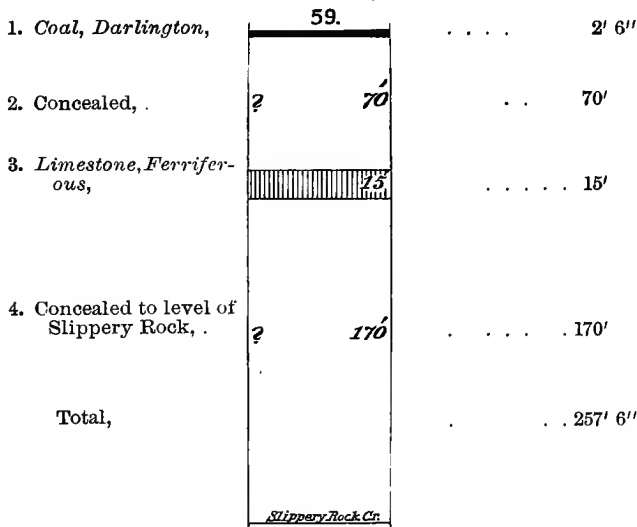
time continuously until 18 months ago, when it went out of blast, and has been idle ever since.

The ore used is that coming immediately on top of the Ferriferous limestone, and its thickness is usually from 1 to 2 feet, but it often thickens up to 4 feet or 5 in the "pots," as the miners term them.

The iron made here was shipped by way of New Castle to Pittsburgh, and is reported to have been an excellent article. In the manufacture of one ton of pig, $2\frac{3}{4}$ tons of ore were used, according to the books of record, and it took 175 bushels of charcoal per ton.

The *Ferriferous limestone* lies here at an elevation of 170 feet above Slippery Rock, and is 15 to 20 feet thick. It was used as a flux at the Hope and Will Roy furnaces. It is crowded with organic remains.

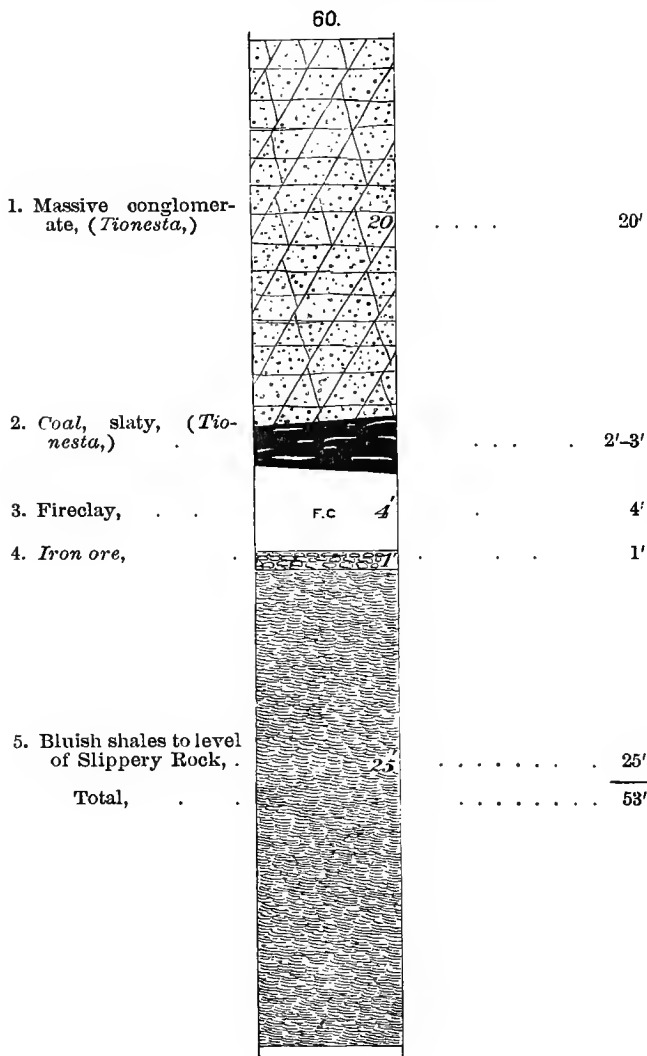
On the high land, one mile west from Rose Point, the *Darlington coal* is mined on the land of Mr. Eakin, and there we get section Fig. 59.



The coal contains many thin partings of pyritous slate, and has a dull resinous lustre. It has a parting of slate nearer the top than bottom.

About midway in No. 2 is seen the blossom of the *Kit-*

tanning coal, but it has never been developed in this vicinity, and nothing is known of its thickness or value.



One and a half miles south from Hope furnace the *Darlington coal* is mined by Mr. Rogers, where it is 85 feet above the *Ferriferous limestone*, is 2½ feet thick, and

has a parting of slate 1 foot below its top. The coal is quite good, though rather friable, and coated with a rusty film from long exposure near the surface. One and a half miles above Rose Point, we come to Kennedy's upper mill, and there we get the succession seen in Fig. 60.

No. 1, the *Tionesta sandstone*, is still very massive, and forms huge cliffs along the stream at this locality. It is also very conglomeratic.

No. 2, which very probably represents the *Tionesta coal*, was once mined here, but it is too slaty and dirty to be of any value, and could only be burned with the greatest difficulty. Some parties here thought it was the representative of the *Sharon coal*, but that coal should be found at least 100 feet below the bed of the creek at this locality.


No. 4 is a tolerably rich carbonate ore, and may represent one of the limestones (*U. or L. Mercer*), which should be found at this horizon. East from Kennedy's mill in the north-eastern portion of the township, a very high knob takes in a small area of the *Darlington coal* at an elevation of 220 feet above the base of the massive sandstone seen at the mill. This is the same interval as that seen between the *Darlington coal* and *Lower Mercer limestone* at Wurtemberg, in Perry township. The coal is mined by Mr. McCormick, and lies 80 feet above the *Ferriferous limestone*.

It comes quite near the surface, and has consequently deteriorated very much in quality, being covered with a rusty coating of iron.

Along the northern line of this township, and for nearly 2 miles south of this line, the hills have been so planed down by erosion that they do not extend up to either the *Darlington coal* or *Ferriferous limestone*, since the upward rise of these strata, as we go north, carries them higher and higher above tide.

Near the north-western line of the township however, and about one mile south from Big Run, we find the hills extending up far above their level along the Big Run valley, and taking in a small area of the Lower Productive coals, on the lands of Messrs. Nelson and Armstrong. The *Darlington coal* is mined by both these gentlemen, and shows

nearly the same structure at each bank. At Mr. Armstrong's it exhibits the following:

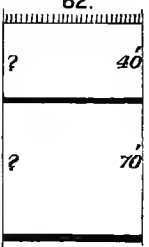
1. Shales, 2. Coal, Dar- <i>lington</i> ,	$\left\{ \begin{array}{l} 1. \text{ Coal,} \\ 2. \text{ Slate,} \\ 3. \text{ Coal,} \end{array} \right.$		$\left. \begin{array}{l} 1\frac{1}{2}'-2' \\ 0' 1''-1\frac{1}{2}'' \\ 6''-8'' \end{array} \right\}$	? 2' 10"
Total,				2' 10"

The coal is quite pure and free from sulphur, and possesses much mineral charcoal interlaminated with pitchy black bitumen. It is in high repute for smithing and culinary purposes. Its average thickness is about 28 inches, and the lower bench is the purer coal.

In the top of the hill, 70 feet above the Darlington, we see the blossom of another coal along the road, and this would come at the horizon of the *Lower Freeport*. Mr. Armstrong once dug into it and found it 1½ to 2 feet thick, but it lies so near the surface that it was worthless as a fuel, and was not pursued.

The knob which holds the Darlington on these two farms contains an area of probably 40 to 50 acres of the coal.

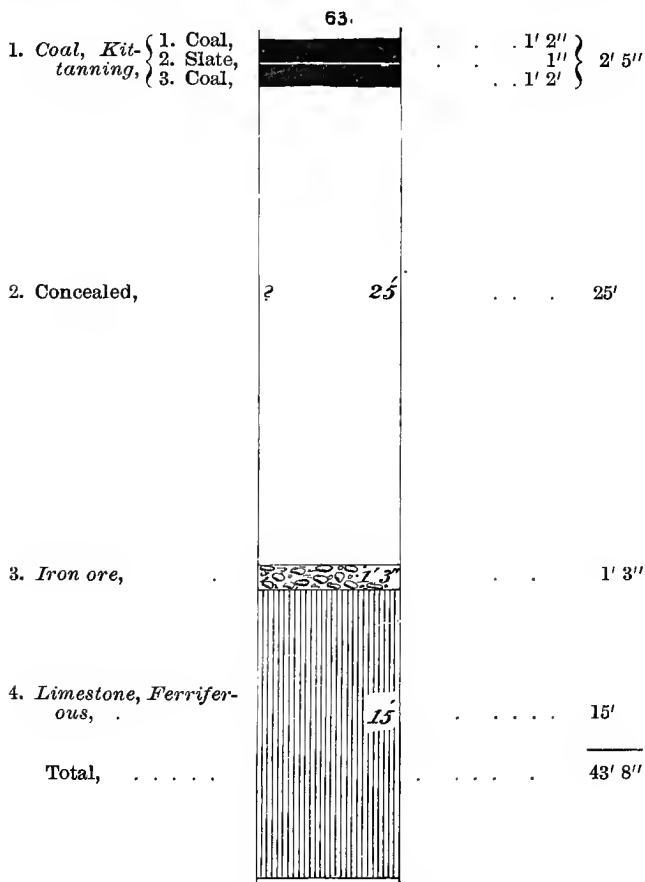
About ¼ mile east from this we get section, Fig. 62, on the land of Mr. Criswell.

1. Limestone, <i>Freeport</i> , (reported,)	$\left\{ \begin{array}{l} ? \\ ? \\ ? \end{array} \right.$		$\left. \begin{array}{l} 40' \\ 2' 6'' \\ 70' \\ 2' 6'' \end{array} \right\}$	? 40' 2' 6" 70' 2' 6"
Total,				115'

No. 2 is the same coal whose blossom is seen along the road which crosses the hill to Mr. Armstrong's. It was once opened at this locality, and is reported to have been quite good, though it comes so near the top of the knob that the roof was entirely rotten and could not be kept up, so that the mine had to be abandoned.

Mr. Criswell tells me that near the top of the ridge, and 40 to 50 feet above where the coal was opened, he has in plowing frequently seen a limestone several feet thick. I had no means of verifying this statement, as everything is now covered by a thick coating of soil, but if the limestone seen were in bed it would represent the *Freeport limestone*.

About one mile north-east from Mr. Criswell's the *Kittanning coal* is mined on the land of Mr. Wm. Book, and at that locality we get the succession seen in Fig. 63.



The section at once shows us that this is the *Kittanning*

coal, since it occurs only 25 feet above the *Ferriferous limestone*, while at no point in the county have we found an interval of less than 60 feet separating this latter rock from the *Darlington*. The coal at Mr. Book's bank is quite good, and contains very little visible pyrites. It is used by the smiths of the neighborhood, and pronounced an excellent coal for their purposes.

The *Ferriferous limestone* is quarried here by Mr. Book, a short distance below where he has the coal opened. It burns into a reddish colored lime, as it contains considerable iron.

Immediately on top of the limestone comes the *Ferriferous ore*, which is here 15 inches thick at the quarry, and has been mined for shipment to the New Castle furnaces. It is rather too silicious for an easily working ore however, and would probably not yield more than 30 to 35 per cent. of iron.

On the opposite side of this knob the *Kittanning coal* is mined by Mr. Young, and there it exhibits a structure in every respect similar to that seen at Book's bank.

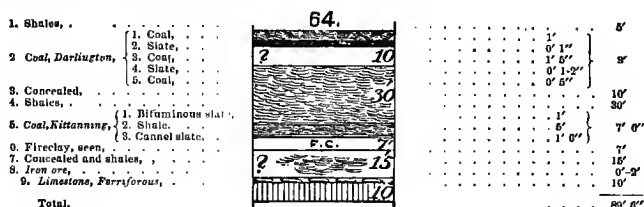
One mile east from Princeton the *Darlington coal* is mined by Mr. Taylor, where it is 3 feet thick, and has a small band of pyritous slate near its middle. The same coal underlies the village of Princeton at a depth of near 50 feet, and is also found on many of the farms at the south.

Three fourths of a mile south from Princeton it is mined by Mr. Stickel, and also by Mr. Thomas.

Near the southern limit of this township, there puts into the Slippery Rock a small stream which, from the wild and rugged country through which it flows, has obtained the suggestive name of "Hell Hollow." About one and a half miles above the mouth of this stream is situated the Lawrence furnace, which was built 10 or 12 years ago, to operate the native ores exclusively, but has now been out of blast for about four years. The ore was obtained almost entirely from the horizon of the *Ferriferous limestone*, in this and the surrounding vicinity.

Just opposite the furnace, the *Darlington coal* was

mined, and descending the hill at this locality along the old coal road, we get section, Fig. 64.



Here we have a good illustration of what is so frequently happening to the *Kittanning* coal in Lawrence county. About four miles north from this, on the land of Mr. Book, we saw it $2\frac{1}{2}$ feet thick, and a very good coal, but here we find, at the same horizon, nothing but some bituminous slate and impure cannel, separated by 5' of shales, as the only representative of the *Kittanning* coal. We know that this is the representative of the *Kittanning*; for it comes at about the same interval above the *Ferriferous limestone* that we often find it in Lawrence county, and then it is underlaid by the great bed of pure fireclay which is so constant an accompaniment of this coal in the Beaver valley, and which is found with no other one in the section.

The strata are rising very rapidly to the north and west, at this locality, and, as we pass down the stream from where the road crosses it, the *Ferriferous limestone* exceeds, in its southward dip, the rapid fall of the stream and passes out of sight below the bed of the same, but the fall of the stream having increased, it is again brought to the surface $\frac{1}{2}$ mile below, and then appears in a vertical cliff along its banks.

At this furnace, the Brush Creek coal, which occurs in Perry township on the opposite side of Slippery Rock creek, was used in the raw state to smelt the ores, and is said to have given very satisfactory results, though it was only used for a short time.

Near the head of one branch of Hell Hollow, and not far from the Baptist church, the *Darlington* coal is mined by Mr. McMillen. The coal is $2\frac{1}{2}$ feet thick, but rather im-

pure, being slaty and sulphurous. Large sulphur binders are of frequent occurrence in the coal at this locality.

One hundred feet above the Darlington is seen the blossom of another coal, which is reported to be 18 inches thick, and 60 feet above this a limestone is reported as occurring in the top of a knob, which would be the *Freeport*.

One and a half miles north-east from this the *Darlington coal* is mined near the Houk school-house, on the land of Mr. McClaren.

It is there 30 inches thick and quite good, coming out in handsome blocks, which are, however, stained red from long exposure of the coal near the surface of the ground. The parting of slate comes 18 inches below the top, and varies from 1 to 1½ inches in thickness.

9. *Scott Township.*

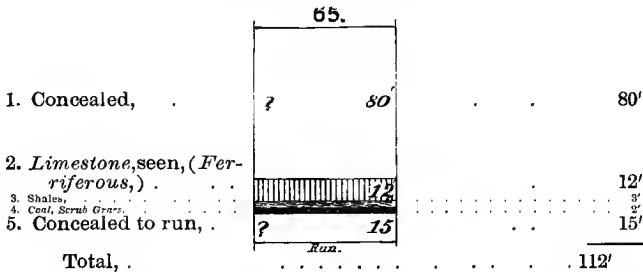
This area lies immediately north from Slippery Rock township, and is bounded on the north by Washington and Plain Grove, west by Hickory and east by Butler county.

Slippery Rock creek flows through its south-eastern portion and receives the drainage from the eastern half of the township, while that from the western part is carried off into the Neshannock and Shenango by way of Hettenbaugh and Big runs.

In ascending the Slippery Rock from Kennedy's upper mill into this township we find a great change taking place in the topography along that stream. Hitherto in ascending Slippery Rock from its mouth we have found it bordered by steep and lofty hills, and have frequently seen the stream rushing along, hemmed in by precipitous cliffs of the massive rocks of XII, but on passing into Scott township we find the lofty hills replaced by broad and gently sloping plains; the cañon-like walls which enclose the stream in the lower part of its course have vanished, and the creek itself becomes sluggish. This great change is due to two causes, viz: a change in the character of the underlying rock, and the addition of another agent of erosion, ice; for as we pass north from the middle line of

Slippery Rock township we find a thick coating of *Glacial Drift* covering a large portion of the surface of the country. In coming north from Kennedy's mill the *Tionesta sandstone* thins away and we see it no more as a massive sandstone or pebble rock, and then the creek's bed has risen so high in the strata as to have only a small portion of No. XII exposed above its level, since where Slippery Rock enters this township the *Ferriferous limestone* is only 80 feet above its level. The general surface having been planed down by ice erosion, we find the *Darlington coal* is caught in only a few outlying patches or knobs in the western half of the township, but the *Ferriferous limestone* coming at a much lower level spreads over a considerable area.

Brown's run puts into the Slippery Rock one mile south-east from the village of Harlansburg, and about one mile north-west from the same village we find the *Ferriferous limestone* exposed along this run on the land of Mr. Brown, at whose quarry we get section, Fig. 65.



The hills rise at this locality (which is $\frac{1}{2}$ mile above the U. P. ch.) 80 feet above the Ferriferous limestone, and should catch the *Darlington coal* near their summits, but nothing has ever been seen of it, and the *Kittanning*, which should come 40 feet lower, has never been looked for. It is probably absent, however, as no blossom from it appears in the roads where they pass over the exposed strata at this horizon.

No. 2 is quarried and burned on the land of Mr. Brown, and is seen extending in a line of massive cliffs around the hills. It is gray in all its upper portion and dark blue below. It has the same shriveled and shrunken aspect which

this rock so often presents, and is a mere mass of broken and comminuted organic remains. It makes a beautiful white lime, and is hauled to a long distance into the surrounding country.

Below that limestone a coal was once mined, and the old drift is still visible near the quarry. The coal was separated from the overlying rock by only 2 to 3 feet of shales, and is reported to have been 2 feet thick. It was rather impure however, containing considerable slate and pyrites. This represents the coal which often comes between the *Clarion* and the *Ferriferous limestone*, and which was termed the *Scrub Grass bed* by H. D. Rogers in the Reports of the 1st Survey.

At Harlansburg the *Ferriferous limestone* is seen along the road which passes up through the village, and there it seems to be overlaid by a very massive sandstone, or that one which in the Reports has been termed the *Kittanning sandstone*. The limestone itself appears to be thin, and it may possibly have been partially eroded by the current, which threw down the massive, coarse sandstone above it.

Passing over the "divide" at the head waters of Brown's run, and descending Hettenbaugh's, we find the *Ferriferous limestone* coming above water level near the Hettenbaugh school house, and where the road crosses this stream 10 feet of it is seen in the bank of the run.

A massive sandstone is seen immediately above the limestone.

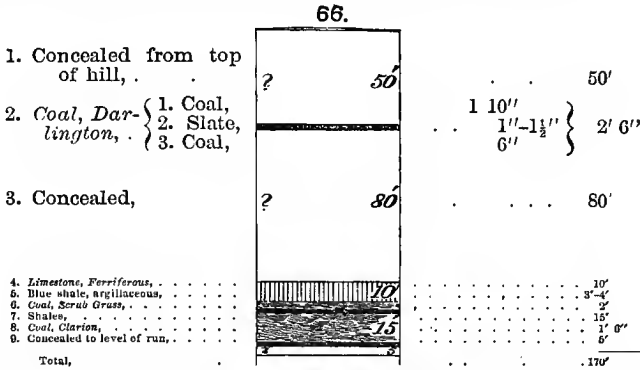
The neighboring hills rise 100 feet above the latter stratum, and should catch the *Darlington coal* in their summits.

As we descend Hettenbaugh run from the school house, the *Ferriferous limestone* gets higher above the stream, and at Mr. Reichel's, one mile below, we get sec., Fig. 66, in descending from his coal mines to Hettenbaugh.

The *Darlington coal* is here caught away back in the hills on the right bank of the run, and has been quite extensively mined by Mr. Reichel for local use.

The coal varies in thickness from 28 to 30 inches, and has a small band of slate near its bottom. It is quite firm, coming out in large blocks, and is tolerably free from

sulphur and other impurities, being a very rich, brilliant coal. The upper part has a semi-cannel structure.



This same coal is also mined a short distance away by Mr. Slater, where it shows the same structure as seen at Reichel's. The hills rise above it only 50 feet at their highest point, so that the area of the coal in this vicinity is limited.

The *Ferriferous limestone* is seen along the steep bluff of the run in a vertical cliff. It consists here of 5 to 6 layers, separated by thin streaks of shale or clay, but the limestone layers are quite compact and burn into excellent lime.

Separated from the limestone by a shale interval of only 3 to 4 feet, we find a coal 2 feet thick, which has also been mined by Mr. Reichel. The coal comes out in rectangular blocks, and is a kind of semi-cannel. It contains some sulphur, and is quite hard to dig, being somewhat slaty. This is the *Scrub Grass coal* of Rogers.

No. 8, the *Clarion coal*, was once drifted upon, but the mine is now abandoned, though the coal is said to have been remarkably pure, and highly prized by the smiths. A short distance below here it was once stripped out of the run on the land of Mr. Connahy.

We shall refer to this section again, when we come to the description of Hickory township.

10. *Hickory Township.*

This lies directly west from Scott, and is bounded on the north by Wilmington, south by Shenango and Slippery

Rock townships, and west by the Neshannock creek which forms the boundary between it and Neshannock township.

The drainage is all west into this last mentioned stream, and the only tributary worth mentioning is Hettenbaugh run, which rises to the east in Scott township and flows across Hickory past the village of East Brook.

In its southern portion the hills rise about one hundred feet above the *Ferriferous limestone*, and consequently catch the *Kittanning* and *Darlington coals* in their summits, but the latter comes so near the surface that it has never been mined and is only known to be present in some of the highest knobs where its blossom was seen along the road.

About one and a half miles east from Croton and one mile north from the southern line of this township, the *Kittanning coal* is mined on the land of Mr. C. Emery, and is transported some distance on a tram-way to the public road. The mine was temporarily closed on account of defective drainage when I visited the locality, and I was thus unable to see the coal.

Mr. Emery reports it, however, as varying in thickness from 2 to $3\frac{1}{2}$ feet. It comes 20 feet above the *Ferriferous limestone*, and is immediately underlaid by a very large bed of pure fire-clay.

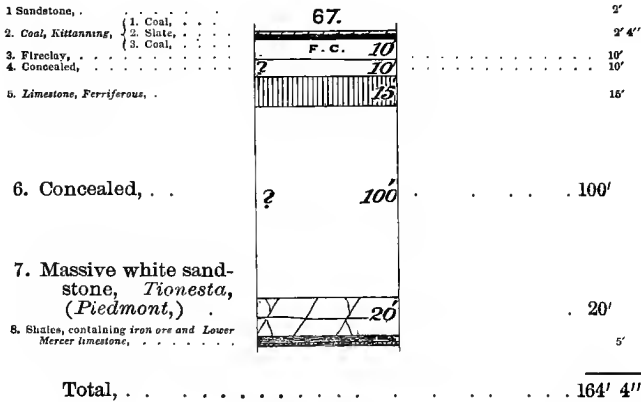
A short distance south from this, the same coal was once mined on the land of Mrs. Emery by a shaft 78 feet deep, but the available coal has now all been taken out, and the works abandoned.

The *Darlington coal* was not passed through in this shaft, as the Drift covers the surface here to a thickness of 50 feet.

A short distance south-west from Mr. Emery's, the *Kittanning coal* is extensively mined by Mr. Henderson, and at his drift we get section, Fig. 67.

The *Kittanning coal* lies in a very uneven bed, as it is constantly rising and falling. Sometimes it will dip down 20 feet in almost as many yards, while again it will suddenly rise quite as fast. The miners say they always find

the thickest and best coal in the "swamps," where it frequently becomes 3 feet thick, but on the "hills" it thins away to 20 inches, or even less. Near the mouth of the bank, the bed has a very rapid dip to the north-west. The coal is quite rich, being pitchy black, oily, and containing only a small amount of visible pyrites. It is used in the manufacture of window-glass at the furnace, a short distance below. The coal below the slate parting is best, and is also used for smithing. There have been many openings on this coal in the vicinity of Mr. Henderson's bank, which are now all abandoned. At one of these abandoned openings, we see 2 feet of massive sandstone immediately above the coal.



Below the Kittanning coal, we see an immense bed of very good fire-clay. The base of the stratum was not seen, though a thickness of 10 feet was exposed. It will be remembered that this same coal is almost universally accompanied by a large bed of fire-clay to the south in Beaver county, for a description of which see Report of Progress "Q."

No. 5, the *Ferriferous limestone*, is seen finely exposed at the head of a ravine, just below an old opening in the overlying coal. It is very compact and massive, and forms a line of cliffs around the hill. It is very full of organic remains, and is seen to possess the wavy or shriveled structure so characteristic of this stratum. A short distance

south-east from here, it is quarried and burned by Mr. Rhodes. About 12 feet of the rock is taken out, the lower part being "blue," and consequently impure, is not burned. The lime from it is very good, both for agricultural and for building purposes.

No. 7 is here quite a massive sandstone, and many portions of it are almost snow-white.

Only a few rods from where the sandstone is seen, is located a glass furnace which has been in operation for 25 years. It is now owned and run by Mr. Holton. The sand is obtained from this No. 5 of the section in the immediate vicinity of the furnace, and from it is manufactured a superior quality of window glass. The sand is first burned to soften it, and is then crushed by immense rollers. The glass is hauled to New Castle, 2 miles south, and shipped on the E. & P. R. R. The lime used in the smelting is obtained from east of the Alleghenies. An attempt was once made to use the *Ferriferous limestone* for that purpose, but it was found to contain too much iron.

Immediately below the massive sandstone, we find some *coaly* shales, and then the *Lower Mercer limestone* which carries on its top a layer of *iron ore* varying in thickness from 0 to 8 inches. The ore was once mined by drifting at this locality, and was taken to the New Castle furnaces, as well as to the old Moffitt furnace, 2 miles north. Many blocks of the limestone are seen on the old dumps, and, at the mouth of one drift, it was seen *in situ*. It varies from 1 to 2 feet in thickness, and is a very hard, compact rock, of a dark-bluish color and filled with organic remains.

We identify this with the *Lower Mercer limestone*, though it may be the *Upper Mercer*, but no other limestone occurs below to represent the former stratum, and, as we have found the lower of the two much the more persistent, we have identified this with it, though practically it makes but little difference which it should be, since they come so close together, never being more than 35 feet apart and frequently much less.

About two miles above Croton, some very high ground is found on the land of Mr. Hinkson, and, near its summit,

a ridge catches a small area of the *Ferriferous limestone* at an elevation of 340 feet above the Neshannock. It has been quarried to a considerable extent, and the limestone is not far from 15 feet thick.

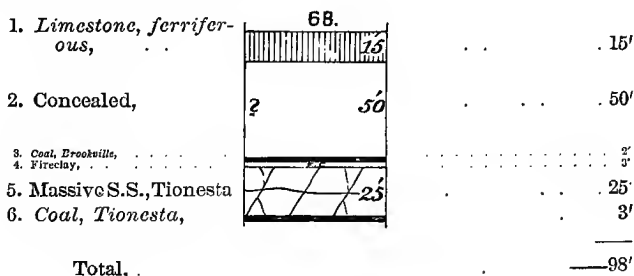
One hundred and twenty-five feet below this, we come to an old ore drift, which was the principal source of supply for the Moffitt furnace that was located near East Brook.

The ore comes immediately on top of the *Lower Mercer limestone*, and, in fact, the body of the limestone itself is frequently converted into iron ore. A large quantity of this "limestone ore" is still lying piled up at the mouth of the drift, and in it were seen two fossil mollusks that could not be distinguished from *Spirifer striatiformis*, and *Cardiamorpha sub-globosa*, which are found in the Waverly of Ohio, and figured in Vol. II of the Ohio Paleontology. The ore would probably make 35 to 40 per cent. of metallic iron.

As we descend to the Neshannock from this point we pass down over a very steep bluff formed of the Massillon sandstone, and at the creek we see it extending along the same in massive cliffs of coarse, grayish-white rock, which frequently splits up into flaggy layers.

Under the Massillon sandstone we see in some of the cuts of the New Castle & Franklin R. R. 30 to 35 feet of bluish sandy shales which frequently contain coaly shales at top, and this coaly shale represents the *Sharon coal*. It is found here 300 feet below where the *Ferriferous limestone* is seen one mile east.

One mile due south from Eastbrook we see the following on the land of Mr. McConahy :



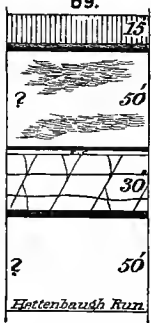
The *Ferriferous limestone* is seen near the summit of the hill, and extends from this point across to where it was seen at the roadside on the land of Mr. Hinkson. The hill rises above it by only a few feet, so that the Kittanning coal is most probably not caught.

No. 3 is the coal which we have identified with the *Brookville*. It is separated from the massive sandstone below by only a small bed of fireclay, and is a very fine coal. It is highly prized by the smiths, and for culinary purposes ; it being quite free from pyritous slate.

No. 5, the *Tionesta, or Piedmont sandstone*, is seen in a very massive cliff extending around the head of the hollow. It is a coarse grayish-white sand rock, and no pebbles of any size were observed in it.

The coal below it has also been mined at this locality, though the drift is now abandoned. It was rather impure, being sulphurous and slaty, as we nearly always find this coal.

In the vicinity of Eastbrook this last bed has been mined to a considerable extent, and one half mile above the village, we get sec. Fig. 69, on the land of Mr. McDowell, in descending to Hettenbaugh run.

	69.	
1. Limestone, <i>Ferriferous</i> ,		15'
2. Shales,		2'
3. Coal, <i>Scrub Grass</i> ,		1' 8"
4. Shales and coneealed,	?	50'
5. Coal, <i>Brookville</i> ,		20' 24"
6. Fireclay,		2'
7. Massive S. S., <i>Tionesta</i> , (<i>Piedmont</i>),		30'
8. Coal, <i>Tionesta</i> ,		3'
9. Concealed to level of Hettenbaugh,	?	50'
Total,	<i>Hettenbaugh Run</i>	150' 8"

The *Ferriferous limestone* is seen in the road which ascends the hill past the coal mines, and is also observed forming a conspicuous cliff around the hills. Where the road passes over its outcrop the blossom of a coal is seen immediately below, and Mr. McDowell informs me that he

once dug into it and found the coal 20 inches thick, but rather slaty. This is the representative of the *Scrub Grass coal* of Rogers, and the same one which is mined on this stream two miles above in Scott township by Mr. Reichel, and given as No. 6 of section on page 169.

Nothing was seen of the *Clarion coal* which should come in the interval No. 4, but it was mostly concealed, and the coal, if present, would most probably not be visible. That the Clarion should come in this interval, and that No. 5 represents the Brookville coal we know; for by tracing these rocks 2 miles further up the stream we see No. 5 pass below water level, and when we come to Mr. Reichel's we find the succession given on page 169, where No. 8 of that section represents the *Clarion coal*, and is found 20 feet below the Ferriferous limestone.

The *Brookville coal*, No. 5, is mined here by Mr. McDowell, and varies in thickness from 20 to 24 inches. Although so thin, it is a remarkably pure coal, and comes out in bright shining blocks, which show no trace of sulphur.

The *Tionesta sandstone*, No. 7, has been extensively quarried at this locality, and is a rather coarse, very white rock. It splits very readily and makes an excellent building stone.

No. 7 is also mined and used for domestic purposes in the vicinity. It contains a layer of slate 3 inches thick, which comes about 6 inches below the top, and also about 10 inches above the bottom we find a layer of bony or slaty coal 2 inches thick. The entire bed is rather slaty and inferior.

In driving the entry into the hill the sandstone came down from above, and at one locality cut the coal entirely away, but a drift from another direction found the coal coming in again a short distance away. This is of course a case of erosion during the deposition of the overlying sand bed.

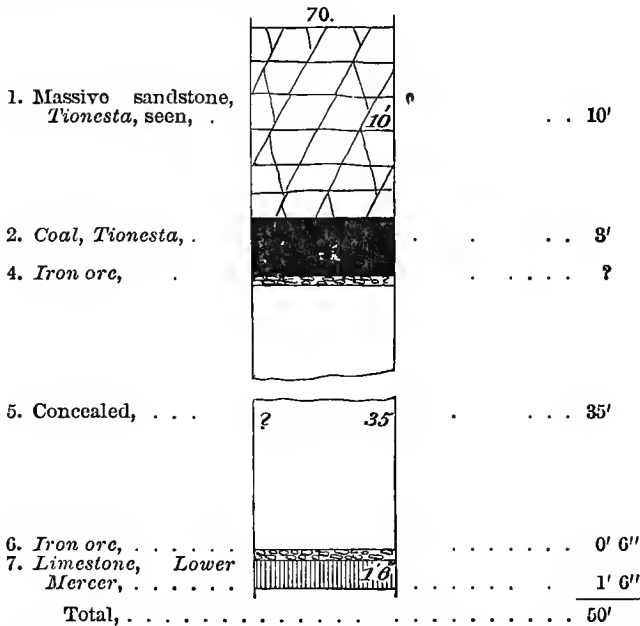
Down near the base of interval No. 9 are seen some blocks of the *Lower Mercer limestone*, and Mr. McDowell informs me that it occurs in a bed 2 feet thick about 10 feet above the level of the stream.

One half mile above this, and near the township line, we

find the *Tionesta coal* has passed below water-level, owing to the rapid rise of the stream's bed, and the massive *Tionesta sandstone* is seen along the banks of the same, while just above, at McConahy's mill, the *Brookville coal* has been mined by Mr. McCurdy, and is reported to be 2 feet thick.

A short distance further up the run, the same coal is mined down near the level of the stream by Mr. Robes, and is there 2 to 2½ feet thick. It is quite pure, and is in high repute as a smithing coal. It is found 50 feet below the *Ferriferous limestone*. This last stratum is quarried and burned by Mr. Robes, making a very white lime.

About 1½ miles north from Eastbrook, we come to Mr. Hezlepp's, and, descending a ravine on his land, we get the succession seen in Fig. 70.



At this locality the *Tionesta coal* was formerly mined to a considerable extent, and taken to the Moffitt furnace, near Eastbrook, where it was used to run the engines. The mines have not been in operation for two or three years, so

that the coal could not be seen except at the mouth of the bank, where it appears to be rather slaty and bad. It has a parting of slate 3 inches thick, and 6 inches below the top.

The sandstone above is quite massive, and a short distance away is seen to be 25 feet thick.

In the shales immediately below the Tionesta coal, there occurs a very rich layer of *iron ore*, and it was mined by stripping, and taken to the Moffitt furnace when that was in operation. It comes in a more or less persistent layer, and also in scattered nodules through the shales above.

No. 6 has been mined at this locality on top of the limestone, and is known as the "Limestone ore." It would probably make 40 per cent. of iron.

This section settles the horizon of the "4 foot vein" of coal, or the one that we have identified with the *Tionesta* which we saw on Hettenbaugh run, near Eastbrook. The iron ore immediately below this coal here probably represents the *Upper Mercer limestone*, while No. 7 is the *Lower Mercer* beyond all doubt. This No. 7 is a dark-blue, very hard and compact rock, and, as usual, is filled with fossils.

The *Tionesta coal* has been mined on Hezlepp's run by Mr. McCreary, but the works are now mostly abandoned.

One and a half miles north-east from Hezlepp's the same coal is mined by Mr. Waters. It is there 3 feet thick, and has a very massive sandstone immediately above.

11. *Neshannock Township.*

This lies immediately west from Hickory and occupies the triangular area between the Shenango and Neshannock creeks, extending from the northern line of Hickory south to the junction of the two streams at New Castle, the county seat. Thus the Neshannock and Shenango enclose it on the east, west and south.

Along its central line is an elevated plateau, from which the drainage passes east and west into these two streams.

Near the summit of this elevated land, and about the central portion of the township, a considerable area of the *Darlington coal* is found, while along the Shenango the

continued northward rise of the strata brings 50 to 60 feet of the Cuyahoga shale above water-level, so that the section may be said to extend from the Darlington coal down 60 feet below the base of the Conglomerate series.

The *Drift* covers up a large portion of the township, especially along the Shenango, and the exposures of the rocks are very poor, except along some portions of the Neshannock, where it has cut down through the massive rocks of No. XII.

In the vicinity of New Castle, at the junction of the two previously mentioned streams, we get two very fine terraces, one about 20 feet above the level of the creeks, and on which the greater portion of the town is built, and the other coming 125 feet above. Both are composed of Drift material, and innumerable rounded boulders of granite, gneiss, sandstone, conglomerate, &c., are seen among the other finer material. The boulders vary in size from 2 to 6 inches in diameter.

As we pass up the Neshannock from New Castle we soon find the terraced areas disappearing, and see them succeeded by almost vertical cliffs along the creek and sharply rising hills, from whose steep declivities the Drift has long since disappeared.

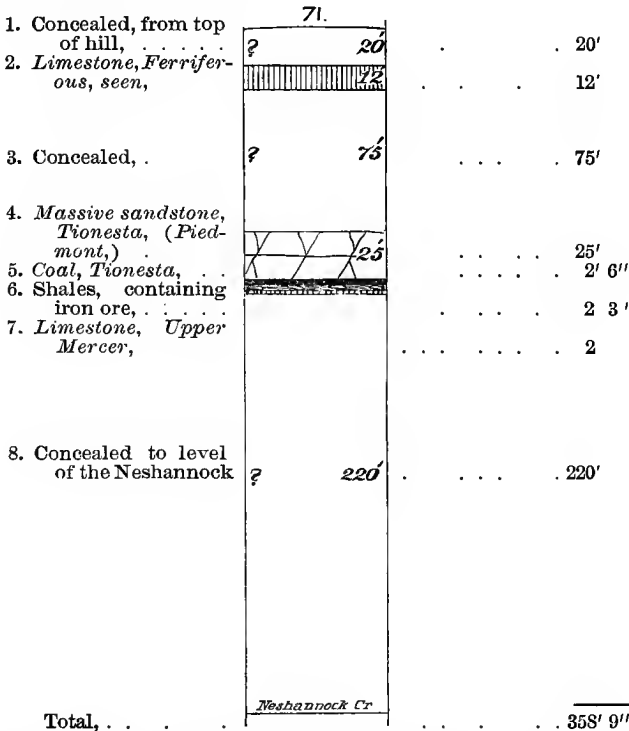
The massive rocks of No. XII are exposed along the stream near Pearson's bridge, and below the base of the sandstone we see 25 to 30 feet of bluish, sandy shales, which very probably belong to the *Cuyahoga*.

The rock which forms the cliffs on both sides of the stream for several miles up the Neshannock is the Massillon sandstone, and immediately below it we should find the *Sharon coal*; but with the exception of a few thin streaks of coal and some bituminous shales nothing has been seen to represent it.

About $2\frac{1}{2}$ miles above New Castle, and a short distance west from the Neshannock, we come to several old *ore drifts*. The *iron ore* obtained here comes at the horizon of the *Lower Mercer limestone*, and is found as "plate ore" immediately upon the latter rock. Directly below the

limestone is seen the representative of the *Lower Mercer coal*, which is thin and slaty.

A short distance above this locality the hills rise to a considerable height, and take in the *Ferriferous limestone* near their summits, on the land of Mr. McKee, and there we get section, Fig. 71.



The *Ferriferous limestone* has here been quarried and burned by Mr. McKee. It is a compact, gray rock, and makes very fine lime. It is seen exposed for some distance along the road.

No. 4, the *Tionesta sandstone*, is quite massive, and forms a line of cliffs along the hill.

It is a coarse, grayish-white rock, and contains many quartz pebbles. They are mostly small, varying in size from a pea to a hazel nut.

Immediately below the sandstone, we find a coal worked

here by Mr. McKee. It represents the *Tionesta coal* of Rogers, although it is found nearer the underlying limestone than usual; for, when the *Tionesta sandstone* is not massive, we generally find an interval of 20 to 25 feet between this coal and the *Upper Mercer limestone*, but when the sandstone thickens up, it cuts this interval down to almost nothing, and brings the coal nearer to the limestone, as we see it in this section. The coal is somewhat slaty and impure, but is said to burn quite well.

Immediately below it, and resting on the underlying limestone, there occurs a vein of "plate" iron ore, which has been mined by drifting along the hill. It is quite rich, and would probably analyze 40 to 45 per cent. of metallic iron.

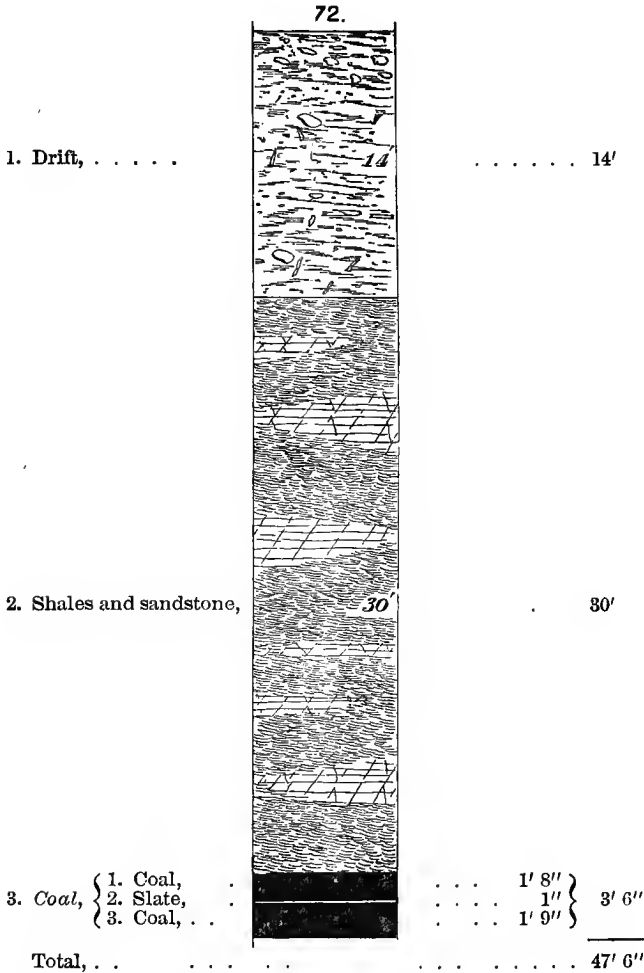
About one and a half miles north from Mr. McKee's, the hills rise still higher, and here take in the *Darlington coal* in a considerable area near the center of the township. It is mined mostly by shafting, and at Mr. Miller's works we get section, Fig. 72.

The coal is rather friable, and comes out in irregular blocks which are easily broken to pieces. It contains considerable pyrites, and is much inferior to the *Darlington coal*, as seen to the south at Clinton, Wampum, Hog Hollow, &c. In fact, it is quite doubtful about the correctness of referring this coal to the latter bed, and it may be the *Kittanning*. There is no way of definitely settling the question, however, since it is $1\frac{1}{2}$ miles to the nearest outcrop of the *Ferriferous limestone*. But there is no doubt that it is either one or the other, with the probabilities in favor of the *Darlington*. The coal in question occurs at an elevation of 380 feet above the level of the Neshannock at New Castle.

On the other side of the road from Mr. Miller's, there are two other shafts to this coal, and they are operated by Messrs. Smith and Pyle. The coal shows about the same structure in all.

One half mile north-west from Mr. Miller's, are the works of the New Castle Coal Company. They mine the coal by a shaft, and have a narrow gauge R. R. leading from their

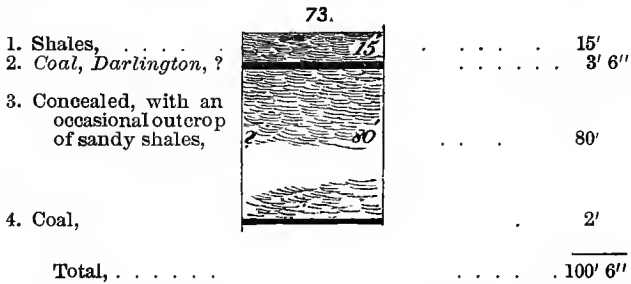
mines to New Castle. The bed is of tolerably fair quality, but yet contains rather too much sulphur for a first class coal.



Still further to the north, Mr. Peebles has a shaft on this coal, and takes out a considerable quantity for local supply.

A short distance west from Mr. Peeble's shaft, the same coal is mined by drifting on the land of Mr. Geo. Craw-

ford, at the head of Sulphur run, and there we get section, Fig. 73, in descending this little stream.



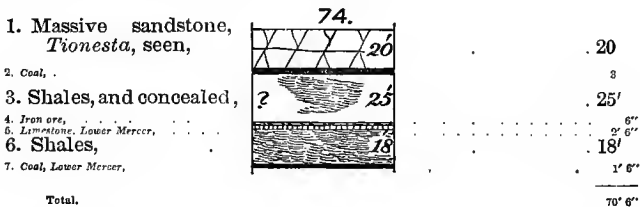
The coal was once extensively mined at this locality, but there is nothing doing at the works at present. These mines have given name to the run which starts from them and flows west into the Shenango, and "Sulphur" run does not speak well for the quality of the coal.

No. 4 is quite a good little coal and is mined on the land of Mr. Watson. It is very free from sulphur, and burns into a rather abundant, fine, white ash. This probably represents the *Clarion coal*.

The *Ferriferous limestone* should come in the interval between this coal and the one above, but it has here thinned away as it so often does.

Just across the road from the Crawford works, No. 2 is mined by Simpson & Blues, where it varies in thickness from 2½ to 4 feet, and is much purer and freer from sulphur than usual.

About one mile south from the northern line of this township, we see the following succession, in descending a ravine on the land of Mr. Buxton :



No. 1 is very massive and forms a bold cliff around the

hill. The coal below it which comes at the horizon of the *Upper Mercer limestone* is mined by Mr. Buxton. It has a parting of slate 2 inches thick near its center, and is of tolerably fair quality.

The *iron ore* which comes immediately on top of the *Lower Mercer limestone*, was once extensively mined at this locality and taken to the old Tremont furnace, as well as to New Castle. It varies in thickness from $\frac{1}{2}$ to 1 foot, and is a calcareous ore which probably contains 35 to 40 per cent of metallic iron.

The *Lower Mercer limestone* is a dark-blue rock and filled with organic remains as usual. The *Lower Mercer coal* below it is thin, and has been mined only by stripping along the little run.

The *iron ore* which comes with the *Lower Mercer limestone* has also been mined at many localities along the northern line of the township.

12. Pollock Township.

This is a small area which lies directly south from Neshannock, and a large part of which is now included within the borough of New Castle.

In the eastern part the hills rise just high enough to catch the *Ferriferous limestone*, and a considerable area of it is there found near the summit of the hill with only two to five feet of dirt or drift covering it. The limestone is quarried, and transported on a tram-road to New Castle, whence it is shipped to the furnaces in the valley. It is quarried by Messrs. Green, Marquis & Johnson, and has an average thickness of 12 feet. About 9 feet of this is mined, the lower 3 feet being impure, or "blue." Six feet below its top we find a layer of clay 4 to 8 inches thick, which sometimes turns to shale. The rock is quite shaly and is also traversed along its faces by the peculiar wavy lines of weathering, which so often give this stratum a wrinkled or shriveled aspect. The quarries are about one mile from New Castle, and gravity carries the loaded cars down the grade to the city, the limestone being here 320 feet above the level of the Neshannock.

In the vicinity of Croton, the *Tionesta sandstone* is seen in a very massive cliff along the hill, and extends for a long distance down the stream.

At Pearson's bridge, one mile above New Castle, a company once erected 80 coke ovens, at a cost of \$18,000, and intended to manufacture coke from the slack obtained at the coal mines in the county, but the enterprise proved unprofitable, on account of the impossibility of keeping themselves supplied with slack, so that the ovens are now going to rack.

Just below this point a cutting on the New Castle and Franklin R. R. reveals the drift extending up 80 to 100 feet above the level of the Neshannock.

As we descend the stream from here we see the *Massillon sandstone* rising in massive vertical cliffs along the creek. One of the most interesting things connected with the geology of this township is the record of a very deep boring made at New Castle, on the left bank of the Neshannock by Reis, Brown & Bergher. The hole was drilled to obtain gas as well as to test this region for oil. It commenced about 15 feet above the level of the Neshannock, and the following record of it was placed at my disposal by Mr. Bergher:

1. Gravel,	15'-15'
2. Blue mud and quicksand,	125'-140'
3. Slate, (end of drive pipe,)	3'-143'
4. Slate,	61'-204'
5. Sandy shales,	54'-258'
6. Shales,	54'-312'
7. Gray sandstone, (gas at 313',)	44'-356'
8. Slate,	26'-382'
9. White sandstone, (oil at 395', and salt water,)	78'-460'
10. Shale, (cased at 468',)	35'-495'
11. Red rock,	70'-565'
12. Slate, (gas at 617' and 657',)	151'-716'
13. Sandstone, (gas at 717',)	43'-759'
14. Slate,	70'-829'
15. Sandy shales,	30'-859'
16. Slate,	75'-934'
17. Gray sandstone,	31'-965'
18. Red rock,	3'-968'
19. Slate,	19'-987'
20. Slate,	207'-1194'
21. Hard shales,	21'-1215'

22. Hard slate,	155'-1370'
23. Sandy shales,	47'-1417'
24. Hard slate,	68'-1485'
25. Gray sandstone,	50'-1535'
26. Slate,	154'-1689'
27. Gray sandstone,	8'-1697'
28. Slate,	64'-1761'
29. Gray sandstone,	15'-1776'
30. Slate,	69'-1845'
31. Sandstone, gray,	17'-1862'
32. Slate,	103'-1965'
33. Shales,	80'-2045'
34. Shales to bottom of whole,	655'-2700'
Total,	2700'

The great depth of the drift extending down 135 feet below the present drainage level is a remarkable fact shown by this record.

The entire depth of the old river channel is not indicated by this, since on the Mahoning we find a buried valley 200 feet below water level. It is very probable that this hole did not strike the center of the ancient valley, or we should have had 175 to 200 feet of Drift.

No. 9 is the same as the "124 foot rock" of the Beaver Falls deep well, 20 miles south, as we see by the intervals at which both occur below the *Ferriferous limestone*. At New Castle this limestone comes 310 feet above the mouth of the well, and adding to this 382 feet, the distance below the well's mouth at which the sandstone was struck we get 692 feet as the interval between these two strata at New Castle. In the Beaver Falls well the "124 foot rock" was struck at 594, and adding 75 feet, the interval from the top of the well up to the *Ferriferous limestone*, we get 669 feet, which demonstrates the two rocks to be the same stratum. Taking the bottom of the rocks as a base line, we get 760 feet for the interval at New Castle, and 793 feet for Beaver Falls, a result equally conclusive.

This is in all probability the representative of the first sand of Butler county, and, as we have shown in "Q," is the Smith's Ferry oil rock.

A small quantity of heavy oil was found in this well at

395 feet, and also abundance of salt water, which still continues to flow in a constant stream.

This well was first drilled to a depth of 1965 feet in 1874, and the next year was put down to its present depth, where the tools were lost, and in an attempt to fish them out the fishing tools shared the same fate, so that both remain in the hole.

The hole was drilled to a depth of 350 feet greater than the Beaver Falls' deep well, and as it commences 225 feet lower in the series, it penetrated the column of rocks 575 feet below that of the former.

The record of this well should convince all oil operators that it is a useless expenditure of capital to seek for oil in paying quantities below the "78 foot" white sandstone of the boring, or No. 9.

This is the rock in which the productive wells along the Mahoning near the Ohio State line were formerly obtained.

The Slippery Rock oil horizon was passed before reaching the bottom of the drift, since it (the Slippery Rock oil sand) comes 350-370 feet below the *Ferriferous limestone*.

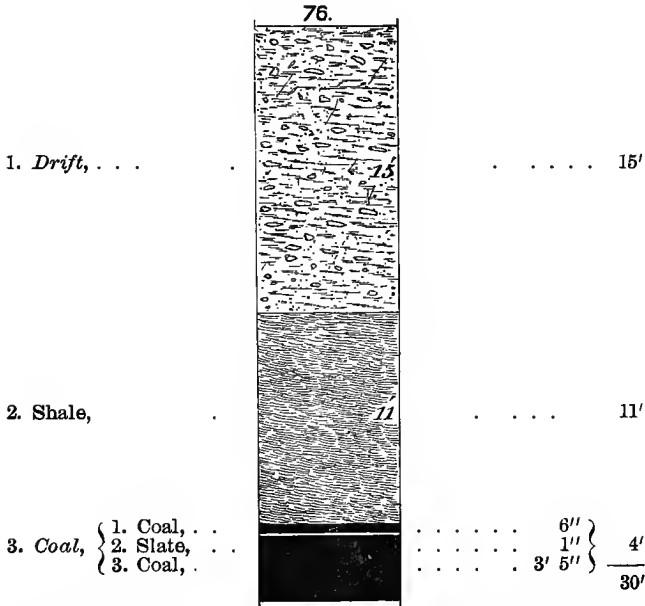
13. Union Township.

This is a small oblong area lying south from Neshannock and west from Pollock. The Shenango flows along and forms its north-eastern boundary, while the Mahoning flowing parallel with the Neshannock forms its south-west boundary. The area in question is thus reduced to a long, broad ridge, from which the drainage passes in either direction into the two streams which border it.

Near the center of the township a very high ridge extends up 400 feet above the Mahoning river and takes in a small area of the *Kittanning coal*, which is now quite extensively mined near the New Castle and Youngstown road, and two and one half miles north-west from the former town by Messrs. Sharpless & Kincaid, at whose shaft we get section, Fig. 75.

The coal is very rich and brilliant, and does not contain any injurious quantity of pyrites. It is somewhat variable in thickness, running from $2\frac{1}{2}$ to 4 feet, and having a band

of slaty or bony coal 1 inch thick 6 inches below the top. The coal occurs here 380 feet above the Neshannock at New Castle, and this is the main reason why we have identified it with the *Kittanning*, since the *Darlington* ought to come at a higher elevation. However, this may be the latter coal, since it is impossible to know certainly which it is, as the *Ferriferous limestone*, which should occur below, has thinned away, and everything is covered up by Drift. It is a matter of no importance anyhow, since it is certain that the coal represents one or the other of them. There are about 100 acres of the coal in this tract. A short distance west from the shaft it was once mined by drifting, and the old drift now serves for a drain.



Passing west from this along the New Castle and Youngstown road, we come down to lower ground, and one and a half miles west from Sharpless and Kincaid's works, we find an old coal opening on the land of Mr. McComb, 170 feet below the coal in the shaft. It was once mined for

domestic purposes, but was only $1\frac{1}{2}$ to 2 feet thick, and rather impure, so that the work was abandoned.

About 25 feet below it is seen a blue fossiliferous limestone 2 feet thick, which is doubtless the *Lower Mercer*, and this would make the shaft coal, the *Darlington*, and the coal opened by Mr. McComb, the *U. Mercer*, or the one we so often find coming in immediate connection with the *U. Mercer limestone*.

At this same horizon, a short distance east from Mr. McComb's, a good bed of fireclay occurs on the land of Mr. Robinson, which was once mined and used at the furnaces of Reis, Brown & Bergher in New Castle.

Along the Mahoning river, and opposite Covert's station, the upper member of the *Massillon sandstone*, is seen forming a long line of bold cliffs at a height of 240 feet above the river. The rock is very massive and conglomeratic, and enormous masses of it have broken away from the cliff and now lie scattered over the hill below.

14. *Mahoning Township.*

This lies directly west from Neshannock and Union, south from Pulaski, and adjoins the Ohio State line on the west, while to the south lies North Beaver township.

It is drained chiefly by the Mahoning river, which, entering the township from Ohio, near the middle point of its western line, flows nearly east to its eastern line and then, turning, flows south-east along the eastern boundary. The tributary streams entering the Mahoning within the township are all small and insignificant.

The hills bordering the Mahoning river, are frequently quite precipitous, and many fine exposures occur.

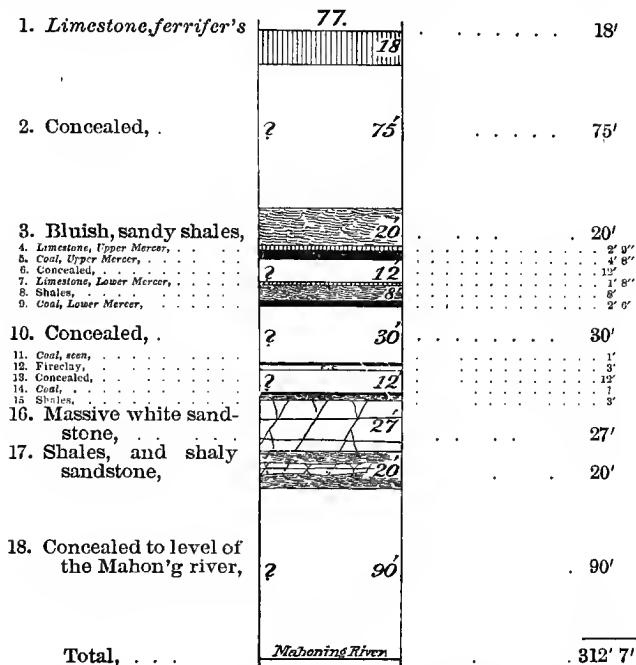
The section of the rocks extends from 80 feet above the Ferriferous limestone down to 60 feet below the horizon of the Sharon coal.

The *Kittanning coal* is only found north from the Mahoning, where two or three isolated knobs catch a small area of it.

The *Ferriferous limestone* occurs in a few limited areas near the summits of the hills in the northern part of the

township, while south from the Mahoning, it extends in an unbroken sheet over a wide extent.

About one and a half miles above Edinburg, we come to some abandoned coal works, on the south bank of the Mahoning, and descending from the summit of the hill, we pass over the succession seen in Fig. 77.



No. 1 is here seen near the summit of the hill, extending along the same in a bold cliff like a sandstone.

No. 4, the *Upper Mercer limestone*, is of almost flinty hardness, and contains much silicious iron ore, imbedded in its mass, in the shape of cylindrical nodules. It is seen forming the immediate roof of the underlying coal.

No. 5, the *Upper Mercer coal*, has a remarkable development, and this fact induced a N. Y. Firm (whose agent knew nothing of the coal business) to buy a large area of it and erect extensive coal works in order to mine it for shipment. A tram-road was built from the coal down to the R. R., a coal tipple was erected, cars built, and a large

sum of money spent in opening up the mine. But the unfortunate operators learned too late that their coal was worthless and could not be marketed at any price. The bed, although reaching such a great thickness, is very slaty, sulphurous and bad in every way. It was supposed by the operators to be the same bed of coal, which occurs 15 miles further up the river in the vicinity of Youngstown, and known as the "*Block*" or *Sharon* coal, but it unfortunately comes about 175 feet above the horizon of that coal. They had arrived at this conclusion by presuming that the fall in the river had thrown the coal in question higher above water-level, and then the slaty character of the coal, to one unacquainted with genuine "*Block*," favored the identification.

This useless expenditure of capital is only one of the many instances which a little business forethought would have prevented by first submitting the intended enterprise to the judgment of a competent geologist.

The interval separating the Upper and Lower Mercer limestones is here very much reduced, since we generally find it from 25 to 30 feet.

No. 9, the *Lower Mercer coal*, was once mined by Phillips & Stevens. The works have long since been abandoned, but it is reported to have been $2\frac{1}{2}$ feet thick, and a tolerably fair coal.

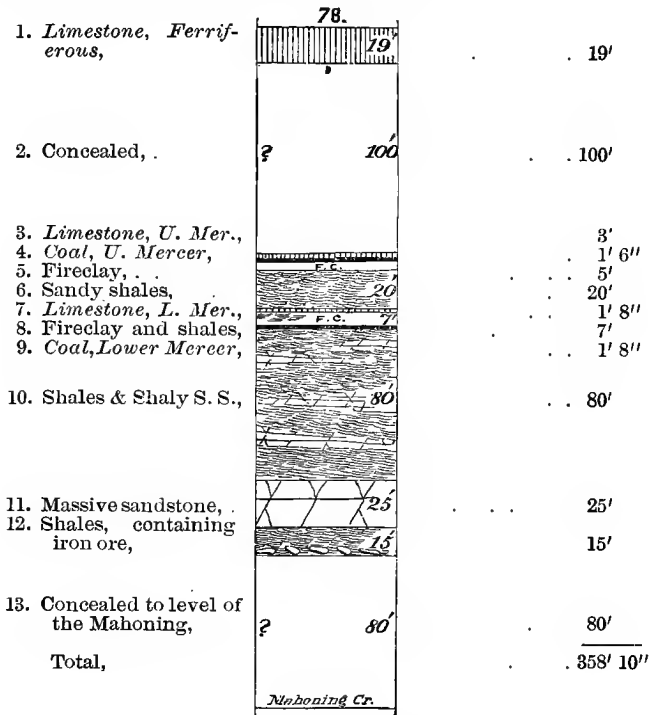
Nos. 11 and 14 are thin coals which have locally made their appearance in the section; both have been mined by stripping out of the little ravine along which the section was obtained, but nothing could be learned of either.

No. 16 is a very white, massive, and tolerably fine grained sandstone, being a part of the *Massillon* of Newberry.

One and a half miles above the last locality we come to Hilltown station, on the P. Y. & A. R. R., where the *Feriferous limestone* is extensively shipped by Mr. Parks. The quarry is nearly a mile back on the hill from the station, and in descending a small stream from it to the Mahoning river we obtain section, Fig. 78.

No. 1 consists, as usual, of two portions, a "blue" and a "gray" rock, which differ much in texture and compo-

sition as well as color. The upper or "gray" portion is 14 feet thick, and is the only part quarried. Many immense masses of this rock have become detached from the original bed and now lie scattered over the hill-side at a considerable distance below. The rock is filled with organic remains, and when broken glistens with calcite.



No. 3, the *Upper Mercer limestone*, is quite hard and compact, and contains iron ore nodules imbedded in its top, or resting immediately upon it in a plate-like mass. Near Hilltown this limestone is seen filled with slender cylindrical nodules of iron ore, which protrude from its weathered surface in vast numbers like so many thorns.

At the same locality the coal which we see immediately below the limestone in this section is only 6 to 8 inches thick, and an immense bed of fire-clay comes under it, which is the same as No. 5 of the present section.

It was once mined extensively near Hilltown and burned into fire-brick at the old works, a short distance below Hilltown station. It is said to have made a very fine quality of brick.

No. 7, the *Lower Mercer limestone*, is found here in two layers; the upper 15 inches thick, and the lower 5 inches thick. It is known locally as the "water lime," since it makes an excellent quality of hydraulic cement. It is very hard, of a bluish-black color, and crowded with fossils.

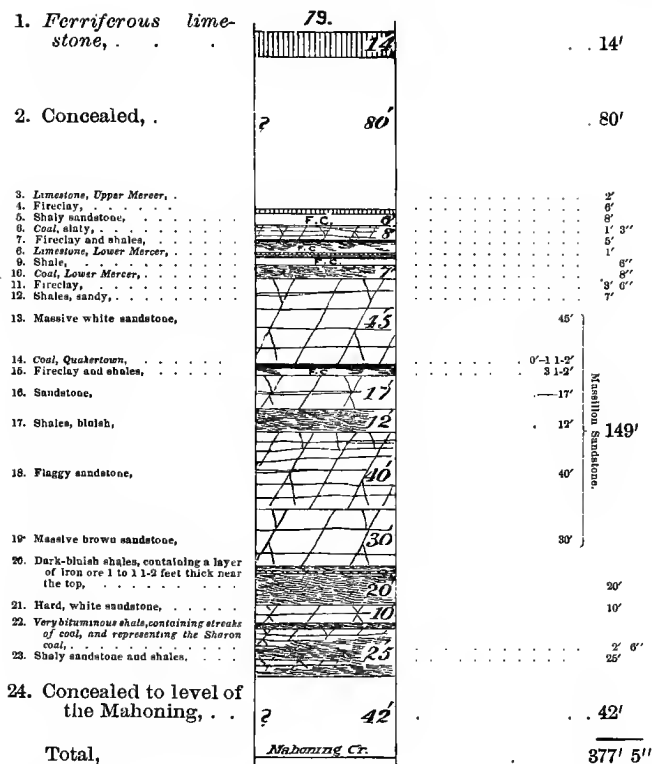
No. 9 was once mined, but the bank is not now in operation. It varied from 1 foot 8 inches to 2 feet in thickness, and is somewhat slaty and bony, being very hard to dig.

No. 11 is the lower portion of the *Masillon sandstone*, and is quite coarse and massive, the little stream making an abrupt plunge of 20 feet over its vertical wall. Immediately below it come the *ore bearing shales* which overlie the *Sharon coal* along the Mahoning. They were drifted on for iron ore once at this locality, but the layer of ore was found to be thin, though a considerable quantity occurs in kidney-shaped nodules scattered through the entire 15 feet of shales which we see exposed.

The *Sharon coal* should come 10 to 15 feet below No. 12; at least, this is its proper horizon, but there is very probably no representative of it here, since it thins away entirely before reaching the State line on the Mahoning; so that it would be useless to look for it.

About one mile above this, and $\frac{1}{2}$ mile east from the Ohio State line, a small stream, called Quakertown run, puts into the right bank of the river. It heads away back on the highlands, and drains a considerable area, so that during freshets it carries a large amount of water.

The rocks of No. XII have here become very massive, and this little stream, descending over and through them in a series of falls and cascades, exposes a splendid section. At the head of one branch of the stream, and near the Ohio line, the *Ferriferous limestone* is quarried by Mr. Pence, and, descending from it to the Mahoning, we get the succession seen in Fig. 79.



No. 1 is extensively quarried at this locality by Mr. Pence and Mr. Davis. The rock is transported down the hill on an inclined plane and shipped on the P. Y. & A. R. R., at the State line, though the quarries are mostly in Ohio. The upper 10 feet of the rock is all that is taken out, the lower part being "blue" and impure as usual.

Hitherto we have found the interval between the *Ferriferous limestone* and the *Lower Mercer* 120 to 130 feet, but here we find it diminished to barely 100 feet. This is evidently caused by the immense thickening of the sandstone mass below, which left a kind of hillock or hump in the ancient sea bottom at this locality.

The *Upper Mercer limestone* is seen jutting out of the bluff on the land of Mr. Davis, and is a dark gray rock, filled with fossils.

No. 6 is a local coal which has here come into the section. It was once stripped out of the run by Mr. Davis, but is slaty and impure.

No. 8, the *Lower Mercer limestone*, undergoes a strange metamorphosis at this locality. On one branch of the stream it is seen as the regular "blue" limestone, being only a little more ferruginous than usual, while on another branch, not more than 100 yards away, it is transformed into a brown silicious *iron ore*, where it was once extensively stripped out of the little bottom, and taken to the old furnace at Lowellville.

The ore is quite rich, and contains much flint scattered through the stratum. This is a case of displacement of the lime by the iron similar to what has happened to the *Feriferous limestone*, on a much larger scale in Wayne and Shenango townships at the "Houk mines."

No. 10 is a semi-cannel coal, and is the only representative of the *Lower Mercer coal*.

Nos. 13 to 19, inclusive, represent the lower portion of the *Conglomerate*, or the *Massillon sandstone* of Newberry. It attains a very great development at this locality, and exhibits the triple structure which is not uncommon with it, and which we have already seen so finely exhibited along the Connoquenessing in Wayne township.

No. 13, the upper member, and which we have termed in Q the *Upper Connoquenessing sandstone*, is a very hard, white and massive rock. It yields very slowly to the elements, and when the stream passes over it, we find it making a vertical plunge of 50 feet, and forming what is known as "*Quakertown Falls*."

The run having leaped by a single bound into a deep and narrow cañon, bordered on either side by immense vertical and overhanging cliffs of sandstone, passes on down through the same amid the wildest scenery. This locality is a noted resort for picnic parties, since in the deep and narrow recesses of the miniature cañon are many attractive nooks where the meridian sun never shines.

Immediately under the top member of this sandstone mass, we find a small coal, No. 14, which has been named,

from this locality, the "*Quakertown coal*." It was once mined at the "Falls" by Mr. Davis. The coal is seen extending all the way across the vertical wall which forms the Falls, and we see it varying in thickness quite rapidly; sometimes the sandstone mass above cuts it entirely away, and then again it thickens up to $1\frac{1}{2}$ feet. Back under the hill it is said to have attained a thickness of 2 feet. This is the same coal which we see under the massive sandstone along the Connoquenessing, and at the mouth of Slippery Rock.

Nos. 16, 17 and 18 also become massive at times along this stream, and then we get a vertical wall of rock 100 feet high.

No. 19 forms the cliff at the lower falls, and is a very massive, coarse, brownish-white sandstone.

Immediately below it come the *ore bearing shales* which are so conspicuous along the Mahoning at all the numerous old drifts in the valley.

Near its top is a somewhat persistent layer of calcareous iron ore 1 to $1\frac{1}{2}$ feet thick, while scattered through the body of the shales are numerous large nodules of the same. The shale always has a bluish-black appearance, when exposed on the dump, which is quite characteristic.

An old drift is seen at this locality, which was made long ago. Sometimes we see a few streaks of coal in this shale near its base.

No. 21 is almost snow white and is quite variable. Where the stream first cuts down to it we see it very massive, and causing an abrupt fall in the run, but only a few yards below, it becomes shaly and seems to pass gradually into the same kind of rock as No. 20 above it.

No. 22, without any doubt, represents the *Sharon coal*; for only $4\frac{1}{2}$ miles above here that coal is mined on the bank of the Mahoning at an elevation of 63 feet above the same, and as there is scarcely any dip to the east, as shown by the elevation of the limestone, No. 1, at both localities, the two must be identical.

This, then, is a very important section, since it exhibits the relations of the *Sharon coal* to the other members of

the series in a vertical section, which also shows that this *Sharon coal* comes near the base of the *Great Conglomerate*. Here it is practically below it entirely; for there is no massive sandstone or conglomerate below No. 21, but we pass down into rock which cannot be distinguished from the *Cuyahoga shale*

We find here a vertical thickness of 294 feet of rock between the *Ferriferous limestone* and the representative of the *Sharon coal*, which is sufficient evidence that this coal is not found above the *Conglomerate*.

One-half mile north-west from the village of Hilltown a high knob takes in several acres of the *Kittanning coal* on the land of Mr. Davis. The coal is mined by a slope, and lies at the slope, 12 feet below the surface. It varies from 2 feet to 2 feet 4 inches in thickness, and is a very black, rich coal, being used by the smiths. It is underlaid by a large bed of fire-clay, and comes 40 feet, by barometer, above where the *Ferriferous limestone* is seen $\frac{1}{2}$ mile north.

We identify this coal with the *Kittanning* on account of this small interval separating it from the limestone below, but if the dip were rapid between the point where the limestone crops out ($\frac{1}{2}$ mile north) and the coal it would be the *Darlington*. So far as can be ascertained, however, the dip is slight. The knob contains about 25 acres of the coal.

A short distance south-east from Hilltown the same coal is mined on the land of Mr. Henley. There are about 30 acres of coal in this knob, and it has the same thickness and appearance as that seen in the slope of Mr. Davis.

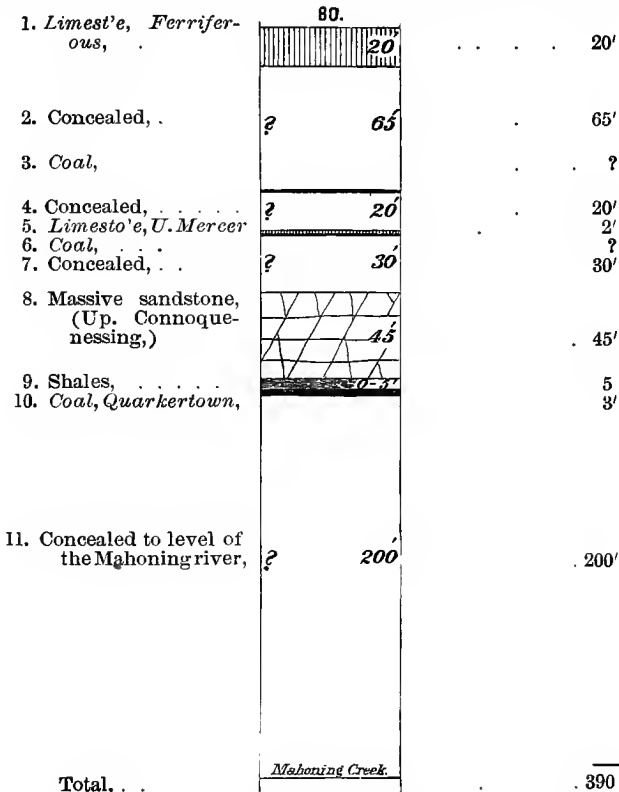
One-half mile west from Hilltown the *Ferriferous limestone* is quarried near the roadside on the land of Mr. Fox. The top portion only is taken out. It is burned and makes a very white and excellent lime. This limestone spreads in a continuous layer over all the southern portion of the township, and is from 15 to 20 feet thick.

Passing to the north side of the Mahoning river we find a considerable area of the *Ferriferous limestone* caught in the high land, west from Coffee run and near the State line. It comes at an elevation of 350 feet above the river, and has been quarried on the land of Mr. Graham, and also that

of Mr. Cowden, the latter having not far from 200 acres of it.

An old coal drift is there seen immediately below a massive sandstone, and 150 feet below the Ferriferous limestone. This would make it the *Quakertown coal*, and it is reported to have been 2 feet thick, but somewhat slaty.

Near the northern line of this township, between the two branches of Coffee run, we find another isolated area of the *Ferriferous limestone* occurring on the land of Messrs. Wright and Cowden. There are only about 30 acres of it, and this is the most northern outcrop of the rock in Pennsylvania, west from the Shenango. It has been quarried to a considerable extent by Mr. Wright, and in descending from his quarry to Coffee run we get section, Fig. 80.



No. 1 has been quarried by Mr. Wright and burned for

agricultural and other purposes. Only the upper portion is taken out. The rock is a mere mass of organic remains, and is of a grayish-white color.

No coal was seen at the horizon of No. 3, but Mr. Wright once bored a hole for coal and reports passing through a bed 2 feet 6 inches thick at that horizon. This would be the "Dirt" vein or *Tionesta coal*.

No. 5, the *Upper Mercer limestone*, is seen in a small ravine below the outcrop of No. 1. It is quite fossiliferous and contains much chert. Immediately below it, we see the blossom of a small coal.

Nothing was seen of the *Lower Mercer limestone*, but it very probably occurs near the base of the concealed interval, No. 7.

We seem to have almost exactly the same condition of affairs here as was seen on the opposite side of the river in the Quakertown section. No. 8 corresponds to the massive sandstone seen there at the upper falls, and is here of the same thickness. It is the upper portion of the *Massillon sandstone* and is very hard and massive, forming an immense cliff around the hill. It is tolerably coarse, but no pebbles were seen in it.

No. 7 is mined by Mr. Wright and is a tolerably good coal, having a tendency to run into the "Block" variety.

It makes considerable ash, however, and contains some sulphur, though not enough to unfit it for smithing purposes.

This is the same coal which occurs on Quakertown run, under the upper portion of the Massillon sandstone, and has been named, from that locality, the *Quakertown coal*.

Welsh's run puts into the Mahoning about two miles below the mouth of Coffee run, and, a short distance west from it, the *Lower Mercer coal* was once mined on the land of Mr. Erskine.

The *Ferriferous limestone* also comes into the hill-top there, and, descending from it, we get sec., Fig. 81.

No. 1, the *Ferriferous limestone*, is here seen extending along the summit of a ridge between Welsh and Coffee runs. It is found on the land of Messrs. Erskine, Book,

Welsh, and others. On one side of the ridge it is seen in a long line of cliffs, but it has not been quarried at this locality.

	81.		
1. Limestone, Ferriferous,	75	15'	
2. Concealed, . . .	?	30'	50'
3. Fireclay, . . .	F.C.	5'	
4. Concealed,	?	20'	20'
5. Coal, ("Dirt vein," Tionesta,)	?	20'	2' 6''
6. Concealed,	?	20'	20'
7. Limest'ne, U. Mercer	?	2' 6''	2' 6''
8. Concealed,	?	30'	30'
9. Limest'e, L. Merc'r.	?	1' 6''	1' 6''
10. Shales,	15	15'	
11. Coal, Lower Mercer,	?	2' 6''	2' 6''
12. Concealed to level of the Mahoning,	?	225'	225'
Total,	Mahoning Cr.	389'	

The Fire-clay, No. 3, has been mined quite extensively, and shipped to the iron furnaces in the valley. It is said to be an excellent quality of clay.

No. 5 is locally known as the "Dirt," or "4 foot vein," and was once mined at this locality. It is slaty and worthless, however.

Nos. 7 and 9, the *Upper* and *Lower Mercer limestones*, are the same dark-bluish, hard, compact, and fossiliferous rocks which we always find them.

No. 11 was once extensively mined and shipped on the old canal which passed along the Mahoning. It is here

a genuine "block" coal of very fair quality, though possessing a little more ash than a really first class "block." It was supposed, when first opened, to be the same bed as the "Block coal," found further up the Mahoning in the vicinity of Youngstown, but the latter coal should come about 150 feet below this, and Mr. Erskine tells me that he once saw a coal uncovered by a wash-out in a ravine, at about that horizon, but that it was only 1 foot thick.

Two miles above the mouth of Welsh's run, the *Tionesta coal*, or No. 5 of the preceding section, is mined by Mr. Cover. It there varies from $2\frac{1}{2}$ to 3 feet in thickness, and contains a parting of slate 2 inches thick, 20 inches below its top.

The coal is somewhat slaty, but is in good repute for domestic purposes, especially for use in stoves.

Near the head of the small stream which puts into the right bank of the Mahoning, near Harbour bridge, a vein of *iron ore* was once mined on the land of Mr. Robinson.

It comes 100 feet below what is known as the "*Dirt vein*" of coal, and is one foot thick. The ore is a blue carbonate and is tolerably rich. It was hauled to Edinburg and shipped to the furnaces in the Mahoning valley.

The "*Dirt vein*" of coal is mined on the land of Mr. Whiting, 100 feet above the ore bed, and is there $2\frac{1}{2}$ feet thick, but rather slaty. The same coal is also mined on the opposite side of the hill by Mr. Robinson, and the iron ore also occurs below it there. This "*Dirt vein*," as it is locally called, comes here at the horizon of the *Tionesta coal*.

But probably the most interesting story of this township's geology remains yet to be told, viz., its oil history. That wild excitement, which spread over all western Pennsylvania, on the discovery of petroleum in immense quantities on the Allegheny river, and which led to the sinking of wells along every water-course of any size, did not fail to reach the Mahoning valley.

The essential facts with regard to the oil operations in this valley were obtained from Mr. Bruce, one of the operators, and an old citizen.

The first well was drilled in 1861, on the Robinson farm, about one mile from the Ohio line, and was called the "Strawbridge well." It commenced about 10 feet above the level of the Mahoning, and striking a "*crevice*," obtained a 25 barrel well at 150 feet.

It was a heavy lubricating oil of an amber color, and several hundred barrels were obtained from this well.

The excitement then increased, and holes were put down promiscuously on each bank of the Mahoning from the State line to its mouth ; 19 on the north and 10 on the south side, in addition to several others just across the line in Ohio.

After a temporary lull the excitement again broke out in 1864, and nearly as many more new wells were drilled. The "*oil belt*" was found to lie between Edinburg and the Ohio line, as no productive wells were obtained below that village, which is situated about midway between the Ohio line and the mouth of the Mahoning.

Though very few of the wells, except the "Strawbridge," produced oil in paying quantities, yet all, without exception, gave some indications.

The "Angus well," one mile above Edinburg, on the south side of the Mahoning, produced at first 10 to 12 barrels per day, and the sand near it was so saturated with oil that a hand pump sunk in the sand could draw out one barrel a day.

Near the Angus well was also one on the Waters' farm, which produced $1\frac{1}{2}$ barrels daily, and on the next farm above, or Mr. "Small's," a "gusher" was struck which threw up a large quantity of oil in a very short time, and then suddenly ceased to flow entirely.

On the McVeigh farm, near the State line, another "gusher" was struck, which behaved in the same manner.

A well on the Bruce farm, 2 miles above Edinburg, on the north side, yielded about one barrel daily, and another, near it on the Pemce farm, produced about the same amount.

No records could be obtained, and I subsequently learned that none had been kept except in the memories of the drillers.

But the true oil rock was found to lie 275 to 300 feet be-

low the bed of the Mahoning, and the oil was nearly all heavy, except when the rock was close and fine grained.

The *Ferriferous limestone* comes into the hills here 350 feet above the bed of the Mahoning, so that the interval between this stratum and the "oil rock" may be considered as about 650 feet, which makes this at the same horizon as the Smith's Ferry oil, or in the first sand of Butler. It is also the same as the "124 foot" rock of the Beaver Falls deep well.

Near Edinburg a well was drilled to the depth of 950 feet, but no sands of any consequence were struck below the *Oil Rock* horizon, and consequently no oil.

All the wells commence on the alluvial flats or bottoms, which border the river and form the first terrace, 15 to 20 feet above the bed of the same. In the vicinity of Edinburg this is very broad, and in sinking the wells no rock was found until they had extended down 175 to 200 feet below the level of the Mahoning. Pipes were driven down to this depth, and in passing through the drift an occasional boulder would be struck, when the drill would have to be put down to break it up.

Salt water was also obtained in nearly every well, and many of them are still throwing up gas and salt water in considerable quantities.

It is very probable that had this territory been operated skillfully at first, it might have been made a productive district, but the reckless methods which characterized the early oil operations have probably ruined it entirely.

None of the wells were cased, and when abandoned they were all allowed to fill up with water, which would, of course, ruin the best oil territory in a short time. The well on the Robinson farm, struck at 150 feet, was the only one found at that depth, so that its oil had very probably come up from below through a fracture.

15. *Pulaski Township.*

This lies directly north from Mahoning, and occupies the north-western corner of the county, being bordered on the west by the Ohio line and north by Mercer county.

Shenango creek passes south, through its eastern portion and drains most of the township, except a small area in the south-west, which sends its water into the Mahoning, by way of Coffee run.

Deer creek is the only tributary of any size, and it enters the Shenango from the west, one mile below the village of Pulaski.

A continuous sheet of Drift spreads over this township, and covers up most everything, so that exposures of the strata are quite rare.

The highest knobs fail to catch a single area of the *Ferri-ferous limestone*, and the highest rock found, is the *Tionesta sandstone*.

Near the head of Welsh's run, on the line between this township and Mahoning, there are several mines on the "Dirt vein" of coal, and, near Mr. Onstat's works, we see section, Fig. 82.

82.		
1. Shales,		5'
2. Coal, "dirt vein,"		3'
3. Concealed,	?	35'
4. Limestone, <i>L. Mercer</i>	?	2'
5. Concealed,	?	10'
6. Massive sandstone, (U. Connoquen'g,)	?	35'
7. Shales,		5'
8. Coal, <i>Quakertown</i> ,		2'
9. Concealed to run,	?	40'
Total,		137'

No. 2 is the *Upper Mercer coal*, since the limestone was seen a few feet above it, at one of the abandoned openings. It is mined quite extensively here for local supply by Mr. Onstat, and varies from 2½ to 3 feet in thickness. It possesses two or three partings of slate and is very poor generally.

No. 4, the *Lower Mercer limestone*, has a layer of plate-ore on its top, which was once mined by stripping, and sent to the furnaces in the valley.

No. 8 has been opened by Mr. Book, who found it 1½ to 2 feet thick, but rather inferior in quality.

No. 6 is the upper part of the Massillon sandstone, and

it is very massive, forming an immense cliff around the hill above the coal. Some parts of it contain numerous quartz pebbles.

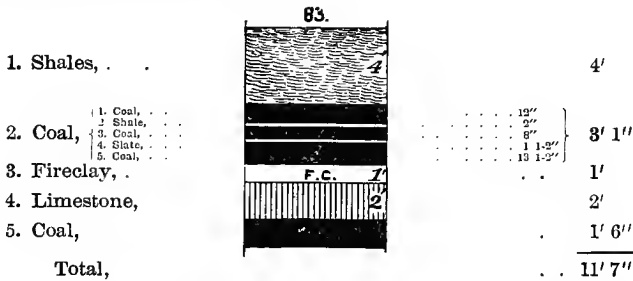
A short distance south-east from New Bedford, Mr. Evarts is opening up the *Lower Mercer coal* at a great expense for draining and driving entries. The coal is there 30 to 50 feet below the surface of the ground and underlies a large tract, probably 1,000 acres. The *Lower Mercer limestone* occurs 10 feet above the coal, and is seen in an old slope which was once put down to it on the land of Mr. Darlington. The coal has a semi-cannel aspect, and is believed by the operator of the works to be the same bed as the genuine "Block coal," which occurs $2\frac{1}{2}$ miles north, just at the county line. The entry has now been driven in a long distance at a cost of several thousand dollars, and still the coal continues slaty and worthless. I endeavored to dissuade the proprietor from a further waste of capital, assuring him that his coal was at least 160 feet above the "*Block coal*," and that it would continue worthless. The "practical" miners, however, have convinced him that, when they get the entry into the center of the basin, the best of "*Block coal*" will be found, and so he gave no heed to my kindly advice.

Two and one half miles north from New Bedford, and just at the Mercer county line, the *Sharon* or "*block coal*" comes in, and has long been mined on the land of Mr. Williams, near the head of Deer creek. It is there 140 feet, by barometer, below the *Lower Mercer coal* at New Bedford. The mines are all in Mercer county, and it thins away to a feather edge, and disappears when followed south into Lawrence, though it comes to within two or three rods of the line.

It is quite possible that some of the farms near this on the Lawrence county side would be found to contain small areas of the coal if properly explored; in fact, I saw a small outcrop of the coal on the land of Mr. Van Vleet, just south of this line $\frac{1}{2}$ mile, but it was only a few inches in thickness. However, this should not discourage exploration, since, on the land of Mr. Williams, where it has

been mined for years, we see it suddenly varying from 4 feet in thickness down to a few inches, and at times disappearing entirely. The coal at Mr. Williams' is tolerably pure, and possesses the genuine "Block" structure of this same coal as seen at Sharon and in the Mahoning valley. A specimen was taken for analysis.

About one mile west from the Shenango a coal is mined near the southern line of the township by Mr. Wallace, and at his drift we get section, Fig. 83.



No. 2 has been mined quite extensively for neighborhood supply, and is, when carefully separated from its accompanying slates, a tolerably fair coal. It has a dull, resinous lustre, and is somewhat friable. The pyrites come mostly in the shape of "binders," which can easily be separated from the coal. The identity of this coal is a little uncertain, since it is impossible to tell whether the limestone underlying it be the *Upper* or *Lower Mercer*. However, it is certain that the stratum is one or the other of the two rocks, with the probabilities in favor of the *Upper Mercer*, as I have never seen a coal sustaining a like relation to the *Lower Mercer limestone*, while it is quite a frequent occurrence with the former.

The limestone, No. 4, is a dark blue rock, and filled with fossil remains.

No. 5 is very slaty and worthless. It, with the rest of the section below No. 2, is seen in the ditch which drains the mine.

Immediately on top of No. 4 a layer of plate-iron ore occurs at this locality, and it was once mined by stripping.

No. 2 is also mined in this neighborhood by Mr. Cox and others, but the coal is best at Wallace's. It lies, by barometer, 275 feet above the level of the Shenango.

One mile east from the village of Pulaski a coal is mined on the land of Mr. Evans, at an elevation of 300 feet above the level of the Shenango. It is 2 feet 4 inches thick, and has two partings of slate; one near the top and the other near the bottom. The coal has a semi-"*block*" appearance and is quite good, though somewhat dirty and stained on account of a bad roof. The *Upper Mercer limestone* is seen 50 feet above, and this would make it the *Lower Mercer coal*.

A short distance north from Evans' we see a remnant of the *Tionesta sandstone* capping the hill, and immediately under it an old ore drift. The iron ore rests directly upon the *Upper Mercer limestone*, and varies from nothing to 2 feet in thickness. The sandstone is somewhat massive, and a thin coal comes between it and the iron ore.

One mile and a half east from this, and near the line of Wilmington township, a coal is mined on the land of Pinkerton & Thompson by a short slope. It is 2½ feet thick, and comes at the same level as that worked by Mr. Evans, though the coal is much better than his.

Along the upper part of the Shenango it cuts down 100 feet below the base of the Conglomerate series, but everything is deeply buried by *Drift*, and no exposures can be obtained in that interval

16. *Wilmington Township.*

This lies east from Pulaski, and like it adjoins the Mercer county line.

It is drained by the Neshannock and Little Neshannock. The former, entering it from Mercer county at its north-eastern corner, flows south-west through perpendicular walls of No. XII till reaching the southern border of the township near its middle line, when, receiving the Little Neshannock from the north, it veers south and passes out of the same.

One mile west from the village of New Wilmington, the

Lower Mercer coal is mined on the land of Mr. Detweiler, by Mr. Baney, where it varies from 2½ to 3½ feet in thickness. The coal has a bony aspect, and sometimes turns to "Block." Near the bottom of the bed we find from 4 to 6 inches of cannel.

The *Lower Mercer limestone* is seen in the roof of the coal, separated from it by 9 feet of shales.

It is of a light gray color, and much purer than usual, having been used as a flux at the old charcoal furnace near New Wilmington. It is filled with fossil mollusks as usual.

In the hill opposite New Wilmington, the *Lower Mercer coal* is also mined on the land of Mr. McClure. It is there only 2 feet thick and quite slaty, while the *Lower Mercer limestone* rests immediately on top of it. Near this village was the Tremont furnace, which was run with charcoal, and obtained its ore principally from the horizon of the *Lower Mercer limestone*. It has not been in operation for several years, and is now in ruins.

On passing south from New Wilmington, a very high knob is found, which extends up 175 feet above the *Lower Mercer limestone*, and should catch, near its summit, both the *Ferriferous limestone* and the *Kittanning coal*, but everything is so deeply buried with Drift, that nothing like an exposure could be seen.

About three miles south-west from New Wilmington, and near the Neshannock township line, a coal is mined by Mr. Francis, and there we see the following in descending a ravine from his opening :

1. Coal, blossom,	84.	?
2. Concealed,	? 40	40'
3. Sandstone, massive, Tionesta, sec.		5'
4. Coal, Tionesta,		2' 6"
5. Fireclay,		8"
6. Limestone, Upper Mercer,		2' 6"
7. Shales,		10'
8. Coal, Upper Mercer,		2' 6"
Total,		88'

The blossom of No. 1 is seen in the road, and is most probably the representative of the *Brookville coal*, since it comes immediately on top of the Tionesta sandstone.

Where the section was made only 5 feet of the latter rock was seen, but, a short distance east, it forms a bold escarpment 30 feet high, and is a coarse, conglomeratic, grayish-white sandstone.

Coal, No. 4, then very probably represents the *Tionesta*. It varies from $2\frac{1}{2}$ to 3 feet in thickness, and has a streak of slate 3 inches thick near its middle. It is quite good, and comes out in handsome blocks.

No. 6 has been quarried and burned for lime at this locality, making a rather good, grayish-white article.

No. 8 has been mined only by stripping along the little run.

Just above Mr. Francis' coal works, Mr. Bartholomew has a shaft to the same coal. The shaft is 23 feet deep, and passes through the *Tionesta* sandstone which is there quite massive, and rests immediately upon the coal. On the dump are seen many stems of *Sigillaria* and *Lepidodendron* brought up from the roof of the coal.

Near the mouth of Little Neshannock the *Tionesta coal*, or the one mined under the *Tionesta sandstone* at Francis & Bartholomew's, is mined by Mr. Davis, at an elevation of 175 feet above the level of the creek.

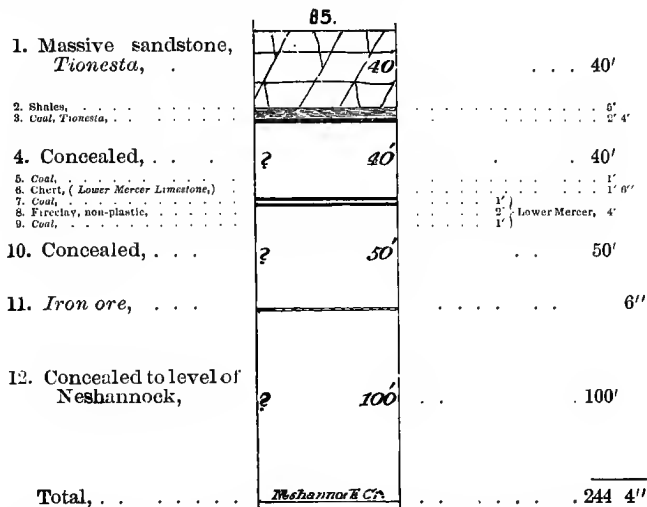
As we pass up the main branch of Neshannock creek from the mouth of Little Neshannock, we find its channel gradually contracting and becoming hemmed in by vertical walls of No. XII, and one mile above we come to *Neshannock Falls*.

Here the creek, plunging over the lower massive member of the Massillon sandstone, descends 25 feet in a few rods. On either side of the narrow gorge are seen overhanging cliffs of Conglomerate 75 feet high, while the bed of the stream is completely blocked up with immense masses of the same. The scenery is very wild, and the locality is a noted place for pleasure parties during the summer season.

At the head of the gorge an old charcoal furnace was once in operation, using native ore, but its site is now occupied by a woolen mill.

One half mile west from Volant P. O., a coal is mined by

Mr. Collins, and descending from that locality to the Neshannock we get section, Fig. 85.



No. 1 is quite massive and is seen in a vertical cliff above the coal. It is tolerably coarse, but no pebbles were seen in connection with it.

The coal immediately below it is somewhat soft and breaks up fine in digging. It contains some slate and sulphur and is rather a bad coal. It has also been mined near Mr. Collin's by Mr. Lurk and Mr. Rece.

No. 6 represents the *Lower Mercer limestone*, here seen as a mass of chert at the mouth of an old coal drift. On the dump were seen some pieces of limestone, however, which had come from the same stratum further back in the hill where it was less silicious.

Nos. 7 to 9 represent the *Lower Mercer coal*, and a large sum of money was spent in drifting into the hill, on it, at this locality, the proprietor thinking the fireclay, separating the two coals would thin away and be replaced by coal, but it is needless to say that he was disappointed.

The bed of *iron ore*, No. 11, has been stripped out along a small stream. It comes under a massive sandstone which is doubtless the upper part of the Massillon. The ore is a carbonate and is tolerably rich.

About two miles east from New Wilmington, the *Tionesta sandstone* is quarried near Shepherd's school-house, and is now being used in building the abutments of the new bridge across the Little Neshannock. It is a very massive, white rock, and makes a splendid building stone, though, on account of its extreme hardness, it is difficult to dress.

On the eastern side of the creek, above Neshannock Falls, the *Lower Mercer limestone* is seen 120 feet above the level of the stream.

Resting on it, at this locality, is a rich layer of "*plate-ore*" which was once mined on the land of Mr. Clark and used at the old furnace near the Falls.

17. *Washington Township.*

This area lies east from Wilmington and Hickory, north from Scott, and west from Plain Grove, while it adjoins the Mercer county line on the north.

It is mostly a Drift-covered highland, since the Neshannock only touches its north-west corner, and all its draining streams are small.

In its northern portion is a large swamp near the head of Taylor's run, and the same extends north into Mercer county. It covers over a thousand acres.

On account of the great elevation of the township it catches a considerable area of the *Ferriferous limestone*. This stratum underlies all its southern portion and all of its eastern half. The hills also frequently extend up above it far enough to take in the *Kittanning* and *Darlington coals*, though owing to the continuous covering of Drift they are seldom seen by the farmers, and consequently rarely mined.

In the very northern part of the township one of these high ridges occurs on the land of Mr. Orr, who mines the *Darlington coal* by a shaft 20 feet deep. The coal is 3½ feet thick, and its upper half is a semi-"block." The lower is more bituminous, and the whole bed is an excellent coal. This coal area extends a short distance over the line into Mercer county, and there are probably 100 acres of coal land in all.

The *Ferriferous limestone* is seen 70 feet below the coal on the opposite side of the run, and has there been quarried and burned in the edge of Mercer county.

There are many high knobs, especially in the southern part of this township, which, in all probability, contain the *Darlington* and *Kittanning coals*, and some of the farmers might get amply repaid for their trouble by testing the matter with the drill.

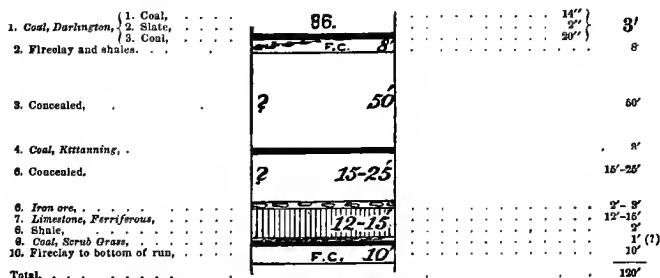
18. *Plain Grove Township.*

This lies directly east from Washington, and occupies the north-eastern angle of the county, thus adjoining Mercer on the north and Butler county on the east.

Its draining streams are Taylor & Jamison's runs, which flow south into Slippery Rock creek. This latter stream comes in from Butler county at the extreme southern margin of the township, and keeps a north-west course for one-half mile, when, veering abruptly about, it passes off to the south-west.

This area is also deeply covered by Drift, and over all its northern half, where the streams have not cut down through the covering, nothing can be seen in the way of rock exposures.

In the south-western portion of the township some isolated knobs extend up and catch a considerable area of the *Darlington coal*. One of these areas occurs on the land of Mr. Mowry, and descending from his coal bank to Taylor's run, one-half a mile east, we get section, Fig. 85.



No. 1 is a very pure coal, and the upper bench is of the "splint," or "block" variety. It was used in the raw state at the old Myra furnace, and is said to have worked

very well. The lower bench is more bituminous, but is a splendid coal, and is highly esteemed by the smiths. This same coal is mined a short distance south, near the edge of Scott township.

No. 4, the *Kittanning coal*, was once mined on the land of Mr. Totten, and is reported to have been 3 feet thick, though somewhat sulphurous. The interval between it and the underlying limestone is subject to great variations. On one side of the stream it is 25 feet, and immediately opposite, on the other side, not 50 yards away, it is only 15 feet.

Resting immediately on top of the limestone is the *Ferriferous ore*, which so often accompanies this rock. It was extensively mined in former years, and used at the Myra furnace near by. The Myra was a charcoal furnace, and went out of blast in 1871. The characteristic "buh-stone," or cellular silicious rock which often accompanies the ore, is seen here at the mouth of the old drifts in large quantities.

No 7, the *Ferriferous limestone*, is seen finely exposed in a line of cliffs around the bluff of the stream. It is a very compact, grayish-white rock, and is quarried and burned by Mr. Totten, making excellent lime.

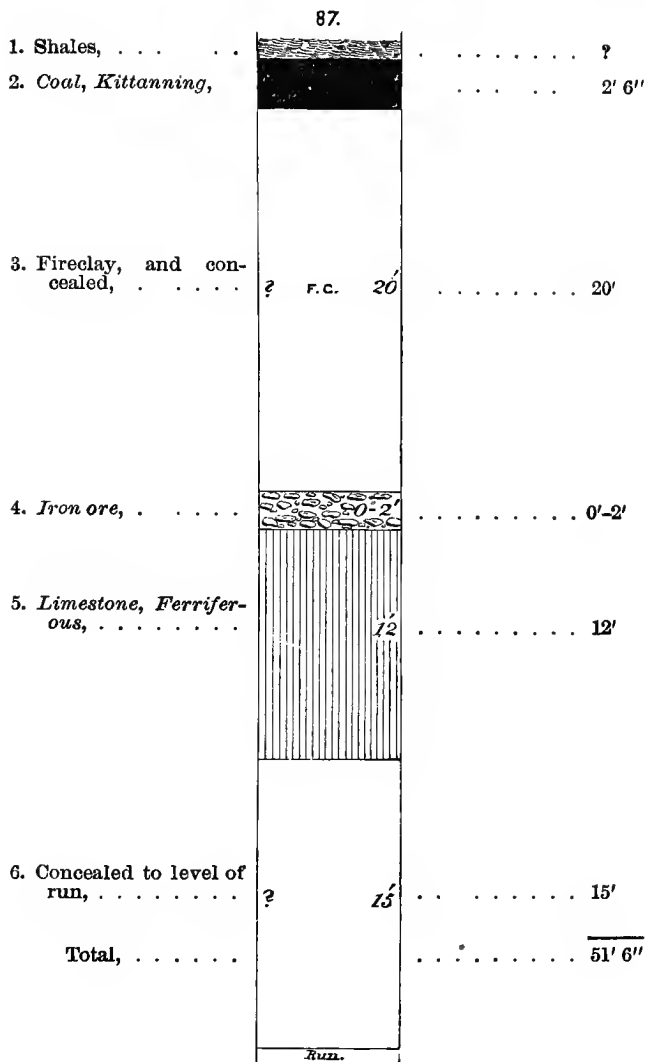
Two feet below it comes a small coal, which Mr. T. reports as being one foot thick, where he once explored it in a ravine. It comes at the horizon of Rogers' *Scrub Grass* coal, and is the same as that mined by Mr. Reichel on Hettenbaugh run in Scott township.

Below this we see an immense bed of tolerably pure fire-clay, which extends down to the bottom of the run.

One half mile south-east from the village of Plain Grove, where the road crosses Jamison's run, the *Kittanning coal* is mined by Mr. Armstrong, and there we section, Fig. 87

The *Kittanning coal* is mined here to some extent for local supply. It contains too much pyrites for a good coal, and burns out the grates in a short time.

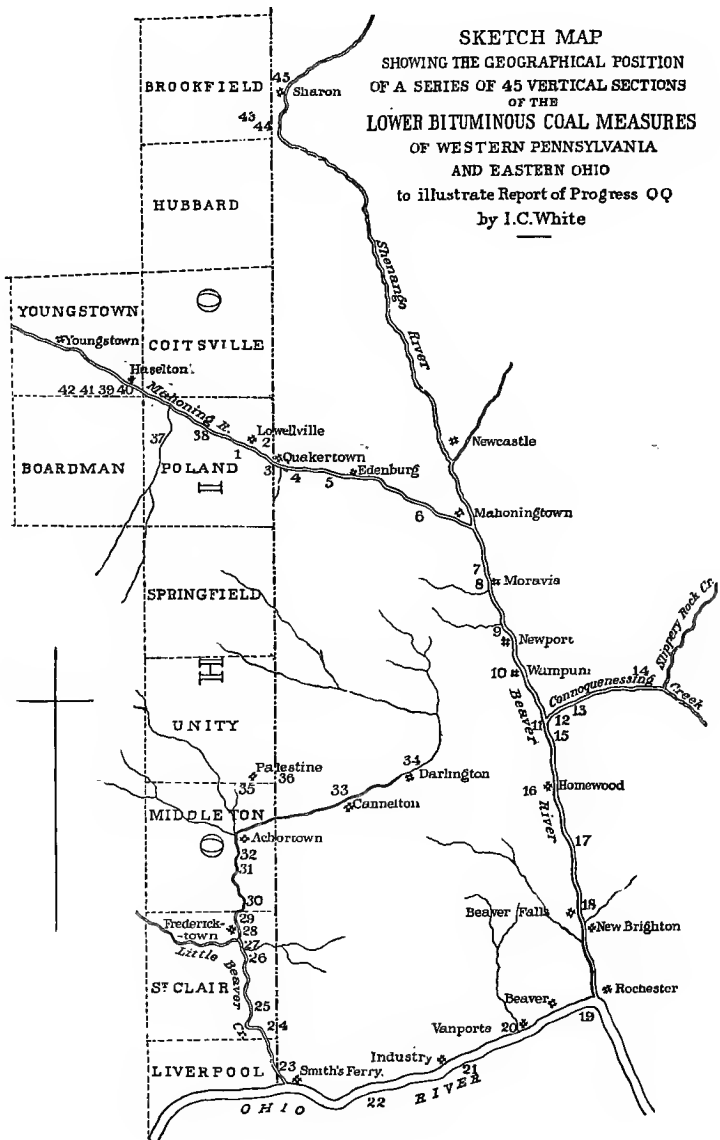
The *iron ore* on the Ferriferous limestone has also been mined at this locality. It is quite variable in thickness, frequently running out entirely, and again thickening up to 2 feet.



The limestone below it is seen in a cliff along Jamison's run, and has also been quarried and burned on this property. It is very pure looking, quite fossiliferous, and possesses the peculiar shriveled or wrinkled aspect so often noted. At the mouth of Jamison's run this stratum comes 80 feet above the level of Slippery Rock.



SKETCH MAP
 SHOWING THE GEOGRAPHICAL POSITION
 OF A SERIES OF 45 VERTICAL SECTIONS
 OF THE
 LOWER BITUMINOUS COAL MEASURES
 OF WESTERN PENNSYLVANIA
 AND EASTERN OHIO
 to illustrate Report of Progress QQ
 by I.C.White



SPECIAL REPORT
 ON THE
 CORRELATION OF THE COAL MEASURES
 IN
 WESTERN PENNSYLVANIA AND EASTERN OHIO.

BY I. C. WHITE.

*Edited, condensed and revised by J. P. Lesley.**

In the beginning of the season of 1876, I was directed by the State Geologist, Prof. Lesley, to make such study of the strata exposed along the line dividing the States of Pennsylvania and Ohio, as might help to settle on a true basis the relationship of the several beds of coal, limestone, &c., described by the Ohio geologist, to the beds of the Lower Coal Measures of Western Pennsylvania. It was plainly desirable that harmony should exist between the reports of the two State geological surveys.

In working out this problem, I was to begin on the *Ohio river, at the State line*, and section up Little Beaver creek past Fredericktown, Achor, Palestine, and Petersburg, and crossing the divide to Poland, pass down Yellow creek to the Mahoning river, and so continue north, by way of Youngstown, Sharon, Orangeville, and Vernon, to connect with Mr. Carll's leveled line across Warren and Crawford counties, where it entered the State of Ohio near Kinney's corners.

[*Nothing material to the purpose of this report has been changed, omitted, or inserted. But I have recast its language into a shape better adapted for quick and easy reference, by keeping the names of the beds at the beginning of the paragraphs, &c. I have also changed the nomenclature, to agree as nearly as possible with that of the Reports of Progress published since this report was handed in, in 1847. J. P. L.]

I accordingly commenced work at the mouth of Little Beaver, and, passing up that stream, found no difficulty in carrying the Ohio valley section as far as Palestine, and even, with tolerable certainty, as far north as Petersburg. But here all exposures ceased, the outcrops becoming hopelessly buried under a covering of northern Drift.

Crossing the "divide" to Poland, therefore, without a section, I again found good exposures along Yellow creek, yet I passed on down into the valley of the Mahoning river in a state of vague uncertainty as to my geological horizon.

This uncertainty, however, was of short duration; for, three miles below the mouth of yellow creek, at Lowellville, on the Mahoning river, I found a large bed of limestone capping the hills, which I recognized at once, both from its character and from its fossils, as the old and well-known *Ferriferous limestone* of western Pennsylvania. In the Ohio reports, this Lowellville limestone is identified with the *Freeport limestone* of the Pennsylvania survey, but the *Freeport limestone* comes at a horizon 250' above the *Ferriferous*.

Here, then, was a wide disagreement between the vertical column of the Lower Productive Coal Measures constructed in Ohio from that constructed in Pennsylvania; a disagreement likely to involve us in a series of mistakes.

In order to be perfectly certain, then, that my identification of the *Lowellville limestone* with the *Ferriferous* of Pennsylvania was correct, in other words, to make quite sure that the *Lowellville limestone* was not the "*White limestone*" of Columbiana Co., Ohio, which is the true "*Freeport limestone*" of Pennsylvania, it became necessary for me to trace the Lowellville limestone around to the south by some other route than that by which I had come, namely: across the Drift-covered divide between the valley of the Mahoning and the head waters of Little Beaver; for, as has been already stated, it is impossible to follow any rock across this interval west of the Ohio State line.

From Lowellville the Mahoning flows south-east into Pennsylvania, and uniting with the Shenango at Lawrence Junction forms the Big Beaver which flows south nearly

parallel to the Ohio line, and 8 to 10 miles east from it. The Big Beaver empties into the Ohio river at Rochester, and the latter stream takes a south-west course from that point until it strikes the eastern line of Ohio near the mouth of Little Beaver creek.

Along this line from Lowellville down the Mahoning, the Big Beaver, and the Ohio, I found the exposures all that could be desired, and so succeeded in carrying the Lowellville section uninterruptedly around through Pennsylvania to the Ohio line again at the mouth of Little Beaver, thus getting a continuous line of sections around nearly three fourths of a circle, and establishing beyond question: first, the identity of the limestone at Lowellville, Ohio, with the Ferriferous limestone of Pennsylvania; and secondly, its identity with a thin limestone near the R. R. level at the mouth of Little Beaver creek, 60 feet below a coal bed identified there by Dr. Newberry as coal No. 3 of his series.

The consequences of this double identification are so important, that no pains will be spared in this report to make its demonstration acceptable to the geologists of both State Surveys, all of them being equally interested in the generalized section common to the two States which it affects.

To state the case in a few words:

1. Coal beds No. 3, No. 4, and No. 5 of the Ohio Survey are said to *underlie the Lowell limestone* on the Mahoning river; and to *overlie the little limestone* at the mouth of Little Beaver, which last stratum we have shown to be identical with the Lowell Limestone.

2. The limestone bed exposed at Lowellville is therefore in Ohio considered to lie 250' feet higher in the series of coal measures than the Ferriferous limestone; namely, at the horizon occupied by the Freeport (White) limestone. But in reality (as the continuous series of sections in this report will place beyond dispute) the limestone in question quarried at Lowellville is not the *Freeport* but the *Ferriferous limestone*.

3. Consequently, three coal beds outcropping from *beneath* the Ferriferous limestone on the Mahoning river in Ohio, have impliedly been numbered 3; 4; 5; and three

other different coal beds, outcropping *over* the Ferriferous limestone on the Little Beaver, have been considered the same beds and have received the same numbers, 3; 4; 5.

In other words, three coal beds on the north side of the drift-covered divide, *having the Ferriferous limestone over them*, have been identified in Ohio with three beds on the south side of the same, *having the Ferriferous limestone under them*.

This report offers the demonstration—by a consecutive series of sections carried around the drift-covered divide to the west, through Pennsylvania,—that the group of three coal beds on the Mahoning is not the same group, but a group *lower* than the group of three coal beds on the Little Beaver.

In other words, the Ferriferous limestone crops out high enough on the Mahoning slopes to show three coal beds *under* it; and outcrops low enough on the Ohio river and Little Beaver slopes to show three coal beds *over* it. Yet the coal beds in both cases have been considered identical.

No blame can attach to any one studying these two groups in the drift-covered area west of the Ohio State line and mistaking the one for the other, since they resemble each other in many respects. To trace them directly across the divide in Ohio is impossible. I would probably have found myself quite as much at fault after crossing the drift-covered divide and reaching the Mahoning valley, had I not previously been so familiar with the *Ferriferous limestone* as to recognize it easily the moment I saw it in its normal condition, and with its usual thickness of 12 to 20 feet.

As the questions to be settled by both the Pennsylvania and the Ohio Surveys concerning the horizon and equivalency of the "different coal beds, and especially concerning the much mooted position of the *Sharon coal* (No. I of Ohio) with reference to the Conglomerate (No. XII of Pennsylvania), depend for their final settlement upon a correct tracing of the *Lowellville limestone* from the Mahoning valley southward to the Ohio river, I shall in this report commence at Lowellville, and carry the limestone in question down the Mahoning, and show that it is actually the

Ferriferous Limestone of Pennsylvania; and then down the Beaver and Ohio rivers, and show that it is the little limestone 60 feet below Dr. Newberry's coal No. 3, on the Ohio river at the mouth of Little Beaver.

It should be stated that in my work along the Ohio line, I went on foot along the streams, and carefully examined every locality where any exposures occur.

In making all the important sections, I used Abney's hand-level, having previously determined, by leveling known elevations, that my personal error in its use was not more than one foot to the hundred; so that the measurements, although not absolutely correct, may be considered practically so for our purpose.

*Section 1.**

At Lowellville in Ohio.

On the Mahoning River.

In a ravine, descending to the right bank of the river, back of the old Furnace, I obtained the following section:

1.	<i>Kittanning Coal</i> ,	2' 4"
2.	Concealed for, . . . . .	. 40'
3.	<i>Ferriferous Limestone</i>, . . . . .	. 10' to 18'
4.	Concealed, . . . . .	. 45'
5. 63'	————— <i>Coal</i>, . . . . .	. 1'
6.	Fire clay,	visible, 3'
7. 101'	Concealed; <i>Coal smut</i> near the bottom, . . . . .	. 34'
8.	Fire clay, non-plastic, . . . . .	. 1' 6"
9.	Shale, sandy, . . . . .	. 6' 6"
10. 109'	————— <i>Coal</i>, . . . . .	. 0' 6"
11.	Shales, sandy, . . . . .	. 13'
12. 122' 6"	————— <i>Coal</i> { <i>Coal</i> , impure, 0' 6" Shale, fire clay, 3' <i>Coal</i> , 1' Fire clay and shale, 2' 6" }	} 7'
13. 129' 8"	<i>Mercer Upper Limestone</i>, . . . . .	. 2' 3"
14. 131' 9"	<i>Mercer Upper Coal</i>, . . . . .	. 2'
15.	Fire clay, . . . . .	. 5'
16.	Sandstone, micaceous, . . . . .	. 15'
17.	Shale, sandy, . . . . .	. 5'
18. 148' 9"	<i>Mercer Lower Limestone</i>, . . . . .	. 2' 4"
19.	Shale, dark, . . . . .	. 8' to 18'
20. 169' 1"	<i>Mercer Lower Coal</i>, . . . . .	. 2' 2"
21.	<i>Connoquenessing shales and sandstones</i>, . . . . .	. 55'

22.	226' 3''	Ore bearing shales, dark,	21' 6''
23.		Shale, <i>calcareous, fossiliferous</i> .	
24.		Shales, dark sandy,	10'
25.		Sandstone flags,	40'
26.		Concealed to level of river,	55'
			395 1''

1. The *Kittanning Coal* (being opened by Mr. Moore when I made the section) is in the top of a high knoll half a mile south of where the *Ferriferous Limestone* is seen, and 30 feet by barometer above it. But I have added 10 feet for the southerly dip.

The coal was bright and richly bituminous so far as explored, and from 28'' to 30'' thick; with a roof of dark sandy shales; and a thick underclay.

3. This is the "White" limestone at the top of Dr. Newberry's Section's No. 6 and No. 7, Chart 1, Vol. II, Ohio Geology; wrongly identified, as I will show by the following sections of this report, with the *Freeport Upper Limestone*, 250 feet above it.

Its character alone suffices to identify it with the *Ferriferous*, and not with the *Freeport*.

The *Freeport* (see my Report Q on Beaver county) never contains any fossils except a minute *bivalve crustacean*.

The *Ferriferous*, on the contrary, is crowded with species of *Spirifer*, *Productus*, *Athyris*, *Euomphalus*, *Bellerophon*, *Pleurotomaria*, and other genera; multitudes of *crinoidal* discs; and numerous *corals*.

These fossils characterize limestone (3) at Lowellville.

The *Freeport* is always so impure as to be seldom fit for the kiln, even for agricultural purposes; containing so much iron and earthy matter, that it slacks with the greatest difficulty; and utterly useless as a flux for the Iron furnace.

The *Ferriferous*, on the contrary, is remarkably pure, and is extensively quarried not only here at Lowellville, but all along the outcrop which I mean in this report to follow, down the valleys of the Mahoning and Beaver river, to the Ohio, and down the valley of the Ohio river to the State Line; and it furnishes all the flux for the iron furnaces of the Mahoning and Shenango valleys.

In color, in structure, and in general thickness also throughout a considerable portion of the region, the two limestones are unmistakably different.

13. The *Mercer Upper Limestone* (called in the Geol. Penna. 1858 the *Mahoning Limestone*) is a very compact darkblue or bluish gray rock, filled with fossil shells, many of them identical with those so abundant in the Ferriferous.

Much siliceous iron ore rests upon it or is imbedded in its upper surface, here and elsewhere.

18. The *Mercer Lower Limestone* (the *Mercer Limestone* of the Geology of Pennsylvania 1858, and the *Blue Limestone* of the Geology of Ohio) is almost precisely like the *Upper*, and more persistent, but usually of a somewhat darker blue color, and if possible more fossiliferous, being often a mere mass of shells, and of the genera mentioned above.

It also carries a plate of iron ore; or, contains cherty ore masses embedded in its upper part. Sometimes, indeed, the whole bed is transformed into a siliceous iron ore.

It is very persistent along the Mahoning and Beaver river valleys, even when, as at Homewood Furnace, the *Upper* limestone with its ore is absent and this *Lower* limestone comes immediately under the great Homewood sandstone.

In spite of its persistency it is seldom more than $2\frac{1}{2}$ feet thick; but its value as a guide to the right interpretations of the following sections of this report will become evident as we proceed. In the exercise of this function the two limestones, separated by only a few feet or yards of shale, reënforce each other.

The natural result of confounding the Lowell (*White*) limestone in Ohio with the *Freeport Upper limestone* in Pennsylvania, was the confounding of this ore-bearing *Mercer Lower (Blue)* limestone of Ohio with the great *Ferriferous Limestone* of Pennsylvania. And in this way the whole column of the Lower Pennsylvania Coal measures in this region was drawn up and shortened by 250 feet; utterly ruining the harmony between the geologies of the two states; and casting a doubt upon the validity of the sections made by the First Survey.

19. These shales are so variable that they measure 8 feet on one side of the ravine and 18 on the other, only a stone throw off.

20. The *Mercer Lower Coal* (the *Lower Porter Coal* of the Geol. Penn. 1858), mined in the ravine back of the Lowell Furnace, is a dull looking, hard and bony coal, sometimes semi-cannel, and sometimes looking like a genuine block coal.

21. These shales represent here the upper part of the *Connoquenessing Sandstone* (*Massillon* of Ohio) which will be seen in other sections to be hard, coarse and massive.

The *Sharon Coal*, which should come in lower down in the section, is more than probably absent; for the last place where it is of minable thickness is at Mt. Nebo, two and a half miles up the valley, where it thins away and is no more seen to the south and east. But the *Ore horizon* above it in the section may be followed by means of a continuous line of old openings and strippings along the sides of the valley.

Section 2.*

On the Mahoning; half a mile below Lowellville.

The strata underneath the Lowell limestone are covered up at Lowellville; but exposed in a run, half a mile below, on the north side of the river thus:—

1.	<i>Ferriferous Limestone</i> ,	16'
2.	Shale, argillaceous,	2' 6"
3. 18' 6'	<i>Scrubgrass Coal</i> , slaty,	6"
4.	Shales, sandy,	12' 6"
5. 31' 6''	<i>Clarion Coal</i> , good,	1' 4"
6.	Sandstone, flaggy,	17
7. 49' 10''	<i>Brookville Coal</i> ,	10'
8.	<i>Homewood Sandstone</i> ; flaggy; locally somewhat massive,	21'
9. 71' 8''	<i>Mercer Upper Coal</i> ,	0' to 4'
10.	{ Fireclay, 3' }	12'
	{ Shales, sandy, . . . 9' }	
11. 86' 0''	<i>Mercer Middle</i> , { <i>Coal</i> , slaty, } <i>Dirt Vein</i> , { Fireclay, } { <i>Coal</i> , . . . }	4'

12.	Fireclay,	2'
13.	Shales, sand,	32'
14. 124'	<i>Mercer Lower Limestone</i> ,	2' 6'
15.	Ore bearing shales, dark,	18'
16. 144' 6'	<i>Mercer Lower Coal</i> ,	2'
17.	Concealed mostly down to river,	200'
		<hr/>
		348' 2'
		<hr/>

Here we have not only the *Mercer Lower limestone*, but a group of coal beds (called in the *Geology of Pennsylvania*, 1858, the *Tionesta Group*,) which are of workable thickness only along the north-western edge of the Coal field, and thin away and disappear as we descend the Beaver river to the Ohio.

1. The *Ferriferous Limestone*, quarried here, is thick, solid, highly fossiliferous, and divided into two benches; the upper of an ashen gray color, and the lower very blue towards the base.

9. The *Mercer Upper Coal* (*Coal No. 4* of Ohio, and the *Tionesta Coal* of the *Geology of Pennsylvania*, 1858,) was once extensively mined and shipped from here. It is still mined by Mr. Lowry, for the supply of the neighborhood.

It is very variable, sometimes running out entirely. It has usually three benches: at the top one foot of slaty coal, seldom mined; a middle bench of very brilliant coal of good reputation; and a (4" to 6") bottom bench of impure, slaty cannel, never mined.

The *Mercer Upper Limestone*, absent in the section, makes its appearance a short distance to the north of the section.

11. *The Mercer Middle Coal* has been opened in several places but is generally very impure and irregular. It is locally known as the "Dirt Vein."

12. A valuable bed of fireclay underlies it all along the Mahoning river valley.

14. The *Mercer Lower Limestone* is the same blue, compact fossiliferous rock as in the last section.

16. The *Mercer Lower Coal* mined here, is reputed good.

Section 3.*

On Quakertown Run.

Two miles below Lowellville.

On the south side of the Mahoning valley, near the Ohio State Line, Quakertown Run cuts down through the Connoquenessing Sandstones in three cascades, 50', 20', and 10' high respectively, exposing the lower part of the following section :

1.		<i>Ferriferous Limestone</i> ; Pence's quarry, . . .	14'		
2.		Concealed,	80'		
3.	94'	<i>Mercer Upper Limestone</i> ,	2'		
4.		Fireclay,	6'		
5.		Sandstone, shaley,	8'		
6.	110'	Coal, slaty,	1' 3		
7.		Fireclay and sandy shales,	5'		
8.	116' 3"	<i>Mercer Lower Limestone</i> , showing a change to iron ore,	1'		
9.		Shales,	6'		
10.	117' 9"	<i>Mercer Lower Coal</i> , semi-cannel,	8'		
11.		Fireclay,	3' 6"		
12.		Shales, sandy,	7'		
13.		<i>Connoquenessing Upper Sandstone</i> , white, very hard and massive,	45		
14.	173' 11"	Quakertown Coal, . . . . .	.0' to 1' 2"	
15.		Fireclay and shales,	3' 6"		
16.	}	<i>Conn. Lower</i> , {	} 99'		
17.				Sandstone,	17'
18.				Shales, bluish,	12'
19.				Sandstone, flaggy,	40'
		Sandstone, massive,	30'		
20.	277' 7"	<i>Sharon Ore bearing shales</i> , bluish,	20'		
21.		Sandstone, massive,	10'		
22.	307' 7"	<i>Sharon bituminous shales</i> , and streaks of coal,	1' 6"		
23.		Sandstone, shaly, and shales,	25'		
24.		Concealed to level of river,	42'		
			<u>377' 1"</u>		

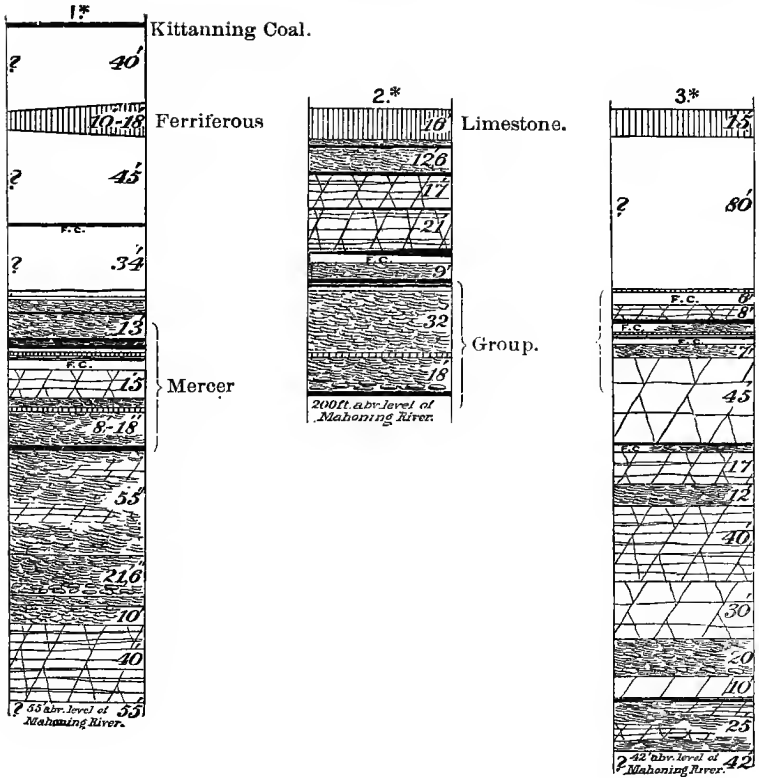
1. The *Ferriferous Limestone*, in the hill tops, is extensively quarried by Mr. Pence for fluxing the Mahoning Valley iron furnaces. It differs in no respect from that at Lowellville, Section 1.

3. The *Mercer Upper Limestone* re-appears here. 94 feet below the (*top* of the) *Ferriferous*. The interval is 35 feet

At
Lowellville.

½ m. below
Lowellville.

At Quakerstown
2 m. below
Lowellville.



less than at Lowellville (Sec. 1,) perhaps because of the great local development of the Sandstone masses under it.

8. The *Mercer Lower Limestone* on one side of the run is typical *blue limestone*; on the other side of the run, not 100 yards distant, it is a bed of *iron ore*, tolerably rich but cherty, once stripped for the Lowell Furnace.

13. The *Connoquenessing Upper Sandstone* is here white, very hard and massive, causing the upper cascade of 50 feet.

14. A small, irregular bed of hard brilliant coal was once mined here. As it is represented at many other places in Western Pennsylvania by streaks of coal and coal shales, fireclay and soft measures, separating the upper and lower portions of the great sandstone mass, I have named it the *Quakertown coal bed* from this locality. It will be noticed again in the sections on the Connoquenessing creek. But in many places the sandstone masses above and below come together and there is no trace of these soft measures between them.

19. The *Connoquenessing Lower Sandstone*, here brownish white, very hard and coarse, makes the second cascade of 20 feet.

20. The *Sharon Ore* horizon is a persistent mass of bluish black shales, containing much iron ore in scattered nodules, and a regular plate of ore from 12" to 18" thick coming in three or four feet beneath the base of the sand rock.

21. A local sandstone fining away to shale appears just below the third cascade of 10 feet, and forms the roof of

22. A bed of black slate, streaked with coal, here representing the *Sharon Coal*, say 200 feet below the *Mercer L. Limestone* and 400 feet below the top of the *Ferriferous*.



A comparison of Sections 1 and 3 is instructive; showing as it does both the variability and the regularity of our *Coal Measures*.

Section. 4.*

At Hilltown Station.

One mile below Quakertown, in a ravine descending to the Mahoning, the following section was made.

1.	<i>Ferriferous Limestone</i> ; Park's quarry, . . .	19'
2.	Concealed,	100'
3.	119' <i>Mercer Upper Limestone</i> , ore bearing, . . .	3'
4.	122' <i>Mercer Upper Coal</i> ,	1' 6"
5.	Fire clay; manufactured at Hilltown,	5'
6.	Shales sandy,	20
7.	148' 6" <i>Mercer Lower Limestone</i> , blue, <i>hydraulic</i> , . .	1' 8"
8.	Fire clay and sandy shale,	7'
9.	157' <i>Mercer Lower Coal</i>	1' 8"
10.	<i>Conno. Upper Shales and Shaly Sandstone</i> , . . .	80'
11.	<i>Conno. Lower Sandstone</i> massive,	25'
12.	263' 8" <i>Sharon ore bearing Shales</i> ,	15'
	Concealed to level of river,	80'

 358 10"

1. The *Ferriferous Limestone* here consists of an upper bench of grey, 14 feet thick, and a lower bench of blue 5 feet which is not quarried.

Huge blocks of the rock, undermined by aerial erosion and falling off, have slid down and now lie scattered on the steep slopes below.

3. The *Mercer Upper Limestone* very hard and compact, here carries a layer of iron ore, and has nodules of ore scattered through it.

4. The *Mercer Upper Coal*, slaty and impure, has the limestone for its roof, and a valuable underclay, from which fire brick has been manufactured at Hilltown.

5. The *Mercer Lower Limestone* has here returned to its horizon at Lowellville. It is here 148½ and there 148¾ feet beneath the top of the *Ferriferous*.

It is in two layers, the upper 15," the lower 5," with a mere parting. It is dark blue and, having been burned for cement, is locally called the *Water-lime*.

6. The *Mercer Lower Coal*, hard, sometimes almost bony, varying from 20" to 2', has been mined.

10, 11. The *Connoquenessing* group, which in Sec. 3 was so massive, so thick (150'), and split by the *Quakertown*

Coal, has in one mile transformed itself to about 100 feet of shales and shaly sandstones (massive at the base) without a trace of coal.

Section 5.*

At Seymore's Coal Works.

Two miles below Hilltown Station.

One and a half mile above Edinburg, in a ravine descending to the Mahoning river, was got the following :

1.	Ferriferous Limestone,	18'
2.	Concealed,	75'
3.	Shales, sandy, bluish,	20'
4. 113'	Mercer Upper Limestone,	2' 9"
5. 115 9"	Mercer Upper Coal; very bad,	4' 8"
6.	Concealed,	12'
7. 132' 5"	Mercer Lower Limestone,	1' 8"
8.	Shales,	8'
9. 142' 1"	Mercer Lower Coal; Phillips & Stephens,	2' 6"
10.	Concealed,	30'
11. 174' 7"	Eden Valley Upper Coal, visible,	1'
12.	Fire clay,	3'
13.	Concealed,	12'
14. 190' 7"	Eden Valley Lower Coal; smut,	1' (?)
15.	Shales,	3'
16.	Connoquenessing Upper Sandstone massive.	27'
17.	Shales sandy,	20'
18.	Concealed to level of river,	90'

331' 7"

1. An outcrop of solid *Ferriferous Limestone* surrounds the hill top, and has been quarried a short distance north west. Its color, structure, and size are the same as at Lowellville.

4. The *Mercer Upper Limestone*, of almost flinty hardness, contains small, cylindrical nodules of iron ore, which protrude like thorns from the weathered surface.

5. The *Mercer Upper Coal*, here a thick bed of coaly slate, was disastrously mined by a New York Company.

7. The *Mercer Lower Limestone* has here again risen (16 feet) towards the (top of the) *Ferriferous*, the interval being now 132½.

9. The *Mercer Lower Coal*, was once mined here by Phillips & Stevens, and reported very good.

11. *Local Coal*. } These beds make their appearance in
 14. *Local Coal*. } the series here, and the lower one was once stripped along the ravine, but nothing could be learned of its thickness. [I have given them provisionally the names *Eden Valley Upper and Lower Coals* for convenience of reference in the remainder of this report.—J. P. L.]

16. The *Connoquenessing Upper Sandstone* becomes massive again in this section; but whether anything here represents the *Quakertown* group; or the *Sharon* group below it cannot be seen.

We here bid farewell for a while to our guide the *Ferriferous Limestone*, and take the *Mercer Lower Limestone* in its stead. For the general level of the highland bordering the lower part of the Mahoning Valley has been lowered by extensive erosion.

Nor until we pass down from the valley of the Mahoning into that of the Beaver river do we find side hills high enough to take in again the *Ferriferous Limestone*.

In this interval also the *Mercer* group of coals and limestones are everywhere concealed. But the massive horizontal outcrops of the *Connoquenessing* group, and underlying *ore bearing shales* of the *Sharon* group, exposed for furnace use, enable us to pass on in safety with our general section to the junction of the rivers.

As a specimen of these exposures the following short local section, made in a ravine near the lower end of the Mahoning valley will suffice.

*Section 6.**

On the Mahoning River.

One and a half miles above its mouth.

1. Shales (bituminous on top, sandy below), 15'

2. <i>Eden Valley? Coal</i> ,	1' 6"
3. Shales, dark, sandy,	10'
4. <i>Connoquenessing Sandstone</i> , conglomerate, massive,	25'
5. Sandstone, flaggy, with sandy shales,	50'
6. Ore bearing shales, sandy, blue,	15'
7. Concealed to level of river,	30'
	146' 6

2. This bed has been stripped along the little stream in the ravine, and yielded a very brilliant pure looking coal. It seems to be a continuation of one of the beds over the great Sandstone in the last section.

4. The *Connoquenessing Upper Sandstone* is here a true conglomerate, many of its layers being filled with white quartz pebbles varying in size from a pea to a hazelnut, and the rock is traceable far up the opposite side of the valley in a line of massive cliffs.

The Mahoning and Shenango unite their waters a mile and a half below this section and form the Beaver river, which we now descend.

*Section 7.**

On the Beaver River.

Two miles below the mouth of the Mahoning.

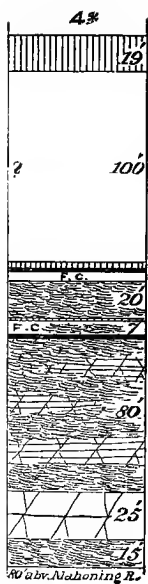
Descending a ravine from Shinn's quarry to the banks of the Beaver river one mile above Moravia we obtain the following Section, where the river hills have become again high enough to take in the *Ferriferous Limestone* :

1.	<i>Ferriferous Limestone</i> , Shinn's quarry,	20'
2.	Concealed,	60'
3. 80'	<i>Mercer Upper Coal</i> , once opened here,	?'
4.	Concealed,	30'
5. 112'	<i>Mercer Upper Limestone</i> ,	1' 8"
6.	Concealed; (<i>Coal</i> once opened),	25'
7. 138' 8"	<i>Mercer Lower Limestone</i> ,	2'
8.	Shales,	5'
9. 146' 8"	<i>Mercer Lower Coal</i> ,	1

Hilltown
3 m. below
Lowellville.

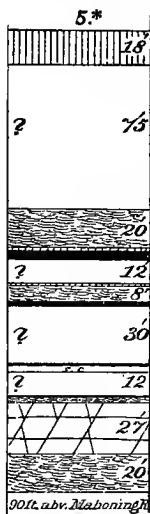
Seymour's
5 m. below
Lowellville.

¼ m. above
mouth of
Mahoning river.

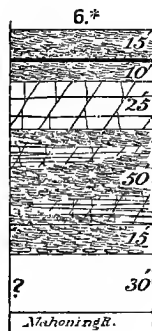


Ferriferous

Mercer
Group.



Limestone.



10.	Concealed,	100'
11.	<i>Connoque. Lower Sandstone</i> , conglom. massive,	35'
12.	Concealed to level of river,	36'
		<u>318' 8''</u>

1. The *Ferriferous Limestone*, here extensively quarried for the furnaces along this valley, has the same lithological character, and contains the same assemblage of fossils which occur in it along the Mahoning.

The upper *gray* part varies much in thickness in different parts of the quarry, running as high as 18' and as low as 5'. This is the merchantable portion of the rock, while the lower *blue* part is too impure to be mined.

5, 7. The *Mercer limestones* have here the same compact structure, and dark bluish color which characterize them along the Mahoning; both are also crowded with fossils, *Spirifer cameratus*, *S. lineatus*, and *Productus longispinus*, being especially numerous in each.

The distance of the *Lower limestone* beneath the top of the *Ferriferous* is an average (say 140') between the distances given in sections 1, 4 and 5.

9. The *Mercer Lower Coal* was once mined here, but the entry is now inaccessible.

11. The *Connoquenessing Lower Sandstone*, quarried along the ravine, near the Erie and Pittsburgh railroad, contains many pebbles in some of its layers, but none were seen larger than a hazel-nut.

*Section 8.**

Near Moravia.

Three miles below the mouth of the Mahoning.

Descending a side ravine into Leonard's run, and thence down the run half a mile to its junction with the Beaver river, a short distance below Moravia, we obtain the following section :

1.	<i>Ferriferous Limestone</i> ,	visible only, 8
2.	Concealed,	60'

ore above it very much in every respect, and, like the latter, rests immediately upon a small coal; below which we see coaly shales, fireclay, and 11 feet of sandy shales, when we come down to the very persistent little coal which occurs a few feet below the *Lower Mercer Limestone* in all the preceding sections. It has been mined by stripping along Leonard's run; and though only one foot thick is quite good, having a brilliant luster, and showing very little pyrites.

Its depth beneath the top of the *Ferriferous Limestone* (if the latter be called here 18' thick) is about 140 feet.

19. The *Connoquenessing Sandstones*, Upper and Lower, seem here to be united. The shaly interval with its *Quakertown coal* bed has thinned entirely away, and given us a solid mass of rather coarse, grayish-white sandstone, 100 feet thick. At times however it shows a tendency to become shaly near its center. Many casts of *Sigillaria* and *Lepidodendron* are seen in it. A streak of coal one or two inches thick was noticed in it a few inches above its base.

Section 9.*

On the Beaver River.

Five miles below the mouth of the Mahoning.

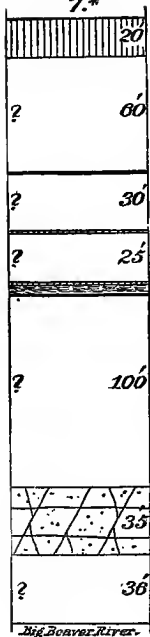
Descending the (Jenkins') run on the west side of the Beaver river three-quarters of a mile to its mouth, one mile above the village of Newport, and two miles below Moravia, we get the following section:

1. <i>Mercer Lower Limestone</i> ,	2' 4'
2. Shales, { Bituminous at top,	} 9'
{ Sandy below,	
3. <i>Mercer Lower Coal</i> ,	1' 6''
4. Shales, bluish,	10'
5. Concealed,	25'
6. <i>Connoquenessing Sandstone</i> , massive,	73'
7. Concealed to level of river,	20'

140' 10''

*Shinn's,
2 m. below
mouth of
Mahoning*

7.*

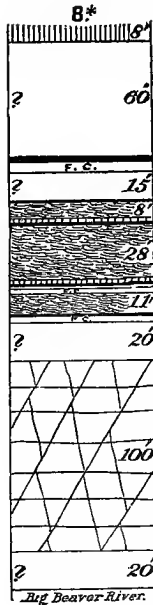


Ferriferous

Mercer

*Moravia,
3 m. below
mouth of
Mahoning.*

8.*



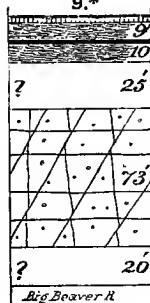
Limestone.

Group.

Big Beaver River.

*Jenkin's run,
5 m. below
mouth of
Mahoning.*

9.*



Big Beaver R.

Big Beaver River.

The *Ferriferous Limestone* leaves the vicinity of the river between Sec. 8 and 9, and sweeps westward, to keep in the high land. It has been quarried in the bed of Jenkins' run one mile higher up than the commencement of our section.

The *Mercer Upper Limestone* was not seen in the run itself. But numerous blocks from its outcrops lie upon the side slopes just above where the *Lower Limestone* is exposed in the run.

1. This *Mercer Lower Limestone* is the same dark bluish rock which we have seen in all the previous sections at this horizon. It is filled with fossils, and its weathered surfaces look sandy.

3. The *Mercer Lower Coal* has been stripped along the run, and is reported to be very good.

6. The *Connoquenessing Upper Sandstones* cause a succession of cascades, descending forty feet in as many yards. These rocks are very massive, and contain some quartz pebbles. Near the base is seen a conglomerate mass of iron ore, rounded and angular pieces of sandstone, quartz pebbles, vegetable fragments, &c.

*Section 10.**

At Wampum on the Beaver River.

Eight miles below the mouth of the Mahoning.

As we pass south from Jenkin's run the *Ferriferous Limestone* once more comes into the hills along the Beaver river, and on its left bank down past Newport forms a huge cliff far up on the hillside; it is almost constantly in sight until we come to the village of Wampum, where three miles from our last section and on the west bank of the river, we get the following section:

1.	Ferriferous Limestone (quarries), . . .	15' to 25' = 20'
2.	Concealed,	75'
3.	Homewood Sandstone, Conglom. massive,	35'
4.	Shales sandy,	20'
5.	150' Mercer Lower Limestone,	2'
6.	Coaly slate,	1' to 2'

7.	Shales, sandy,	0 to 10'	
8.	164' <i>Mercer Lower Coal</i> ,	1' to 2'	
9.	Fireclay,	3'	
10.	Shales, sandy and sandstones, flaggy,	15'	
11.	184' <i>Coal</i> ,	1'	
12.	Ore bearing shales, sandy,	10'	
13.	} <i>Conn. Upper</i> , {	Sandstone, massive,	15'
14.		Shales, sandy,	5'
15.		Slate, black,	3'
16.		Sandstone, massive,	8'
17.	Concealed to level of river,	20'	
		<u>246'</u>	

1. The *Ferriferous limestone*, varying in thickness from 15 to 25 feet, has long been extensively quarried and shipped from this point, and has the same features in every respect which we have seen it possessing at every locality between here and Lowellville.

By comparing the Railway levels at Lowellville and Wampum with the sections made at those places, it appears that the *Ferriferous limestone* dips to the south-east 210 feet in about 15 miles, or at an average of 14 feet per mile.

At Wampum the hills extend up a considerable distance above this limestone and take in the *Darlington coal*, which occurs 60 feet above, 3 feet thick, and is largely mined. Going back still further into the country the other members of the Lower Productive Coal Series are seen to come in above it, viz: the *Freeport sandstone*, *Lower Freeport coal*, the *Upper Freeport coal* and its underlying *limestone*, and the *Barrens* in the summits of the highest hills capping all.

It will thus be seen that we have traced the *Lowellville limestone* continuously to the south until the whole *Lower Productive Coal Series* has come into the hills above it, and there can no longer be any doubt that the *Lowellville limestone* is the *Ferriferous limestone*.

3. *Homewood Sandstone*.—An important change takes place a short distance above Wampum in the lithological character of the interval between the *Ferriferous* and the *Mercer Limestones*, thus:

North of Wampum our sections have been showing no massive sandstone in this interval; only sandy shales and flaggy sandstones holding several small coal beds.

South of Wampum, on the contrary, a very massive and conglomeratic sandstone comes in. Where the section was made only 35 feet of it is exposed; but just around, on the other side of the hill, only a few rods away, we see 50 feet in a massive cliff. At Homewood, seven miles south of Wampum, it is 150' feet thick. See Report Q, page 208.

The *Mercer Upper limestone*, whose place is usually 25 to 30 feet above the *Lower*, has here been cut away by the massive sandstone coming in above; and we see it no more along the Beaver river south of this.

5. The *Mercer Lower limestone*, is found in the section at its proper horizon. It is more sandy than usual; but possesses the dark bluish aspect so common to it, and is crowded with fossils. It is seen near the Railway depot, and along the town road which passes up the little run from Wampum. At one point on this little stream it disappears entirely from the section; but it comes in again a short distance above.

8. The *Mercer Lower coal*, is quite variable. Where exposed in the cuttings along the tram road it is seen to vary from 1' to 2' 4". Sometimes it comes immediately below the limestone; at other times it is separated from it by from 8 to 12 feet of shales. Its coal is too slaty to be of any economical importance.

13-16. The *Conn. Upper Sandstone* is here very much split up by shaly subdivisions. But a short distance below (south) it makes a massive cliff 50 feet high.

*Section 11.**

Mouth of the Connoquenessing.

Eleven miles below the mouth of the Mahoning.

From Wampum southward the *Kittanning Coal* beds, above the *Ferriferous Limestone*, are mined in a continuous line; and the *Freeport Upper Coal* is occasionally caught in the hill tops; so that the horizon lines of the sections

are maintained even when the Ferriferous Limestone itself thins away to nothing, and ceases to be our guide.

Three miles below Wampum and opposite the mouth of the Connoquenessing creek is seen the following section, at an old ore drift:

1. <i>Homewood Sandstone</i> , conglom. massive,	visible, 15'
2. <i>Homewood Ore shales</i> , sandy, bluish,	10'
3. <i>Mercer Lower Limestone</i> ,	1'
4. <i>Mercer Lower Coal</i> (smut),	?
5. Concealed,	15'
6. <i>Conn. Upper Sandstone</i> , white, massive,	visible, 20'
7. Concealed to level of river,	80'
8. Sandstone, massive, top seen in river.	

141'

1. Here the *Homewood Sandstone* has been eroded far back from the stream, and only the lower portion of it remains along the river bluff; very coarse, massive, and conglomeratic.

2. Immediately under it come the ore bearing shales which supplied the old Homewood furnace with a large portion of its iron ore, which lies in huge nodular masses, and also in a tolerably persistent stratum from 6 inches to 1 foot thick.

3. At the base of these shales we see the *Lower Mercer Limestone*, where it has been dug out of the drain at the ore drift; very compact and fossiliferous, and with a sandy look on its weathered surface.

4. Below it, is seen the blossom of a coal which very probably represents the *Lower Mercer*.

6. The *Connoquenessing Upper Sandstone* is here a very hard, white, and tolerably coarse rock; only 20 feet of it seen; the rest concealed by débris. But immediately opposite, on the other side of the Beaver, is a vertical cliff 45 feet high.

8. The *Connoquenessing Lower Sandstone* shows its top layers at water-level, where the old dam was built across the Beaver; a massive, coarse, brownish-white rock.

The *Sharon Coal* horizon ought therefore to be about 40

feet below water-level at the mouth of the Connoquenessing creek.

To show the relationships of these lower Measures it is necessary here to connect the sections made along the Beaver river with those made up the Connoquenessing creek, which flows in a gorge, between steep walls of its massive *Upper Sandstone*; while its *Lower Sandstone* is frequently seen in its bed; as in the following section of the southern bluff, one and a half miles above its mouth.

Section 12.*

Up the Connoquenessing; 1½ miles.

1. <i>Connoquenessing Upper Sandstone</i> , yellowish white and coarse,	45'
2. Ore bearing fireclay,	3'
3. <i>Quakertown black slate</i> , fissile,	12'
4. Shales, sandy and sandstones, flaggy,	25'
5. <i>Conoq. Lower SS.</i> , bluish gray, massive,	20'
Level of Connoquenessing creek.	

105'

1. A very hard, massive white sandstone, frequently streaked with iron stains.

2, 3, 4. This *Ore and Coal* soft interval is seen separating the *Upper and Lower Sandstone* formations all along the creek, from its mouth up to the mouth of Slippery Rock creek; and the section here resembles section 3 at Quakertown.

2. Large nodules of iron ore are scattered through this bed of fireclay.

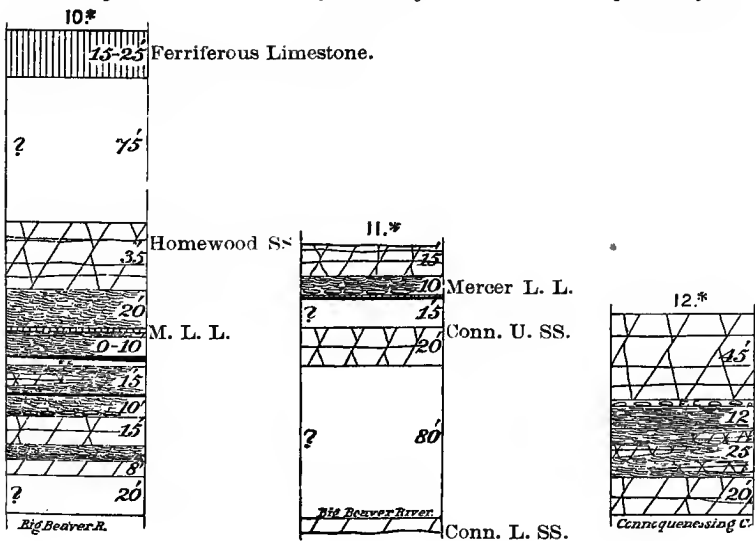
3. *The Quakertown Coal* which is here represented by black slate, shows thin streaks of coal further up the creek.

5. Very coarse, bluish gray, much discolored with iron stains, and gnarly and contorted in structure.

Wampum 3 m.
below mouth of
Mahoning.

Mouth of Conno-
quenessing creek.
11 m. below mouth
of Mahoning

1 1/2 m. up Conno-
quenessing Cr.



Section 13.

Up the Connoquenessing; 2 miles.

Half a mile above the last section, and on the same southern steep hill-side we get the following section :

1.	<i>Ferriferous Limestone</i> ,	23'	
2.	Shales, sandy,	30'	
3.	53' <i>Clarion Coal</i> , slaty and impure,		6''
4.	Shales, sandy,	30'	
5.	<i>Homewood Sandstone</i> , somewhat massive,	10'	
6.	Concealed,	66'	
7.	159' 6'' <i>Mercer Lower Limestone</i> , (Reported,)	1'	
8.	Concealed,	10'	
9.	<i>Connoquenessing Upper Sandstone</i> , massive,	45'	
10.	Concealed to level of creek,	55'	
			<hr/> <hr/> 270' 6''

1. The *Ferriferous Limestone* is here seen forming a huge cliff around the hill, while its numerous outliers are scattered over the surface below. It is filled with fossils, and has the same character in every respect which it possesses at Lowellville, on the Mahoning.

5. The top of the *Homewood Sandstone*; which extends down through 6, whose slope is covered by débris; but the topography would indicate that the rock material of 6 is not massive.

7. The *Mercer Lower Limestone* was not seen in place; but Mr. Wilson, on whose land the section was obtained, showed me where he had plowed it out of the field at the horizon where I have placed it in the section, viz: 159½ feet below the top of the *Ferriferous*. In Sec. 10* the interval was 155 feet when the *F. L.* was 25 feet thick, and 145 feet when the *F. L.* was only 15 feet thick.

Section 14.

Up the Connoquenessing; 4 miles.

For the next two miles the *Lower Sandstone* skims along near water level, its base never rising above the same. But here a sharp roll in the strata throws it above water, and be-

low it we find a stratum of iron ore and some dark shales which contain fossil plants characteristic of the *Sharon coal*.

Here on the north bank of the creek the following very interesting little section was obtained :

1. <i>Connoquenessing Upper Sandstone</i> , white, <i>massivo</i> , . . .	50'
2. Concealed,	40'
3. <i>Connoquenessing Lower Sandstone</i> , <i>massivo</i> ,	20'
4. Shales, bluish—fossil <i>plants</i> ,	2'
5. Iron ore in one stratum,	1'
6. <i>Sharon Shale</i> , bluish and blackish ; fossil <i>plants</i> characteristic of the <i>Sharon coal</i> , visible down to the level of the creek,	4'
	<hr style="width: 100%; border: none; border-top: 1px solid black; margin-bottom: 2px;"/> <u>117'</u>

1. The *Upper Connoquenessing Sandstone* makes a continuous line of cliffs from the mouth of the creek to the place of the section. No quartz pebbles were seen either in it or in the *Lower Sandstone*.

5. The *Homewood* ore is here a regular stratum of carbonate of iron.

6. The *Sharon shale* here seen is a perfect *fac-simile* of the plant bearing shale which occurs in the roof of the *Sharon coal* in the Mahoning and Shenango Valleys ; it contains the same grouping of plants which are characteristic of that coal ; great numbers of *Cardiocarpus*, *Trigonocarpus*, and *Cordaites*, also *Odontopteris neuropteroides*, *Alethopteris lonchilica*, *Sphenopteris macilenta*, and many others which have the same facies as the plants seen in the roof shales of the *Sharon coal* wherever that bed is mined.

The lower part of this little stratum is very bituminous, and scattered streaks of coal are seen in its lowest exposed layers, so that not many feet below the creek at this locality there may be a deposit of the *Sharon coal*.

This little plant bearing shale is very interesting from the fact that it harmonizes perfectly with the horizon which we have shown by *stratigraphy* the *Sharon coal* must occupy, when traced to the south from the Mahoning valley.

The *Ferriferous Limestone*, 20 feet thick, occurs in the hills back from the creek, at an elevation of 275 feet above this *Sharon shale*.

Going still further back on to the high tongue of land

which separates the Connoquenessing creek and Beaver river, we pass over the outcrops of the *Kittanning* and *Darlington coals*, and come to the *Upper Freeport* with its underlying limestone, 500 feet above where the *plant shale* is seen in the bed of the Connoquenessing.

There can therefore be no doubt about the identity of the shale (6) here with that at Sharon, although it is seen but for a few rods distance at the edge of the Connoquenessing creek, when a sudden change of dip puts it again under water level.

It is not necessary for our purpose to ascend the Connoquenessing Valley any further to the east. Cliffs of massive *Conn. Upper Sandstone* continue to shut in the gorge, as far as the mouth of the Slippery Rock, where the base of this sandstone has descended to within 10 feet of water level. Ascending the Slippery Rock the dip carries the whole mass under. Its top layers are in the bed of the stream at Wurtemberg, and here may be seen the *Mercer Group* in its proper place; the *Lower Limestone* 8 feet above water, and the *Upper Limestone* 45 feet. (See Appendix to J.) Even the *Mercer Lower Coal* is there, 2½ feet thick, parted by shale and mined.

We now return to the Beaver river, and continue down its valley southward to the Ohio river.

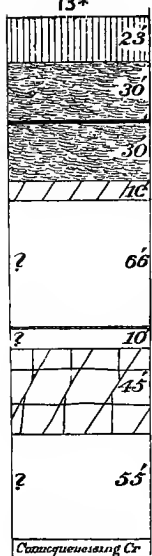
*Section 15.**

Homewood Furnace; On the Beaver River.

Twelve miles below the mouth of the Mahoning.

One mile below the mouth of the Connoquenessing Creek, at the old Homewood Furnace, I made the following section:

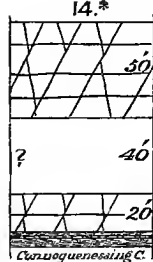
2 m. up
Connoquenessing
Cr.
13*



Mer. L. L.

4 m. up
Connoquenessing
Cr.
14.*

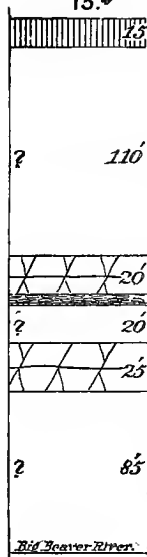
Ferriferous Limestone.



Mer. L. L.

Sharon

Homewood
Furnace.
12 m. below
mouth of
Mahoning.
15.*



1.	<i>Ferriferous Limestone</i> ,	15
2.	Concealed mostly,	110'
3.	<i>Homewood Sandstone</i> , massive,	20'
4.	145' <i>Homewood Ore Shales</i> , partly exposed,	5'
5.	150' <i>Mercer Lower Limestone</i> ; dark blue; fossiliferous,	1'
6.	Concealed,	20'
7.	<i>Connoquenessing Upper Sandstone</i> , massive,	25'
	Concealed mostly down to the river,	85'
		<hr/>
		281'
		<hr/>

1. The *Ferriferous Limestone* is here fifteen feet higher above the Beaver river water level than it is in Sec. 11 one mile distant to the north, denoting the presence of a low anticlinal.

It was once quarried here for Homewood Furnace. It is not so massive as usual but splits into layers separated by shales. It is richly fossiliferous. Some of its layers are earthy.

Although 15 feet thick here, it grows thinner and thinner as we follow its outcrop down the river, and before reaching Homewood station, three miles south of the furnace, it has thinned away to a feather edge, and disappeared.

2. The *Homewood Sandstone* thickens up enormously in the same direction; so that its top layers get at last to lie at higher elevation than the horizon of the Ferriferous Limestone. The thinning away of the limestone is evidently against the flank of this great sand and gravel bank.

3. The lower portion of the *Homewood Sandstone* which is visible in the section, is very massive and contains many pebbles in scattered streaks.

At the top of the shale, and immediately under the Tionesta sandstone, a little coal bed is frequently seen between this locality and Homewood station, and one mile below Clinton it attains workable dimensions on the land of Mr. Beaty.

4. The numerous old drifts and strippings give evidence to the amount of ore which has been taken out.

5. The *Mercer Lower Limestone* appears under the ore drifts here, for the last time going south, being invaded from above by the great sandstone, as the Ferriferous

Limestone is invaded by it from below. But the Mercer Group does not disappear with the limestone. In this section only 26 feet of *Mercer* interval intervenes between the *Homewood Sandstone* above and the *Connoquenessing Upper Sandstone* below. But this interval gradually expands to 80 feet at Homewood Station, three miles below; and the expansion must be at the expense of the *Connoquenessing Sandstone*; for the base of the *Homewood Sandstone* runs along the hillsides at nearly a level line, being still 100 feet above the river at Homewood Station, although the *Connoquenessing Sandstone* is only 20 feet above the river there.

*Section 16.**

At Homewood Station; on the Beaver.

Fifteen miles below the mouth of the Mahoning.

Between Homewood furnace and Homewood station there are numerous mines on the *Darlington coal* along the right bank of the Beaver, whence it has been extensively shipped as a gas coal, while the *Kittanning* with its great underlying bed of *fireclay* occurs below, so that there is no difficulty in following the section down to Homewood station, 3 miles below Sec. 15.

Here, descending from the Summit cut along the Pittsburgh, Fort Wayne and Chicago Railroad to the Beaver river, we obtain a magnificent section which exhibits in a vertical column the entire Lower Productive Coal Measures, and passes far down into the Conglomerate Series.

It was obtained by combining two sections; first (1-11), from the top of the Summit cut, $1\frac{1}{2}$ miles west from Homewood station, to the outcrop of the *Kittanning Coal*, which we can then follow around to Homewood, where it has been mined; the rest of the section was got by descending the slope from the mines to the Beaver river.

- | | |
|--|-----|
| 1. <i>Freeport Upper Limestone</i> with shales and fire-clay partings, | 10' |
| 2. Sandstone, flaggy, | 15' |
| 3. Shales, sandy, dark, | 20' |

4.	Bituminous slate,	10'	
5.	<i>Freeport Lower Coal</i> ,	1'	
6.	Fireclay,	—	6''
7.	<i>Freeport Lower (or Butler)</i> ,	$\left. \begin{array}{l} \text{Limestone, } 1' 6'' \\ \text{Shale, } 2' \\ \text{Limestone, } 2' \end{array} \right\} 5' 6''$	
8.	<i>Freeport shales and sandstone</i> ,	73'	
9.	<i>Kittanning Upper (Darlington) Coal</i> ,	1'	8''
10.	Ore-bearing shales,	20'	
11.	159' <i>Kittanning Middle Coal</i> ,	2'	
12.	232' Concealed; in which comes <i>Ferriferous Limestone</i> horizon,	73'	
13.	387' <i>Homewood Sandstone</i> , conglomeratic,	155'	
	14. One of the <i>Mercer Coals</i> ,	1' to	2'
15.	402' <i>Ore shales</i> , bluish,	15'	
16.	447' <i>Shales</i> , sandy, dark,	45'	
17.	<i>Local Coal</i> , impure, semi-cannel,	5'' to	7''
18.	453' <i>Fireclay and shales</i> , sandy,	5'	
19.	455' <i>Iron ore</i> , calcareous, stratum,	2'	
20.	468' <i>Shales</i> , sandy dark,	13'	
21.	<i>Connoquenessing Sandstone</i> , white, very hard, massive, to river level,	18'	6''
		<u>485' 11'</u>	

The *Freeport Upper coal* is not seen above 1 at the Summit cut; as it has there locally thinned away and replaced by an immense bed of fireclay; but a short distance north, as well as south, we find it coming in again at that horizon, and attaining a thickness of 4 to 6 feet.

1. The *Freeport Upper limestone*, occurs in the very top of the Summit cut, in six or seven layers, separated by fireclay and shales; much brecciated and very ferruginous. Its base is here 1115 feet above tide; while at the State line, where the P. Ft. W. & C. R. R. passes into Ohio it is 1090 feet above the same, or 25 feet lower than at this point.

5. The *Freeport Lower Coal* is represented by a bed of coal only one foot thick with a roof of bituminous shale (4). The coal and the underlying limestone are seen exposed for several rods in the Summit cut.

9 and 11. The *Darlington* and *Kittanning coals* have both been mined along the Railroad between the Summit cut and Homewood, and at the latter place the *Kittanning* was once extensively mined, but the works are now abandoned, as the coal was thin and rather inferior.

12. The *Homewood Sandstone* probably extends up into this interval. So the topography indicates; and massive sandstone blocks lie scattered over the interval, which could have come from no rock higher in the series.

The *Ferriferous Limestone* should come theoretically near the bottom of this interval; but it is probably cut away by the uprise of the great sandstone mass. Only three miles north of this, it is seen in Sec. 15, fifteen feet thick and 265 feet above the Beaver river. As the strata are nearly horizontal between the two points, there being but a slight dip to the south, it should come in near the top of 13 in this section, here 255 feet above the Beaver river, which has no appreciable fall in this distance.

13. The *Homewood Sandstone* is here enormously thick, as above described. It is a coarse whitish sandstone, as a whole. But many of its layers are very conglomeratic, although I could find none of the pebbles larger than hazelnuts. It was probably a sand and gravel bar or beach line in the ancient sea; for it thins away (its top descending) in all directions in which it can now be examined. We have seen the Ferriferous Limestone disappear against its sloping surface up the Beaver toward the north. So, going south, we see the thin edge of the limestone come in again on the southward sloping surface of the Sandstone.

14. Here again we find the little streak of coal which so frequently appears along the Beaver river Valley between this and Homewood furnace.

15. These shales contain so much iron ore that they were drifted in upon for the use of Homewood Furnace.

19. This stratum contains a good deal of iron ore.

13 to 20. All the shales in this interval are dark or blackish. I think the interval of 80 feet which comprise them corresponds to the "black slate" interval (from 778 down) in the record of the Boyd's Hill well at Pittsburgh.

21. *The Connoquenessing Sandstone* is here seen rising rapidly above water-level, and as we pass up the Beaver we see it extending upwards and cutting down the "Black shale" interval above, from 80 feet at this point, to only 25 at the old furnace.

It is a tolerably coarse, and very hard, white sandstone and is the same rock which we see forming the top wall along the gorge of the Connoquenessing between its mouth and Slippery Rock.

The *Sharon* horizon cannot be less than 70 feet below the river level here; for the *Freeport Upper Coal* at Homewood Station is 485 feet above it. The interval between the two would be approximately 550 feet.

*Section 17.**

At Economy Gas Well No. 3.

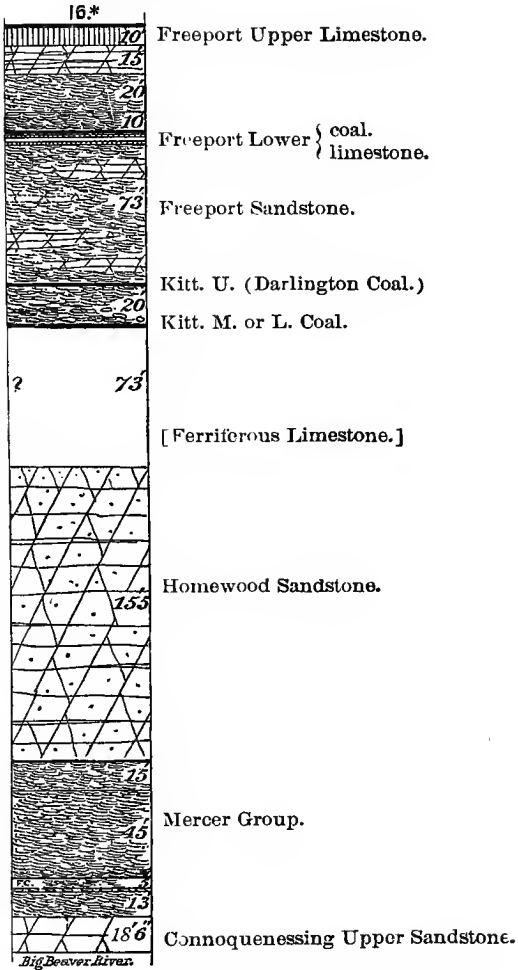
18½ miles below the mouth of the Mahoning.

Passing Homewood Station the strata begins to dip south at the rate of 25' to 30' per mile. About 3½ miles below Sec. 16* the base of the *Homewood Sandstone* nearly reaches river level, and then (half a mile below the mouth of Bennett's run) we get the following section, by combining surface exposures with the record of the Economy gas well No. 3, originally bored to a depth of 925', where not much oil, but a great flow of gas and salt water came from the bottom rock (16) of the section.†

1. <i>Dartington Coal</i> ,	1' 8"
2. Fireclay,	5'
3. <i>Ore-bearing shales, sandy</i> ,	30'
4. <i>Kittanning Coal</i> ,	2' 4"
5. Fireclay,	10
6. Sandstones and sandy shales,	70'
7. <i>Ferriferous Limestone</i> ,	1' 6"
8. Shales, fossiliferous, dark,	12'
9. <i>Homewood Sandstone</i> , massive, conglomeratic; well mouth 18 above its base,	95'

† The Economy Society lately obtained control of the well in order to convey the gas to their cutlery works, at Beaver Falls, two and a half miles below. The well was then reamed out by Mr. J. W. Ramsey, (who has charge of the deep boring at Beaver Falls) down below the base of 16, to ease off the salt water which interfered with the gas pipes. At my request Mr. Ramsey kindly bottled a sample from each stratum passed through, and labelled its thickness. The record may be considered reliable, as Mr. R. is a careful and pains-taking driller, and takes pride in keeping a correct record of his work.

Homewood Station
15 m. below the mouth
of the Mahoning river.



10.	<i>Ore-bearing shale, sandy, dark; level of Beaver river,</i>	7'
11.	<i>Mercer shales, sandy, dark,</i>	108'
12.	269' 6" <i>Connoquenessing Sandstone, white, hard, massive,</i>	46'
13.	313' 6" <i>Sharon? Shales,</i>	44'
14.	337' 6" <i>Sharon? Conglomerate, brownish, white, hard,</i>	24'
15.	<i>Shales, with streaks of sandstone,</i>	286'
16.	<i>Pebbly sandstone, white, massive, with much salt water,</i>	102'
17.	<i>Blue shale to the bottom of reaming,</i>	5'
		<hr/>
		849' 6"
		<hr/>

The *Freeport Upper Coal* is seen in the hills above, back from the river.

The *Darlington* (1) and *Kittanning* (2) *Coals* have frequently been opened between here and Homewood, so that there is no difficulty in following their outcrops.

The *Kittanning* moreover is characterized by its usual heavy bed of pure *fireclay*.

7. The *Ferriferous limestone* here comes again into the section, after having thinned entirely away on the hump of *Homewood Sandstone*.

It is here only $1\frac{1}{2}$ feet thick, somewhat earthy, and has the "cone-in-cone" structure, so characteristic of it when thin. It is somewhat fossiliferous, and the shales immediately below it are crowded with the organic remains always found in connection with this limestone.

9. The *Homewood Sandstone* makes massive cliffs on both sides of the river, all the way from Homewood Station down to our section; but diminishing from 155 to 95 feet, having thinned away 60 feet in the $3\frac{1}{2}$ miles. The reduction seems to have taken place both from the top and bottom of the rock; for its top at Homewood Station is 73 and its base 228 feet below the *Kittanning Coal*; here the top and bottom of the rock come 94 and 189 feet respectively below the same coal.

10, 11. That the base has lost, as well as the top, may explain why the dark shaly interval, under it, has increased from 80 feet in Sec. 16,* to 115 feet here.

12. The *Connoquenessing Sandstone* lies 304 feet beneath

the *Kittanning Coal*, here ; 308 feet, at Homewood Station. And this co-incidence is in spite of all the irregularities of the several intervening rocks.

13. The Sharon coal in Secs. 3*, 4*, and 13* (combined with 14*) underlies the *top* of the *Ferriferous* 308', 278'±, and 283'±, respectively ; and in this section (17*) 300' to 318' ; provided it be placed in the lower 13 feet of this shale interval.

15. This mass of bluish sandy and argillaceous shales, with frequent interpolations of hard grits a few feet thick, contains no massive sandstone, and probably represents the *Cuyahoga* formation of Ohio.

16. Fragments of a grayish white conglomerate, and quartz pebbles half an inch thick, were here pumped up. A constant stream of salt water, amounting to several hundred barrels per day, flows from this conglomerate ; with gas, and a show of oil. I consider it the oil sand of the Smith's Ferry region. But if it be the great 1,588 foot salt water rock of the Boyd's Hill well at Pittsburgh, then, the 858 feet over it to the top of XII (top of *Homewood Sandstone*) has diminished north westward to 604 feet in our section.

Section 18.

At Beaver Falls.

Economy Gas Well No. 2.

21 miles below the mouth of the Mahoning.

Passing on from the last section down the valley of the Beaver two and a half miles to Beaver Falls, the side hills become high and abrupt, exposing to view *in detail* the whole Lower Productive Coal Measures, as shown from No. 1 to No. 21 of the following section :

Its lower part is a record of well boring No. 2, commenced May, 1876, by the Economite brethren, near their Cutlery Works at Beaver Falls, and now (July, 1877) 2300 feet deep.

Realizing the importance of a correct record of a well to be drilled to so great a depth, I talked to Mr. J. W. Ramsey, the superintendent of the drilling, and found him perfectly willing and anxious to aid in its accomplishment; so bottles were procured, and Mr. R. instructed to examine carefully the drillings and reamings brought up by the sand pump, and whenever a change of rock was noted, to bottle a sample and attach a label with its thickness and the depth at which it was struck. This Mr. R. has very kindly and generously done at the expense of much care and trouble to himself. The bottles are now about 50 in number. I visited the well two or three times every week until the boring had passed below No. 28 of the section, and personally examined the different strata passed through from the piles of reamings that were brought up from the monster hole, one foot in diameter, which was put down 557 feet, so that the section as represented in No. 18, may be considered as nearly accurate as it is possible to attain by this method of drilling.

<i>Mahoning Sandstone</i> ,	40'	40'
<i>Freeport Upper Coal</i> ,	4'	
Fire clay,	2' 6"	
<i>Freeport Upper Limestone</i> ,	3'	
Shales sandy,	35'	
<i>Freeport Upper (Butler) Sandstone</i> ,	30'	
<i>Freeport Lower Coal</i> ,	1' 4"	
Freeport Lower Shales and Sands,	78'	
<i>Darlington Coal</i> ,	1' 8"	
Ore bearing Shales,	35'	
<i>Kittanning Coal</i> ,	2' 8"	
Fire clay,	12'	
Shales and Sands,	70'	
		275' 2"
<i>Ferriferous Limestone</i> ,	2'	
Shales, fossiliferous, dark,	8'	
Sandstone,	17'	
<i>Clarion Coal</i> ,	1'	
Sands and Shales,	50'	
<i>Brookville Coal</i> ,	0 6"	
Fire clay,	4'	
[Well mouth here.]		
<i>Homewood Sandstone, massive</i> ,	56'	

One of the <i>Mercer Coals</i> ,	0' 8"	}	112' 8"
Sandstone fine grained,	10'		
<i>Mercer Black Slate</i> ,	25'		
Shales, dark sandy,	15'		
<i>Mercer Calcareous iron ore</i> ,	2'		
Shales, soft, argillaceous,	10'		
Shales, hard and soft,	50'		
<i>Conn. L. SS.</i> { hard, white,	35'	}	41'
{ Conglomerate,	6'		
<i>Sharon?</i> shales (no coal recorded,)	40'		—
			332' 2"
Shales,	24'		
<i>Sharon?</i> Conglomerate, pebbly,	26'		
Shale, dark sandy,	40'	}	237'
Sandstone, pebbly,	5'		
Shale, sandy bluish,	85'		
Sandstone, fine (1st gas flow,)	40'		
Shale sandy dark,	12'		
Shale or fine sand (2d gas flow,)	5'		
Shale, dark sandy,	25'		
Shale, brown sandy,	18'		
Shales, soft, argillaceous,	7'		
Sandstone, pebbly, white,	157'		444'
Heavy flow of gas at,	557'		
More gas at,	571'		
Gas and salt water,	690'		
Soft measures for the next			356'
Sandstone hard white quartz ore,			30'
			1477' 4"

Well No. 2 starts immediately on top of the *Homewood Sandstone*, and in going through it shows that it has continued to lose thickness, southward, for it is here only 56 feet thick, and the top is here 355 feet below the base of the *Mahoning Sandstone*.

In the Boyd's Hill well record at Pittsburgh it is called 59 feet thick, and 379 feet beneath the *Mahoning Sandstone*.

At Homewood Station (six miles north) its top is 72 feet beneath the *Kittanning Coal*. Here 164 feet.

Here again a small coal bed at its base was bored through.

The rest of the record of boring No. 2 agrees very closely with that of No. 3, Sec. 17.*

The *Mercer* interval in Well No. 2 measures 12; in Well No. 3, 115 feet.

The *Connoquenessing Sandstone* has about the same thickness in both wells.

The *Sharon* shale interval also has about the same thickness in both wells; and the horizon of the *Sharon Coal* would be between 300' and 332' below the *Ferriferous Limestone*, as in the sections along the Mahoning Valley given above.

The Conglomerate sandstone at the bottom of this section (the same sandstone as at the bottom of Sec. 17*) has here the great thickness of 124, even if the upper 33' of the 157' in the section be carried to the division above. It is a very pebbly, coarse, bluish or grayish white rock, charged with gas and salt water, and represents, I think, the 1588 foot conglomerate at Pittsburgh; for, the next massive rock was not struck until 356 feet of soft measures† had been passed through, when the bit went through 30 feet of a very hard white quartzose sandstone.

From Beaver Falls down, four and a half miles, to the mouth of the Beaver river, it is plain sailing; for the *Kit-tanning coal*, with its great underlying bed of fireclay, is worked in a continuous line; and the whole series, both above and below it, is exposed at numerous points along the ravines which fringe the Beaver valley. The southward dip continues; and the *Ferriferous limestone*, which is seen to be thickening up southward, gets below the level of the Ohio river on its southern shore opposite the mouth of Beaver. It is frequently seen, 60 to 80 feet below the *Kit-tanning coal*, between Beaver Falls and the Ohio river.

*Section 19.**

South bank of the Ohio River.

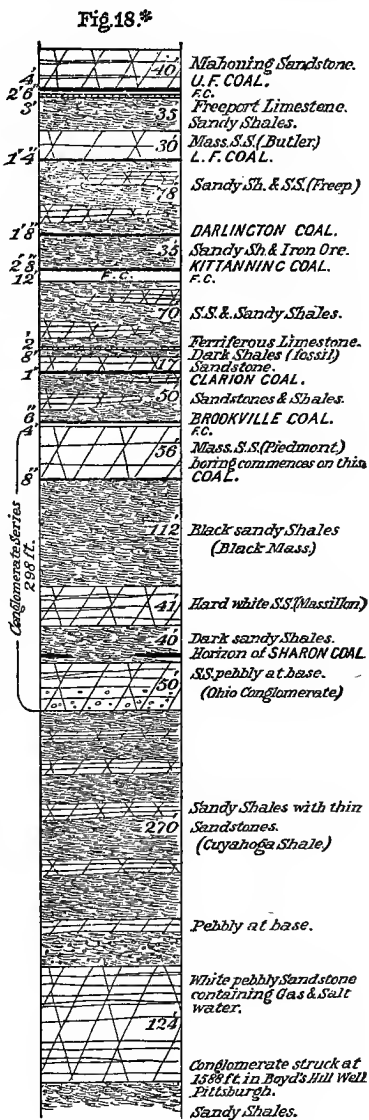
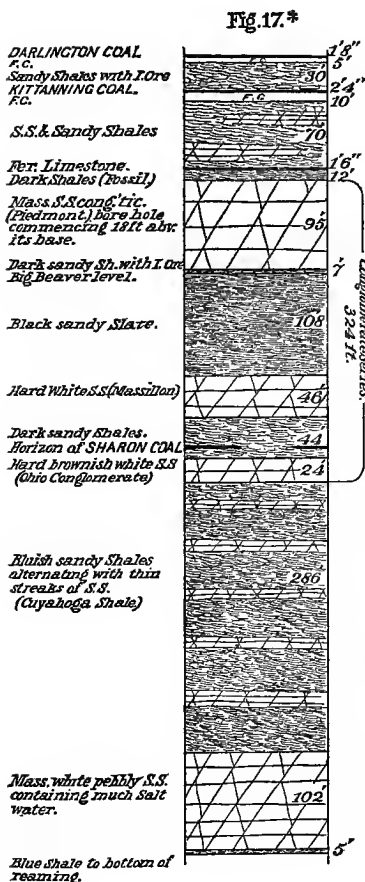
Half a mile below the mouth of Beaver.

One half mile below the mouth of the Beaver a steep cliff

† These are apparently Mr. Carll's *Crawford Shales* overlying the Oil Sand Group of the Venango-Butler Belt.—J. P. L.

Fig. 17. Section seen on the left bank of the Big Beaver 3½ miles below Homewood, combined with the record of Economy Well No 3.

Fig. 18. Section seen at Beaver Falls, combined with record of the boring at the Economy Well, No 2, near the Cutlery Works.



on the southern bank of the Ohio affords the following section; the *Ferriferous* Limestone being just below water level, and, according to Prof. Rogers, visible in the river bed at low water mark.

1. <i>Mahoning</i> { Sandstone at top,	{ 75'
{ Massive, conglomerate below,	
2. Shales, sandy,	6'
3. <i>Freeport Upper Coal</i> ,	2' 6''
4. Fireclay,	4'
5. <i>Freeport Upper Limestone</i> ,	2'
6. Shales, sandy,	55'
7. <i>Freeport Lower Coal</i> ,	1'
8. Shales, sandy,	12'
9. <i>Freeport Sandstone</i> , massive,	75'
10. <i>Darlington Coal</i> ,	10'
11. Fireclay,	3'
12. Shales, sandy, dark,	40'
13. <i>Kittanning Coal</i> ,	2' 6''
14. Fireclay,	8'
15. Sandstone, flaggy,	40'
16. Concealed to Ohio river level,	10'
	336' 10''

From the mouth of the Beaver river to the Ohio line, the Ohio river flows along the strike of the rocks, southwest, and we get the succession exhibited in Sec. 19 all the time. The *Mahoning Sandstone* is continually seen capping the hills. The *Kittanning coal*, with its very thick underclay, is never less than 40 feet, nor more than 100, above the Ohio; and splendid exposures along the steep bluffs of the river are too numerous to admit of any mistake.

One of these is given below. It was made at Tygart's limestone quarry on the north bank, half a mile below Vanport, and two and a half miles below the mouth of the Beaver river.

Section 20.*

On the Ohio River; Tygart's Quarry.

Three miles below the mouth of Beaver.

1. <i>Freeport Sandstone</i> , massive,	60'
2. Shales, sandy,	10'
3. <i>Darlington Coal</i> ,	1' 6''

4. Ore-bearing shales, sandy,	35'
5. <i>Kittanning Coal</i> ,	2' 6"
6. Fireclay,	11'
7. Sandstones and shales, sandy,	45'
8. Buhrstone ore,	0' to 2'
9. <i>Ferriferous Limestone</i> , Tygart's quarry,	18'
10. Concealed to Ohio river level,	35'
	220'

9. The *Ferriferous Limestone*, when above the level of the Ohio, between the mouth of the Beaver and the Ohio State line, is nearly always concealed by the Terrace deposits; but here, at Vanport, Two-mile run puts into the Ohio and exposes the limestone, and it has been extensively quarried for a long time.

It varies in thickness at the different quarries from 12 to 18 feet, being thickest at Tygart's quarry, where it is always separated into two benches by a parting of shale 6 to 12 inches thick, which comes in above its middle line.

No one who has carefully compared this limestone with the one capping the hills at Lowellville, on the Mahoning (Secs. 1* and 2*), can hesitate as to their identity, even aside from the stratigraphy, which proves incontestably that they are one and the same rock; for the two rocks are as much alike in every respect as two eggs; both are filled with the same organic remains, and have a similar structure, color, and fracture. If two car loads of the rock from the two localities were placed in conjunction they could not be distinguished.

But the section itself shows that this is the *Ferriferous Limestone*; for above it we find the *Kittanning coal* (5) with its great bed of fireclay, here manufactured into firebricks. Above this, in proper succession, come the *Darlington coal*; the *Freeport sandstone*; far up the hill, the *Freeport Upper Coal*, with its underlying *limestone*; and capping all the *Mahoning sandstone*, and then the *Barren Measures*.

Below the Vanport quarries the *Ferriferous limestone* is again covered up by the Terraces, and we see nothing more of it until we come to the vicinity of Industry, 6 miles below; though the rest of the section above it is well exposed all the time. Just above Industry, the Ohio washes its southern shore, and has entirely removed the Terrace deposits, once more revealing the *Ferriferous limestone* in the following section, a part of which was obtained from the north bank at Industry, and the rest of it from the south bank, half a mile above the village.

*Section 21.**

On the Ohio; at Industry.

Nine miles below the mouth of Beaver.

1. Mahoning Sandstone, massive,	70'
2. Shales,	5'
3. <i>Freeport Upper Coal</i> ,	3'
4. Shales, sandy and sandstones,	60'
5. Concealed,	10'
6. <i>Freeport Sandstone, massive</i> ,	100'
7. <i>Darlington Coal</i> ,	1' 6"
8. Shales,	30'
9. <i>Kittanning Coal</i> ,	3'
10. Fireclay,	8'
11. Sandstone, somewhat massive,	50'
12. Buhrstone iron ore,	6"
13. <i>Ferriferous Limestone</i> ,	15'
Shales, sandy to Ohio river,	10'
	366'
	366'

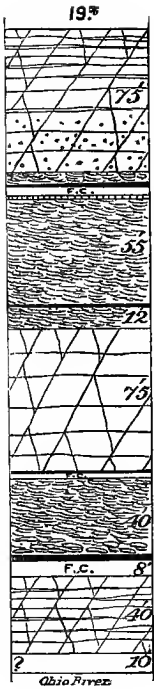
The section speaks for itself.

1, 6. The *Mahoning* and *Freeport Sandstones* are here very thick.

3, 9. The *Upper Freeport* and *Kittanning Coals*, have both been mined at this locality.

13. The *Ferriferous Limestone* has been extensively quarried, and shipped to Pittsburgh, and other points as a flux for iron ores.

It has its usual facies when thick, and is crowded with fossils of the same species as at Lowell, and all along the

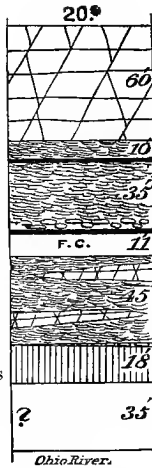


Freeport Group.

Freeport.

Kittanning

Ferriferous

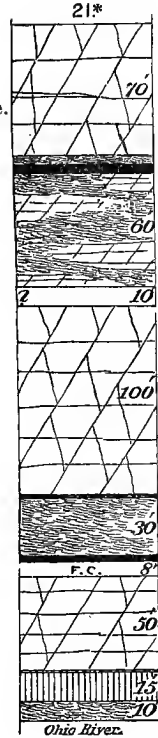


Sandstone.

Group.

Limestone

3 m. below mouth
of Beaver River.



Mahoning Sandstone.

Industry,
9 m. below mouth
of Beaver River.

1/4 m. below mouth
of Beaver Riv.

Mahoning and Beaver rivers ; for a list of which see page Q 62, where this stratum is fully described.

The sudden and rapid variations which the *Ferriferous Limestone* often undergoes, is here well illustrated. At the quarry, we see it 15 feet thick, only a few thin partings of shale separating the different layers. As we follow it along the steep bluff of the river, all the time perfectly exposed, we see the layers become arenaceous and shaly. In 400 yards it has entirely disappeared, except an impure layer at the top six inches thick, exhibiting the *cone-in-cone* structure. There can be no mistake about the change, for the exposure is perfect between the two points, and the limestone is *seen* graduating into and being replaced by sandy shales.

The Ohio river after passing Industry, bends to the south and the *Ferriferous Limestone* sinks below water-level for some distance. But the river returning to the north-west, about half way between Industry and the Ohio line, the *Ferriferous Limestone* rises again above water-level, although the terraces conceal it at every point until we come to the mouth of the Little Beaver, five miles below Industry.

The entire section of the Lower Productive Coal Measures, however, overlying the limestone is frequently exposed along these five miles, and there is not the least difficulty in tracing the strata from the one point to the other.

*Section 22.**

On the Ohio ; three miles below Industry.

Twelve miles below the mouth of Beaver.

The following section, made about midway between Industry and the mouth of Little Beaver,—shows us the same structure which we have hitherto seen along the Ohio, and it might be duplicated in all its main features at fifty different points in the 15 miles down to the State line.

Its exact locality is on the south bank of the river, three

quarters of a mile below Shipping Port, and two miles below Smith's Ferry.

1.	Mahoning Sandstone,	visible,	30'
2.	Shale,		1'
3.	Freeport Upper Coal,		3' 2"
4.	Fireclay,		3'
5.	Shales, sandy,		5'
6.	Freeport Upper Limestone,		2'
7.	Shales, soft and hard,		60'
8.	Freeport Lower Coal; streaks of coal and bit. shale,		1'
9.	} Freeport, {	Sandstone, massive,	65'
10.		Streak of Coal,	—
11.		Sandy shales,	25'
12.		Sandstone,	20'
13.	Darlington Coal,		1' 2"
14.	Fireclay, (not 25' as in the cut,) 5'		5'
15.	Shales, sandy,		25'
16.	Kittanning Coal,		2'
17.	Fireclay,		10'
18.	Concealed to level of the river,		40'
			298' 4"

Section 23.*

At the mouth of Little Beaver River.

Fourteen miles below the mouth of Beaver.

By the north-west course of the Ohio river, against the south-east dip, the *Ferriferous Limestone* here lies 40 feet above the water level, as shown by the following section, made in the east bank of the Little Beaver, just above the Cleveland and Pittsburgh Railroad bridge, and therefore not far from the place of Dr. Newberry's Sec. 2, Chart 3, Vol. I, Ohio Geology, with which it agrees quite closely.

1.	Mahoning Sandstone,	visible	30'
2.	Concealed,		10'
3.	Shales, sandy,		35'
4.	Ore bearing Shales, dark, bituminous,		3'
5.	Freeport Lower Coal, thin, impure,		10"
6.	Shales, sandy,		20'
7.	Freeport Sandstone, massive,		50'
8.	Shales, sandy,		15'
9.	Coal (local,)		1'
10.	Shales, sandy,		20'
11.	Darlington Coal,		2'
12.	Fireclay,		5'

13. Ore bearing Shales, dark,	15'
14. <i>Kittanning Coal</i> ,	2' 6"
15. Fireclay,	10'
16. Shales, sandy, and sandstones,	50'
17. <i>Ferriferous Limestone</i> , impure, earthy, and fossiliferous,	1'
18. Shales, sandy, bluish,	8'
19. <i>Clarion bituminous shale</i> , with ore at top,	5'
20. Sandstone,	15'
21. Shale, sandy; at bottom of which lies (<i>Brookville?</i>) bituminous shale in bed of Little Beaver river,	10'
22. <i>Homewood Sandstone</i> , massive, rising from bed of Little Beaver river.	

308' 4"

1. The *Mahoning Sandstone*, is well developed at the point of section, and very conglomerate. Its top was not seen here.

2. The *Freeport Upper Coal* which should come in concealed interval 2, is seen at this horizon only one mile above, and also immediately opposite this on the south bank of the Ohio river, 4 feet thick.

5. The *The Freeport Lower Coal* is thin and impure, as usual.

9. Is an impure local streak of coal; not seen at this immediate point; but at Smith's Ferry, a short distance above, where the shale interval between the *Freeport Sandstone* and *Darlington Coal* is fully exposed.

11. The *Darlington Coal*, of which a full account is given in Report Q, is a very pure coal in this vicinity and extensively mined for local supply. It is identified by Dr. Newberry and Mr. Newton in their section from this locality (previously referred to) as Coal No. 4 of the Ohio system.

14. The *Kittanning Coal* is identified in the same section as the Ohio coal No. 3.

17. The *Ferriferous Limestone*, which is shown in their section, but not identified, is somewhat impure and earthy, and has the *cone-in-cone* structure, so common to it when thin. It is fossiliferous, and in it were seen at this locality *Spirifer cameratus*, *Productus longispinus*, and *Chonetes mesoloba*.

In tracing this rock from the Mahoning valley down the Mahoning and Beaver valleys into the valley of the Ohio, I have been enabled to hold on to it by means of the characteristic *Mercer Limestones* below it until the entire Lower Productive Coal Series, represented by the *Kittanning*, *Darlington*, and *Freeport Lower and Upper Coals*, had come into the hills above it to bear witness to its identity. From that point, as the sections show, the Coal Series are fully exposed above it all the way around to the State line on the Ohio. The limestone itself is in nearly every section at its proper interval (50 to 75 feet) below the *Kittanning Coal* and *fireclay*, both worked in a continuous line. These are of themselves a sufficiently trustworthy guide; but they become infallible when checked and supplemented by all the other overlying members of the series, and by the *limestone itself* below. Nothing in geology then can be more certainly established than that 1. the *Lowellville Limestone* is the *Ferriferous Limestone* of the Pennsylvania geologists; and that 2. it is identical with the small limestone (17) of our section at the mouth of the Little Beaver.

The importance of this now well established *Ferriferous Limestone horizon* is evident; for it follows that

19. The five feet of bituminous shale not far beneath it, must be the representative of the *Clarion Coal*; and

21. The bituminous shale in the bed of the Little Beaver must in like manner represent the *Brookville Coal*; and

22. The *Homewood Sandstone* must be the hard rock which floors the stream, a little way above the bridge, and rising faster than the water level, soon edges the banks with layers of coarse, hard, white sandstone, and throws a dam across the river over which the water has a rapid fall, wearing out deep trenches in the softer portions and leaving the harder standing up in ridges.

*Section 24.***On the Little Beaver River.**Two and a half miles up.*

Ascending the Little Beaver the top of the *Homewood Sandstone* is constantly exposed, slowly rising on the sides, until, near the mouth of Island Run, a steep bluff on the east bank gives the following section :

1. <i>Mahoning Sandstone</i> , massive, conglomeratic.	
2. <i>Freeport Upper Coal</i> , irregular,	0' to 6''
3. <i>Freeport Upper Limestone</i> and firelay,	2'
4. Shales, sandy, dark,	35'
5. <i>Bituminous shale</i> ,	10'
6. <i>Freeport Lower Coal</i> ,	1'
7. Fireclay and shales, sandy,	6'
8. <i>Freeport Lower (Butler) Limestone</i> ,	3'
9. <i>Freeport Sandstone</i> and sandy shales,	70'
10. Shales, dark, with well preserved <i>plants</i> ,	5'
11. <i>Darlington Coal</i> ,	1' 6''
12. Concealed,	25'
13. <i>Kittanning Coal</i> ,	2'
14. Concealed,	100'
15. <i>Homewood Sandstone</i> , in Little Beaver,	10'
	<hr style="width: 100%; border: none; border-top: 1px solid black; margin-bottom: 2px;"/> <u>271'</u> <hr style="width: 100%; border: none; border-top: 1px solid black; margin-top: 2px;"/>

3. The *Freeport Upper Limestone* is only seen here in nodular masses embedded in fireclay.

8. The *Freeport Lower Limestone* is much brecciated and very hard.

11. The *Darlington Coal* is opened here, and its fine grained roof shales hold splendidly preserved plants.

13. The *Kittanning Coal* is also opened here, ten feet above the top of the *Homewood Sandstone* (15) reported 35 to 40 feet thick in the oil wells.

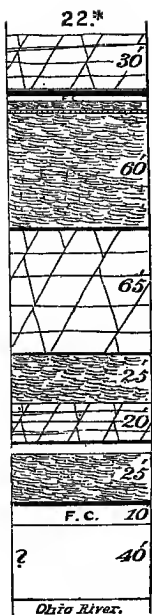
The oil obtained from the neighboring wells comes from a rock about 700 feet beneath the *Kittanning Coal*. This corresponds to the 124 foot rock in the Beaver River Falls boring (Sec. 18*).

The drillers report that at 250 feet (from the top of the *Homewood Sandstone*) they pass through their "Glass Sand," a very hard white rock. †

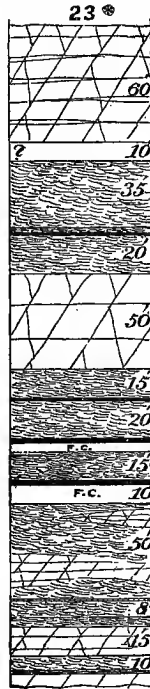
Then they have easy drilling for 300 feet. ‡

† Sharon Conglomerate?—J. P. L.

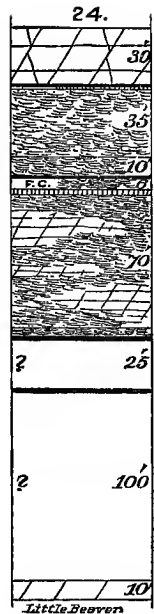
‡ Crawford Shales?—J. P. L.



12 m. below
mouth of
Beaver River.



Mouth of
Little Beaver
River,
14 m. below
mouth of
Beaver River.



2 1/4 m. up
Little Beaver
River.

*Section 25.***On the Little Beaver; 4 miles up.*

The *Homewood Sandstone* lines the river banks with low but massive cliffs, 25 to 30 feet high, from which huge coarse blocks have fallen and choke the channel.

At an old coal mine on the *Kittanning bed* (here split into two benches) the following little section was made; but all the outcrops above and below the coal are covered with debris down to a massive stratum of the *Homewood Sandstone*, 35 feet thick; a very coarse, grayish white rock, in which I could find no pebbles.

1. <i>Kittanning</i>	{	<i>Coal</i> ,	1' 7"	}	3'
		<i>Shale</i> ,	3'		
		<i>Coal</i> ,	1' 2"		
2.	Concealed,	. . . . .			100'
3.	<i>Homewood Sandstone</i> , massive,	. . . . .			35'
4.	Concealed to Little Beaver,	. . . . .			5'
					<u>143'</u>

*Section 26.***On the Little Beaver; 6 miles up.*

Continuing on up the stream the strata maintain their northward rise at a rate about equal to the fall of the creek, so that we have the massive *Homewood Sandstone* always in sight. But two miles above the locality of Sec. 25*, the dip of the rock steepens, and throws the base of that stratum 25 feet above the Little Beaver.

Here, a short distance below the mouth of Bealer's run, and one mile below Fredericktown, we get the following exposure :

1.	<i>Homewood Sandstone</i>,	. . . . .	30'
2.	Concealed,	. . . . .	20'
3.	<i>Mercer Lower Limestone</i> ; blue; fossils,	. . . . .	1'
4.	<i>Mercer Lower Coal</i> ; impure cannel,	. . . . .	1'
5.	Black fissile slate to level of Little Beaver,	. . . . .	5'
			<u>57'</u>

This is the first locality on the Little Beaver at which we have seen any exposure below the *Homewood Sandstone*. Although the rock is constantly in sight, from the mouth of the stream to this point, it comes so close to water-level that its base is nearly always below the same, or else concealed by its own talus.

Now however we find again the *Mercer* group beneath it, with at least one of its characteristic limestones.

This is gratifying enough; for it is an additional proof that we have not lost our hold on the general section.

3. This *Mercer (Lower?) Limestone* has here much the same appearance as along the Big Beaver and Mahoning rivers, being a dark bluish, very compact rock, often a perfect mass of fossils, among which were seen *Athyris subtilita*, *Spirifer cameratus*, *Productus longispinus*, multitudes of *Crinoidal* fragments, and a beautiful *Bryozoan*.

4. Immediately under the limestone comes a very bituminous shale, 1 foot thick, which has a *cannel*-like structure, and which graduates down into a black fissile slate extending to the bottom of the stream.

The *Homewood sandstone* (1) forms a wall-like cliff along the stream at this point, over the outcrop of the limestone.

Section 27.*

On the Little Beaver; $6\frac{1}{4}$ miles up.

A short distance above the mouth of Bealer's run, and three quarters of a mile below Fredericktown, a little stream plunges down the steep left bank of the Little Beaver, and gives us the following fine exposure:

1.	Freeport Sandstone, massive,	80'	
2.	Ball ore shales, dark,	9'	
3.	{	Cannel, 6''	} 2' 5''
		Parting, 1''	
		Coal, 1' 10''	
4.	Fireclay,	13' 6''	
5.	Sandstone and shales, sandy,	28' 6''	
6.	Concealed,	25	
7.	<i>Ferriferous L.</i> represented by <i>Iron ore</i> ,	3''	

8.	Sandstone shaly,	25'
9.	Fireclay,	4'
10.	<i>Homewood Sandstone</i> ,	25'
11. 54'	<i>Coaly shales</i> ,	8'
12.	Sandstone, cherty,	10''
13.	} 66' 4'' <i>Mercer Middle?</i> {	Fireclay, 3' 6''
14.		Coal, 1'
15.		Fireclay, 6'
16.	Ore-bearing shales, sandy,	18'
17.	Concealed,	12'
18. 103' 4''	<i>Mercer Lower Limestone</i> , blue, fossiliferous,	1'
		263'

1. The *Freeport sandstone* is here unusually thick and the current which deposited it tore up and washed away not only the underlying *Darlington coal*, but also the larger part of the ferriferous shale separating it from the *Kittanning Coal*; and the evidence of this is seen in the lowest layers of the sandstone, which is a conglomerate mass of nodules of iron ore, pieces of shale, and fragments of coal.

The sandstone is probably 100 feet thick, as we see 80 feet of it, and its top is not then reached. It is very massive; and the stream makes a vertical plunge of 60 feet over its lower half.

The very hard blue siliceous layer which is so characteristic of this rock in southern Beaver and along the Ohio river, is here seen about 50 feet above its base, polished perfectly smooth by the stream.

3. The *Kittanning coal* has a layer of impure cannel at its top; the rest a very bright, pure looking coal.

4. The immense bed of fireclay which is so characteristic of this coal all along the Beaver, Ohio, and Little Beaver rivers is here a very pure clay $13\frac{1}{2}$ feet thick.

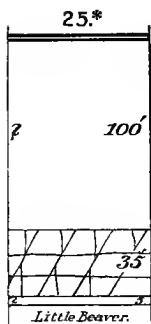
7. The *Ferriferous limestone* has here again disappeared from this section, but is represented by a little stratum of iron ore. As we follow the outcrops on up the Little Beaver the limestone comes in again at its proper horizon.

9. The Clarion and Brookville coals have no representatives whatever in the section, unless the fireclay which rests immediately upon the *Homewood Sandstone* is the underclay of one of them, perhaps the Brookville.

4 m. up
Little Beaver
River.

6 m. up
Little Beaver
River.

6 1/2 m. up
Little Beaver
River.



Kittanning Coal.

Homewood

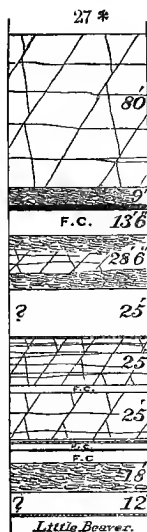
26.*

Sandstone.

Mercer Lower



Limestone.



Freeport Sandstone.

27 *

80'

F.C. 136'

286'

25'

25'

25'

78'

12'

Little Beaver.

10. The *Homewood Sandstone* which has kept in sight all along the river up to this point is here quite massive and makes a cliff.

11. Here the *Mercer Group* commences

12. The *Mercer Upper Limestone* is perhaps represented by this chert.

14. A small bed of tolerably pure coal comes in here between two beds of fireclay, and represents the coal often seen immediately below the *Mercer Upper Limestone* along the Mahoning and Beaver rivers, where we also often see a large bed of fireclay.

18. The *Mercer Lower Limestone* in the river bed is rather siliceous, and furnished hydraulic cement for the Beaver and Sandy Canal locks.

*Section 28.**

At Fredericktown.

On the Little Beaver; 7 miles up.

From the last section the rocks rise rapidly and we get still lower measures, exposed on the road from Fredericktown to the State line, at the bottom of the following section:

1. <i>Mahoning Sandstone</i> , massive pebbly,	35'
2. Shales and fire clay,	5'
3. <i>Freeport Upper Limestone</i> (<i>White Limestone</i>),	3'
4. Ochery Shales,	40'
5. <i>Bituminous Shales</i> , [<i>Freeport L. C.</i> ,]	10' to 15'
6. Frequent outcrops of massive Sandstone,	100'
7. Ore bearing shales, dark,	10'
8. <i>Kittanning Coal</i> ,	2' 6''
9. Concealed,	135'
10. <i>Mercer Lower</i> (<i>blue</i>) <i>Limestone</i> ,	8'' to 1'
11. <i>Bituminous Shales</i> ,	4'
12. Sandstone, white, massive, hard,	10
13. <i>Eden Valley Coal</i> ,	0' to 2'
14. Shales, dark, full of <i>plants</i> ,	2' to 5'
15. <i>Connoq. Upper Sandstone</i> , whitish, massive, in the bed of the Little Beaver,	10'

367' 6''

1. The *Mahoning Sandstone* is here so coarse as to account for the absence (by erosion) of the *Freeport Upper Coal*.

3. The *Freeport Upper Limestone* (*White Limestone* of the Ohio Survey) is here tolerably compact and of a light grey color weathering to a light buff. I have already sufficiently proved by the foregoing sections how wrong it would be to identify it with the Limestone at Lowellville.

5. The *Freeport Lower Coal* is here a thick mass of black slate. Several hundred dollars were at one time spent in drifting on it, near here, for cannel coal. It was supposed to be the Darlington cannel, but the horizon of that is nearly 100 feet below. Of course, no cannel was obtained.

9. The dip will increase this interval by several feet.

10. The *Mercer Lower Limestone*, blue and fossiliferous, (the same as the lowest bed of the last section,) is exposed near the dam above Fredericktown, and is called by the people the *Button Rock*, because its surfaces are studded with *enocrinal joints*.

13. This *Lower Mercer*, irregular, brilliant and tolerably pure little *coal bed* is often cut away by the overlying Sandstone, thickening up again to 2 feet, and even mined for local use in the cement kilns.

14. *Cordaites* are abundant in these shales.

15. The *Connoquenessing Upper Sandstone* here makes rapids in the river, with huge furrows and deep pot holes.

An anticlinal axis here crosses the valley of the Little Beaver river.

The ensuing north dip carries under the lower measures above described, and brings the outcrop of the *Kittanning Coal* slowly nearer to water level, as in the following section :

lineatus, *Athyris subtilita*, *Aviculopecten Whiteii*, and many other species not identified.

12. The shales immediately below this, contain much iron ore in scattered nodules; and this brings us down to a little stratum of coal, (13) which very probably represents the *Clarion*. Neither it nor the calcareous shale (11) are present in Sec. 27, two miles below the present locality.

*Section 30.**

On the Little Beaver North Branch.

Two and a quarter miles above Fredericktown.

One mile further up the North Branch than the last section, a steep ravine in the east bank, gave the following succession:

1. <i>Freeport Sandstone</i> , massive,	60'
2. <i>Darlington Coal</i> ; streaks.	
3. Ore-bearing shales, dark, sandy,	20'
4. <i>Kittanning Coal</i> ,	2'
5. Fireclay, very pure,	10'
6. Sandstone flaggy and sandy shales,	60'
7. <i>Clarion Coal</i> ,	10''
8. Fireclay, non-plastic, full of <i>stigmarias</i> ,	5'
9. Sandstone, somewhat massive to <i>Little Beaver</i> ,	20'
	177' 10''

1. The *Freeport Sandstone* is here very massive and nothing is seen of the *Darlington Coal* bed but some thin streaks at the base of the sandstone.

3. As all along the Little Beaver.

4. Fully exposed; excellent coal; no copperas; no tendency to disintegration.

The *Ferriferous Limestone* is not even represented here by fossiliferous shales. Nothing could better illustrate its variability, when thin.

8. The *Clarion underclay* is here full of *Stigmaria ficoides*, to which the rootlets† are still attached. The former lie horizontally in the fireclay, while the rootlets go

† Or cylindrical leaves. J. P. L.

off at right angles from them. These rootlets are about $\frac{3}{4}$ inch in diameter at the point of insertion, and taper rapidly to a point 8 to 10 inches from the attachment. They seem to have a slight furrow traversing them longitudinally, and they go off both above and below from the main root, or stem.

Section 31.*

On the Little Beaver North Branch.

Five miles above Fredericktown.

On a small stream entering the east bank of the North Branch two and a half miles above the last section and two miles below Achortown, we get the following section :

1. <i>Buffalo Sandstone</i> ; conglomerate, massive,	20'
2. <i>Brush Creek?</i> (<i>Three Foot</i>) <i>Coal</i> , (No. 7, Ohio,) . . . ?	?
3. Concealed,	20'
4. <i>Mahoning Sandstone</i> , flaggy,	15'
5. Ore bearing shales, dark, sandy,	20'
6. <i>Freeport Upper Coal</i> ,	2'
7. Fireclay and shales,	5'
8. <i>Freeport Upper Limestone</i> ,	4'
9. Fireclay, with large balls of iron ore,	5'
10. Shales, sandy,	40'
11. Bituminous shale,	9'
12. <i>Freeport Lower Coal</i> ,	6'
13. Shales, sandy,	10'
14. <i>Freeport Sandstone</i> ; flaggy at top, very massive below,	70'
15. Ore bearing shales, dark,	25'
16. <i>Kittanning Coal</i> ,	2'
17. Fireclay,	11'
18. Sandstones and shales, sandy,	55'
19. <i>Ferriferous Limestone</i> , represented by black fissile shales, richly fossiliferous, with ore balls,	10'
20. Concealed to Little Beaver,	5'
	328' 6''

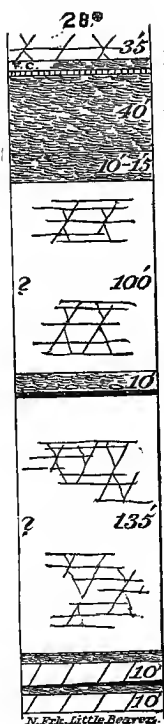
1. The *Buffalo Sandstone*, or Middle member of the great Mahoning mass, surrounds the hill top with a cliff-like ledge of massive conglomerate rocks; while huge pieces lie scattered down the slopes.

2. Immediately below it a coal was once opened, but the

Frederick,
7 m. up
Little Beaver.

8½ m. up
Little Beaver.

9½ m. up
Little Beaver.

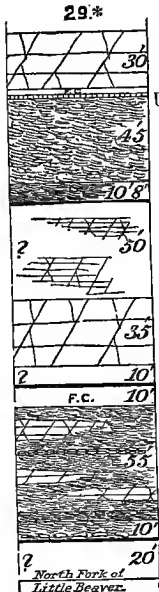


Mahoning

Freeport

Kittanning

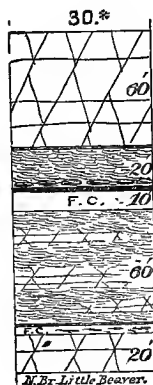
Mercer Lower Limestone.



Sandstone.

Upper Limestone.

Coal.



entry has now caved in, and the bed cannot be seen. I was told, however, that the coal is 2½ feet thick, and very good. This is the "Three foot" vein of Columbiana, and Western Beaver cos., and identified in this region by Dr. Newberry as his coal No. 7, and doubtfully referred by myself to the "Brush Creek" coal. But if the rock over it be the *Buffalo Sandstone* there can be no doubt about the correctness of this identification.

6. The *Freeport Upper Coal* appears again in its place in this section, over its Limestone (8) and has a very pure looking outcrop in the ravine.

12. The *Freeport Lower Coal* holds its place; but its roof shales are here more sandy.

14. The *Freeport Sandstone* is here very massive in its lower half, and still keeps out the *Darlington coal*.

16. The *Kittanning* is mined here; bright, resinous and showing very little pyrites.

19. The *Ferriferous Limestone* is here represented by a black fissile, and very fossiliferous shale such as we often find immediately below the *Ferriferous limestone* when that stratum is thin. Directly on top of it is a vein of iron ore 3 inches thick; and scattered through the mass are many kidney-shaped nodules.

*Section 32.**

On the Little Beaver North Branch.

Six miles above Fredericktown.

One mile above the last section, and a mile below Acherville, the following succession may be seen in the steep bluff of the east bank of the Little Beaver:

1. <i>Kittanning Coal</i> , smut,	?
2. Fireclay,	10'
3. Sandstone, flaggy, and shales sandy,	50'
4. Ore bearing shales, bluish,	10'
5. <i>Ferriferous Limestone</i> ,	2'
6. Slate, dark, fossiliferous, to level of Little Beaver,	4'
	76'
	76'

This is a very interesting little section, from the fact that

it shows the *Ferriferous limestone* coming into the section again at its proper horizon below the *Kittanning coal*, after having been absent as a limestone from every section between here and Fredericktown, and indeed this is the first time we have seen it as a proper *limestone* since leaving the mouth of Little Beaver.

It comes in immediately on top of the black fissile slate which we saw in section 31*, one mile below; and is a hard and somewhat earthy limestone, showing the *cone-in-cone* structure and containing some fossils; but not near so many as the black slate immediately under it.

It is constantly in sight for half a mile from here up to the mouth of Brush run, running along at from 2 to 4 feet above the creek level, and varying greatly in thickness; sometimes thickening up to 2½ feet, and again thinning away to 6 inches.

Following up the Little Beaver North Branch from the last section, soon carries us back across the State line into Pennsylvania, just above the mouth of Bull creek; and so on to Cannelton, three miles further.

There is no difficulty in keeping the section; for although exposures are not numerous, there is a succession of entries on the *Kittanning coal* bed

At Cannelton, the *Darlington Coal* makes a fresh appearance in the section on Mr. Mansfield's land, where its great bed of *cannel* has been long mined; and where the following section was obtained:

*Section 33.**

At Cannelton.

Eleven miles above Fredericktown.

1. Surface debris; (<i>Brush Creek Coal?</i>)	8'
2. <i>Mahoning Sandstone</i> ,	12'
3. <i>Three Foot Coal</i> , (not seen,)	3'
4. <i>Mahoning Sandstone</i> ,	37'
5. Shale,	11'

6. <i>Freeport Upper Coal</i> ,	4'
7. Fire clay,	2' 4"
8. <i>Freeport Lower Coal</i> ,	1' 8
9. Shales, sandy,	58'
10. <i>Freeport Lower Coal</i> represented by Bituminous Shale with streaks of coal,	3'
11. <i>Freeport Sandstone</i> , massive,	63'
12. <i>Darlington</i> , { <i>Cannel</i> , slaty, 0' to 6'	} 21' 6"
{ <i>Cannel</i> , 0' to 12'	
{ <i>Bitum. Coal</i> , 0' to 3' 6'	
13. Shales, sandy; fossil plants,	4'
14. Ore bearing shales, dark,	25'
15. <i>Kittanning—Coal</i> ,	2'
16. Fire clay, visible,	5'
17. Concealed to level of L. Beaver,	38'
	<u>298' 6"</u>

It will be seen at a glance that this is the same section which we have been following up the Little Beaver from its mouth, and that the great bed of cannel comes at the horizon of the coal which we so often find between the *Kittanning coal* and the *Freeport sandstone*, but which has been absent from some of our sections below, having been cut out by the great development of the sandstone.

3 of this section was not seen, but a bench at that horizon indicates a coal, and Mr. Mansfield has placed the "three foot" vein at that horizon in boring, from which this section was partially compiled.

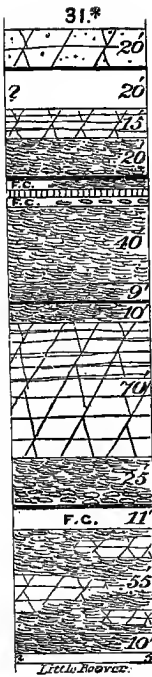
A full account of all these beds is given in Report Q, on the Beaver district, to which the reader is referred.

Section 34.*

At *Darlington*.

Three miles above Canneltown and half a mile south of *Darlington*, are very good exposures of the following measures :

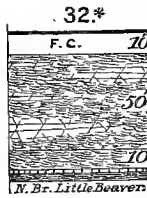
1. Mahoning Sandstone, massive, Visible, 10'
2. *Freeport Upper Coal*, 0' to 2'
3. Fire clay, 1'
4. *Freeport Upper Limestone*, 3'
5. Concealed, 50'
6. *Freeport Lower Coal*, impure, 2' to 3'



Kittanning.

Ferriferous.

12 m. up
Little Beaver.

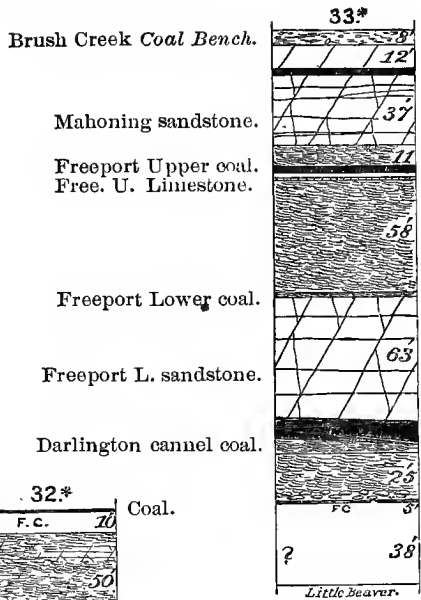


Coal.

Limestone.

12 m. up
Little Beaver.

1 m. below
Achorville.



18 m. up
Little Beaver.

Cannelton.

7.	Concealed,	10'
8.	<i>Freeport Sandstone</i> , massive,	75'
9.	Shales sandy,	5'
10.	<i>Darlington Coal</i> ,	1' 6''
11.	Ore bearing shales, dark,	20'
12.	<i>Kittanning Coal</i> ,	2'
13.	Fire clay,	15'
14.	Concealed to level of L. Beaver,	35'
		282' 6''

We see that the (*Darlington*) *Cannel bed* has vanished, and been replaced by a bituminous coal only 1½ feet thick.

The section explains itself. Both it and the preceding are given only to show the position of the *Darlington coal* in the series, as that bed is found over a wide area and was named from these localities. It is the same bed which occurs on Bull creek in Columbiana county, Ohio.



We return to the mouth of Bull Run, at the Ohio State Line, and ascend Leslie's Run, a branch of Bull Run, towards the north, four miles, to the Prospect Hill Colliery at Palestine, where the following section was obtained :



*Section 35.**

At Palestine. On Leslie's Run.

Four miles above the mouth of Bull Run.

1.	<i>Brush Creek Coal</i> ? gas coal (No. 7. Ohio),	3'
2.	Fireclay and shales,	16'
3.	<i>Mahoning Sandstone</i> , massive,	15'
4.	Shales, sandy,	19'
5.	<i>Freeport Upper Coal</i> , mined,	4'
6.	Fireclay,	2' 6''
7.	<i>Freeport Upper Limestone</i> ,	3'
8.	Shales and sandstone,	50'
9.	<i>Freeport Lower Coal</i> ,	1
10.	Fireclay,	4'
11.	<i>Freeport Lower (Butler) Limestone</i> ,	3' 6''
12.	Freeport shales and sandstone to water in Leslie's run, 70'	
		191'

1. This bed yields an excellent gas coal and is extensively mined by the Prospect Hill Coal Company.

5. This bed is also mined by the same company, whose superintendent gave me the above measurements in their slope between the two coal beds.

The *Mahoning (Lower) Sandstone* is therefore here only 15 feet thick.

9. Exposed along the road down the run.

11. Very ferruginous and impure.

12. The *Freeport sandstones* is here destitute of massive layers, being a mere mass of sandy shales, interstratified with thin flags.

13. The *Darlington Coal* must be from 20 to 40 feet beneath the run.

The *Kittanning Coal* and Ferriferous Limestone have of course gone down still lower.

*Section 36.**

One mile east of Palestine.

State Line Coal Company's Works.

1. <i>Mahoning Sandstone</i> , massive, visible,	10'
2. <i>Freeport Upper</i> {	4'
Coal,	2' 4"
Parting,	1" to 2"
Coal,	4" to 6"
3. Fireclay,	1' 6"
4. <i>Freeport Upper Limestone</i> ,	3'
Concealed to R. R. 1,045' above tide,	45'
	63' 6"

2. The *Freeport Upper Coal* is very extensively mined here at the State line by Mullen & Co., who ship it for a gas coal.

4. The *Freeport Upper (White) Limestone* is seen below the coal at an elevation of 45 feet above the Pittsburgh, Fort Wayne and Chicago Railroad.

This makes its elevation above tide, 1,090'.

The *Ferriferous (Lowell) Limestone* in Sec. 1* stands at an elevation above tide of 1,150'.

Lowellville is *fifteen miles* to the north of Palestine.

If the two limestones were the same, the south dip would amount to only 4 feet per mile. It is known to be from 15 to 20 feet per mile. This—the actual dip—carries the Lowell limestone down to a level 200 to 240 feet beneath the *White* limestone in our section; in other words into the place occupied by the *Ferriferous Limestone*.

The country to the north of Enon Valley Station, up the valley of the Little Beaver North Fork is covered by the Drift, and there are no satisfactory exposures of the rocks.

The *Kittanning Coal* bed however is frequently enough mined to be traced with some certainty as far as Petersburg. There it also is lost to view, and nothing recognizable remains in sight, until the divide is crossed and Yellow creek is reached.

On Yellow creek, however, one and a half miles above Poland, the *Mercer Upper Limestone* shows itself a few feet above the water, and may be traced all the way to Poland.

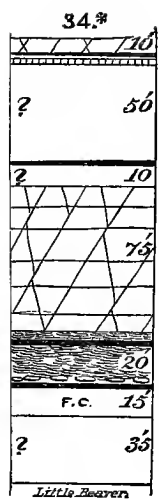
At Poland the *Mercer Lower Limestone* also shows itself in the bed of the creek.

From Poland down to its mouth Yellow creek cuts a deep and narrow gorge through the underlying *Connoquenessing Sandstone mass*, presenting splendid exposures, from which the following section was compiled.

Section 37.*

On Yellow Creek, below Poland.

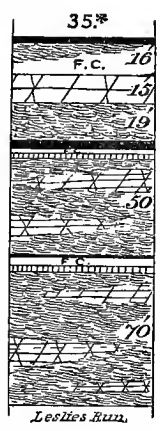
1. Shales, sandy,		visible, 12'
2. Ore bearing Shales,		2'
3. <i>Mercer Upper Limestone</i> ,		2' 4''
4. <i>Mercer Upper</i> , {	Cannel, impure, 1' 4''	} 1' 8''
	Coal, 4''	
5. Fireclay, {	Plastic, 1' 6''	} 3' 6''
	Non-plastic, 2'	
6. Sandstone, flaggy, bluish white, very hard,		25'
7. <i>Bituminous</i> slate,		1
8. <i>Mercer Lower Limestone</i> ,		2'
9. <i>Bituminous</i> shale,		3' to 4'



Freeport

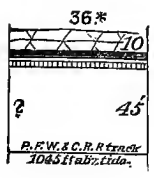
Freeport

} Kittanning group.



U. Coal.
U. Lime.

L. Coal.
L. Lime.



21 m. up
Little Beaver.
Darlington.

Leslie's run.
4 m. up
Bull run.
Palestine.

State Line Col-
liery.
1 m. east of
Palestine.

10. Shales, dark, sometimes replaced by Sandstone, white, hard,	15'
11. <i>Mercer Lower Coal</i> ,	3' to 5''
12. Ore bearing Shales, sandy, dark,	25' to 40'
13. <i>Connoquenessing Sandstone</i> , massive,	50' to 80'
14. <i>Sharon shales</i> , { Small coal often atop, . . . } { Always much iron ore, . . . }	15' to 45'
15. Shales, sandy, and Sandstone, flaggy,	40'
16. Sandstone, { Massive atop, } { Bluish white, flaggy, below, } { To level of Mahoning river, }	35'
	<hr/> <hr/> 307' 5''

3. The *Mercer Upper Limestone* is first seen on Burns' run, 1½ miles above Poland, finely exposed for some distance near the iron bridge, until it passes under the run. Imbedded in its top are many nodules of cherty iron ore; a plate-like mass of them sometimes resting immediately on the limestone. The rock is grayish-blue in color, very compact, and is a mere mass of fossil shells.

4. Below it we see an impure, slaty cannel, 1½' thick, which rests on 4'' of bituminous coal, and then comes a bed of fireclay, the lower half of which is non-plastic and filled with *Stigmaria*, to which the rootlets are still attached in a similar manner to those seen on Little Beaver, and described in Sec. 30.*

6. This brings us down to a very hard, bluish-gray, flaggy, micaceous sandstone, seen in cliffs along Yellow creek just below Poland, and so extensively quarried at Lowellville for furnace hearths which are said to be unsurpassed.

5. The *Mercer Upper Limestone* comes above water-level a short distance below Poland, and is seen stretching across the creek bed in regular blocks like a pavement. It continues in sight for sometime, until the rapid fall of the stream leaves it far up on the hillside. It is blue, very compact, and crowded with fossils, among which I noticed *Athyris subtilita*, *Spirifer cameratus*, *S. lineatus*, *Productus longispinus*, *P. nebrascensis*, and immense numbers of *Crinoidal* fragments; also two species of *Bryozoans*: fossils common to the *Mercer Upper Limestone* also.

11. The *Mercer Lower Coal* is quite thin and impure as seen along Yellow creek ; but in a boring at Poland it is reported 2 feet thick.†

Below it comes a bed of dark shales which contain many fossil plants, among which I find *Cordaites*, *Cardiocarpus*, *Schizopteris*, and an *Alethopteris* which could not be distinguished from *A. grandifolia*, Newberry.

12. A dark sandy shale containing much bituminous matter, and also considerable iron ore in kidney shaped nodules. Near the bottom is a somewhat persistent stratum of ore which rests upon a very earthy calcareous little stratum $1\frac{1}{2}$ feet thick with *cone-in-cone* structure, looking as if it had segregated from the enclosing shales.

13. This *Connoquenessing Sandstone*, called *Massillon Sandstone* by Dr. Newberry, is splendidly exposed for two miles along Yellow creek, and the rapid changes which it undergoes can there be seen taking place. In one place it is a solid massive bed 80 feet thick ; a few rods off the massive portion is but half that size, split up by shales. Sometimes the massive part disappears entirely, and there is nothing left but a mass of shales with thin, flaggy-layers of sandstone.

When massive, it is a coarse, grayish-white rock, much specked and discolored by iron stains, and it occasionally contains small pebbles about the size of a pea. The lowest layer of the rock is frequently a conglomerate of iron nodules, pieces of shale, &c., torn up from the underlying beds by the current which deposited it.

14 is the shale which has been so extensively stripped and drifted for iron ore along the Mahoning river, above the horizon of the *Sharon Block coal*.

The ore is scattered in nodular masses throughout the shale bed ; but the most of it comes in a more or less persistent stratum a few feet below the base of 13. Mined to supply the old charcoal furnaces on Yellow creek, on the old dumps are seen many calcareous masses which have the *cone-in-cone* structure, which may sometimes be seen

† This is the bed in the Mahoning Valley originally numbered 3 by Dr. Newberry.

enclosing nodules of the ore and radiating in all directions from it, the apices of the cones being always pointed toward the nucleus.

Eight to ten feet below the top of these ore-bearing shales we often see an impure coal 4 to 6 inches thick; it is not persistent however, but one of those local streaks of coal which frequently make their appearance in the roof shales of the *Sharon Block coal*.

This coal bed should be found at the base of this 14; but it was not deposited at this locality; and in passing down Yellow Creek to the Mahoning river we see nothing but sandy shales, interstratified with thin flaggy sandstones for 40 feet; then we come to a rather massive and tolerably coarse, yellowish-white sandstone, 15 to 20 feet thick; below which is a fine-grained, bluish, shaly sandstone which extends to the level of the Mahoning river.

*Section 38.**

On the Mahoning; two miles above Lowellville.

One and a half miles below the mouth of the Yellow Creek the *Sharon coal* comes into the series, on a little stream called Mt. Nebo, where we obtain the following section:

1.	Connoquenessing Lower Sandstone,	70'
2.	Ore bearing shales, dark blue,	35'
3.	Shales, sandy,	20'
4.	<i>Sharon Coal</i> , (block; No. 1, Ohio,)	0' to 4'
5.	Fireclay and shales, sandy,	10'
6.	<i>Sharon Conglomerate</i> , a massive Sandstone,	20'
7.	Sandstone, flaggy, bluish, and shales, containing Cuyahoga fossils,	13'
8.	Concealed to level of Mahoning river,	20'

192'

4. This is reported to be the first locality at which the *Sharon Coal* was mined in the Mahoning valley. It occupies a narrow trough extending to the south-west an unknown distance. Northward and eastward it runs out en-

tirely within a few rods from the center of the basin. Its outcrop is 63 feet above the level of the Mahoning, but it was mined to the south-west far below the bed of the river, and finally when the pumps could not control the water the mines were abandoned.

This is the most southern locality at which the *Sharon coal* has ever been found along the Mahoning river. It is only about two miles above Lowellville, the locality of Sec. 1,* with which it is very easy to connect our present section, as the shales (2) above the coal have been stripped and drifted for *ore* in a constant line between the two points.

Comparing sections 37,* 38* and 1* together, it is seen that the *Sharon coal* lies from 250 to 300 feet beneath the Ferri-ferous Limestone.

6. The *Sharon Conglomerate* has no pebbles in it here.

7. These shales furnish specimens of *Straparollus*, *Allo-ri-sma*, and other fossils characteristics of the Cuyahoga shale formation in Ohio; [which may perhaps be a sufficient reason for confining the Ohio Conglomerate to the 20 foot Sandstone (6) over them. J. P. L.]

We now ascend the Mahoning river.

*Section 39.**

On the Mahoning river; at Hazleton.

Two and a half miles below Youngstown.

Four miles north of our last section, on a run which enters the river from the south, at Andrews Brothers' shaft, we get the following:

1. Mercer shales, sandy,	} In the Upper Shaft.	15'
2. Mercer Lower Limestone,		2'
3. Shales, sandy,		10'
4. Mercer Lower Coal,		2
5. Shales, sandy and sandstone flaggy, to top of the lower shaft,		108'
6. Sandstone and shales, sandy, in lower shaft,		72'
7. Sharon Coal,		4'
8. Bottom of coal above Mahoning River,		40'
		<hr/> <hr/> 253'

2. In a shaft on Brownlee's land, half a mile south from the Andrew's shaft; as usual, blue, compact and fossiliferous.

3. The coal is mined by this shaft (30 feet deep) and also by an entry; has a dull luster and is somewhat bony; is 2 feet thick at the bottom of the shaft, but is reported $2\frac{1}{2}$ in the gangway.

5. The *Connoquenessing Sandstone* has here totally disappeared as a massive rock. Nothing but shales appear in this interval, which is fully exposed along the little run which passes the lower shaft. Careful levelling resulted in placing

7. The Sharon Coal at 192 feet beneath the *Mercer Lower Limestone*.

No workable areas of this *Sharon Coal* exist in the four miles between this section and the last (38*).

Mr. Powers has a drift upon the bed at a height of 45 feet above the river.

Section 40.*

Same Locality.

If instead of connecting with the record of the shaft, we keep on down the little run, over the surface exposures, to the Mahoning river,—beginning at the top of the shaft, we get a glimpse of the remarkable variations to which the Sharon coal is subject, in the following section:

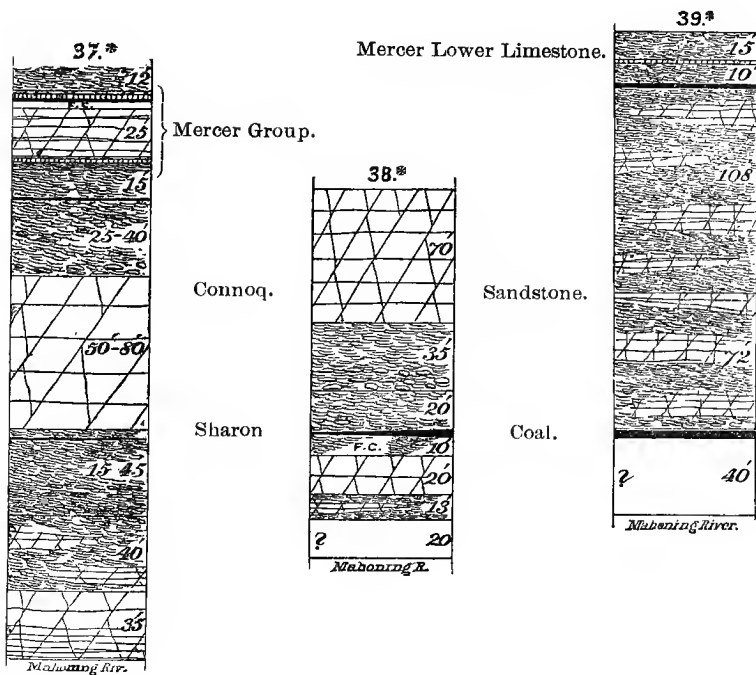
1.	Sharon shales and sandstone,	21'	6''
2.	<i>Cannel Coal</i> ,	8'	
3.	} Sharon, {	Shales,	6'
4.		Coal,	6'
		7'	2'
5.	Fireclay,	3'	
6.	Concealed,	10'	
7.	} Sharon, {	Sandstone, flaggy, blue, fossiliferous	25'
8.		Sandstone, coarse, massive,	15'
9.	Flagstones, with <i>Productus</i> , <i>Straparollus</i> and <i>Allor-</i> <i>isma</i> ,	20'	
	Concealed to level of Mahoning river,	15'	
		16'	18''

On
Yellow
Creek.
—
below
Poland.

On the Mahoning River.

3 m. above
Lowellville.

Hazleton.
8 m. above
Lowellville.



4. The *Sharon coal* in the shaft (Sec. 39*) only 150 yards distant is 2 feet thick. Here it is only 6 inches thick.

The level of the coal in the shaft is also 44 feet lower than the outcrop in the run.

The superintendent states, that the coal rises rapidly and thins away when followed from the bottom of the shaft in the direction of this outcrop in the run, so that there can be no doubt of their identity; for, as we pass on down the little stream we see everything exposed down to within 15 feet of the Mahoning river, and no appearance of coal is to be witnessed in the interval.

It is evident that we are here at the margin of one of the numerous pools or basins in which this coal was accumulated; and as the coal marsh spread from the center of the depression, it extended up over the sloping sides of the sand banks which enclosed it, and left thereon a thin coating of vegetable matter at a considerable elevation above the thicker deposit in the center of the basin below.

7 and 9. These shales contain *Productus*, *Straparollus* and *Allorisma*, fossils of the *Cuyahoga shales* of Ohio

Section 41.*

Andrews Brothers' Upper Shaft.

*1200 yards S. W. from Section 39.**

1. Surface débris (place for the <i>Mercer Lower Limestone</i> as seen half a mile south of the shaft,)	20'
2. <i>Connoq. U. Sandstone</i> , flaggy, shaly,	75'
3. <i>Connoq. L. Sandstone</i> , massive,	65'
4. <i>Sharon shales</i> , sandy, dark,	30'
5. <i>Sharon coal</i> ,	3' 6''
6. Interval to level of Mahoning at Hazelton,	40'
	233' 6''

The *Mercer Lower Limestone* which shoots over the low hills around the shaft, is caught in the hill sides half a mile south of it, and nearly on a level with its mouth.

3. The *Connoquenessing Sandstone* here appears again in a massive form. In Sec. 39, nothing but shales is seen. This is only an illustration of the variability of the interval above the *Sharon coal*.

Hazleton.

Andrews' Brothers.

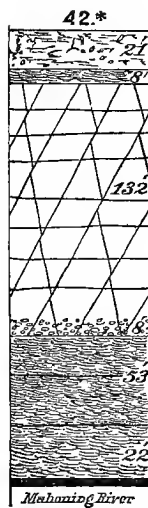
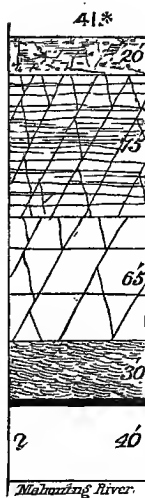
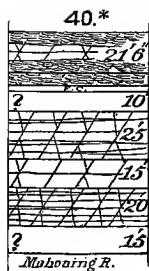
2 m. west of Hazleton.

Conn. U. Sandstone.

Conn. L. Sandstone.

Sharon

Coal.



Section 42.**The Foster Shaft; head of Mill Creek.**Two miles West of Hazelton.**Two and half miles south of Youngstown.*

1. Surface débris,	. . . . .	21'
2. Shales,	. . . . .	8'
3. <i>Connoq.</i>	{ <i>Sandstone</i> , massive, 124' } 132'	
	{ Pebble rock at bottom, 8' }	
4. Shales, sandy, dark, two small streaks of coal,		53'
5. Sharon shales, sandy, gray,		22'
6. <i>Sharon Coal</i> , "5 feet below the level of the Mahoning river at Youngstown,"		4'
		240'

This section was given to me by Mr. Head, the Superintendent of the Foster mine. The shaft is reputed to be the deepest in Mahoning county.

3. The *Connoquenessing Sandstone* (*Massillon* of the Ohio Reports) here very thick (132 feet) is reported to be massive throughout, and the lower part quite conglomeratic. Three quarters of a mile further west, in the Cuyler shaft (170 feet deep) only 12 feet of massive rock was passed through in reaching the *Sharon coal*.

6. The *Sharon coal* in Section 39* lies 192 feet beneath the *Mercer Lower Limestone*. (See above.)

Here the interval is 216 feet, if it be true that that limestone was struck (at 20 feet) in a bore hole a few rods away from the Foster shaft.

At Youngstown the *Sharon Coal* is about 50 feet above the Mahoning river.

From Youngstown, northeastward for 14 miles, along the Sharon Branch of the Atlantic and Great Western Railroad, the *Sharon Coal* keeps about the same level.

At Hubbard's Station, 14 miles from Youngstown, and half way to Sharon, the *Sharon Coal* is 5 feet below grade (881 feet above tide level) or 876 feet above tide level.

It now begins to rise until it lies at Sharon 1067 feet

above tide.† The distance is about 14 miles ; the difference 191 feet ; the average rate about $13\frac{1}{2}$ feet per mile.

There is no difficulty in tracing the coal across from the Mahoning valley at Youngstown to the Shenango at Sharon, since a perfect net work of mines on the coal connects the two points, and there is no question about the identity of the "Block," "Briar hill," "No. 1," &c., of the Mahoning valley, with the "Sharon" of the Shenango, as all who have been over the ground admit.

But it is impossible to connect the two points by sections ; for the Drift covers up everything, and no surface exposures giving anything like a section can be found ; but this is not necessary for their identification, since we can almost pass from one point to the other through the entries and passages of the mines themselves.

Whittaker's run, leading up to the Brookville Colliery, $2\frac{1}{2}$ miles southwest of Sharon, exposes a fine section as follows : Sec section Fig. 43*, page 301.

1. Sharon Coal,	4'
2. Concealed,	10'
3. Sharon, { Sandstone, white, massive,	8' } 17'
{ Conglomerate,	9' }
4. Sandstone flaggy ; shales sandy,	47'
5. Ore bearing Sandstone, coarse, massive,	7'
6. Flags, bluish ; sandstone, shaly,	60'
7. Concealed to level of the Shenango,	55'
	<u>200'</u>

2. The *Sharon Conglomerate* here seen is nowhere visible beneath the Sharon coal in the Mahoning valley sections.

Its upper part (8') is of snowy whiteness, massive, but moderately fine grained.‡

Its lower part is a mere mass of both angular and rounded pebbles of quartz so loosely held together by the matrix of coarse bluish sand, that they drop in quantities from the weathered surfaces and accumulate in a talus along the base of the cliff.

4. Flaggy at top graduates downward into shale.

† On the authority of Mr. Chance.

‡ The polished surfaces and glacial grooves on this rock will be described in the Mercer County Report QQQ.

5. Ore balls, 1" to 2" in diameter, are numerous in the top layer of these massive, coarse, brownish white rocks, over which Whittaker's run makes a cascade 10' high.*

6. Thin layers of sandstone occasionally appear in this mass of bluish sandy shales.

The tunnel of the Brookville Colliery affords another section (44*) of some importance to the purpose of this report. But the description of the *Sharon Coal bed* here so extensively mined must be left for a more proper place.

1. <i>Sharon Coal</i> ,	4'
2. Fireclay and shales,	2'
3. <i>Sharon Conglomerate</i> ,	6'
4. Shales, sandy, bluish to upper heading of tunnel,	5'
5. Distance yet to be tunneled 380 yds. (Sep. 1876) through unknown rock,	23'
6. Shales bluish and sandstone shaly,	6'
7. Sandstone, hard, quartzose; <i>fish</i> , shell and plant remains,	3'
8. Shales, sandy, bluish; <i>Productus</i> , <i>Spirifer</i> , <i>Allorisma</i> ,	35'
9. Concealed to Shenango river,	80'

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3. The *Sharon Conglomerate* is here a mass of pebbles, on which rests two feet of fireclay and then the Coal. As might be expected, the conglomerate makes a most uneven floor for the coal, everywhere rising and falling in "hills" and "swamps," the hills being mere piles of conglomerated pebbles, sometimes sloping at an angle of 15° to the height of 20 or 30 feet. The "swamps" lie between the hills, and were apparently little valleys of erosion, in which the coal vegetation grew luxuriantly; while the tops of the "hills" were hardly covered by it. The coal is therefore 4' to 5' thick in the "swamps" of the mine; thinning away to a few inches on the "hills."

[† Mr. White has found this rock persistent through Mercer and Crawford counties; and recognized it lately at Franklin, at Oil City, and at Garland, in Warren county, underneath Mr. Carl's Garland Conglomerate. If this be verified by further examinations, and the Garland = the Olean Conglomerate, then this ore-bearing *fish bed*, Conglomeratic Sandstone must be Mr. Ashburner's *Sub-olcan* of McKean county.—J. P. L., July 24, 1879.]

The thickness of the Conglomerate, regarded as a stratum, must necessarily be very variable. In fact, it is only 6' thick at the upper end of the tunnel (in the deepest "swamp" in the mine) while it is from 20' to 25' thick where "hills" are exposed along the surface outcrop.

5. Uncompleted interval of tunnel when the section was made; distance 380 yards; vertical thickness about 30 feet; westerly dip slight; direction of tunnel due west towards the coal.

7. This conglomerated mass of shells and fish teeth, scales and bones, fragments of plants and waterworn pieces of rock, is almost as hard as granite.†

8. A layer of shells (*Allorisma*, *Productus*, *Spirifer*, and others less numerous) massed together comes in near the middle of these shales.

Fucoids are numerous in the shale.

One more section, at Sharon itself, will be selected, for comparison with Sec. 18* at the Falls of Beaver River; the distance of the two localities from one another being about 34 miles; Sharon at the north; Beaver Falls at the south.

At Sharon the coal is extensively mined by Curtis & Boyce, on the right bank of the Shenango. Combining the various exposures seen in the vicinity of Sharon with the record of a boring made at Sharon furnace by Boyce, Rawle & Co., we obtain the following succession.

*Section 45.**

At Sharon.

1. Sharon Coal,	4'
2. Fireclay and shales,	5'
3. Sharon Conglomerate,	20'
4. Sandy shales,	45'
5. Ore-bearing Sandstone,	10'
6. Shales, sandy,	80'
7. Sandstone, flaggy,	40'

† Some of the bones are an inch in diameter and must have belonged to a large species of fish. A small *Lepidodendron*, much resembling *L. Veltheimianum* is abundant. (See foot-note to the last page.)

*Level of the Shenango.**Sharon Furnace well section.*

8. Drive pipe through Drift,	43'
9. "Soapstone" = blue slate,	85'
10. Sandstone, white, sharp,	75'
11. Shales, light blue,	30'
12. A succession of blue, gray, and brown shales, interspersed with thin layers of grit to the bottom of the hole, 1600 feet deep.	

We have placed beside this Sharon section the one obtained by the boring at Beaver Falls, putting the *Sharon coal horizon* in the latter, where we have previously shown by stratigraphy (sections 1*-18*) that it must be found.

At Beaver Falls the top of the *Homewood (Piedmont) Sandstone* is about 200' above the place of the *Sharon Coal*. So here, in the high knobs southwest of Sharon a very coarse massive sandstone is seen about 200' above the *Sharon Coal*. An immense sandstone layer caps the knob over the Cleveland shaft, $2\frac{1}{2}$ miles west of Sharon, and 225' above the *Sharon Coal*. Gravel Hill, $2\frac{1}{2}$ miles south of Hubbard in Mahoning county, Ohio, (1100' above tide) 189' above the Sharon coal, is covered with quartz pebbles and coarse sand, *not Drift*, for the pebbly mother-rock is quarried.

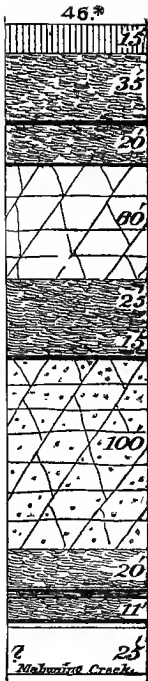
10. This 75' rock is the equivalent of the 124' rock at Beaver Falls.

In the numerous borings made along the Big Beaver and Shenango between the two points, it is constantly found, the northward rise of the strata bringing it gradually nearer the surface, and is always from 75 to 100 feet thick, frequently conglomeratic and often contains some oil.

At New Castle, midway between the two localities, it is 78 feet thick, and is found 360 feet below the level of the Shenango.

Along the Mahoning river this same rock was struck in the borings at a depth of 325' below the Sharon coal, and is the oil rock of that region.

12. This 30' rock corresponds to the 30' rock (at 1048') in the Beaver Falls well. No other massive rock of any kind was found below this in either well, although both wells were carried down more than 1000 feet beneath it.



Ferriferous Limestone on the Allegheny river, in Clarion County.

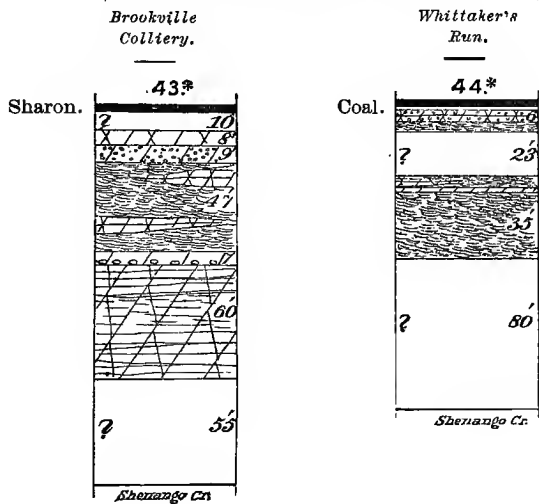
Clarion Coal.

Brookville Coal.

Tionesta Sandstone.

Mercer Group.

At Sharon in Mercer County.



NOTE.

[I have suppressed all the conclusions drawn by the author respecting the identity of the rocks below the Sharon Coal with the Ohio Conglomerate and Berea grit of Ohio, and with the Mountain Sands and Oil Sands of Pennsylvania, because I considered them premature in 1877; and because even yet (July 1879) the demonstration is not complete.

Neither are we yet prepared to decide whether the Great Conglomerate at Pottsville and along the Allegheny mountain, Formation XII, is represented by the Homewood, the Connoquenessing, or the Sharon; singly or combined.

It is not merely a question of names. Then it would be easily settled. It is a question of whether the Mauch Chunk Red Shale Formation XI thins out before reaching the Oil Regions; or whether on the other hand it extends across Western Pennsylvania into Ohio; either as the Sharon Group, which was the general conclusion arrived at on the First Survey; or, as the Mercer Group, to which conclusion the recent surveys of Indiana and Armstrong counties point.

The sole object of this report was to revise the work which Messrs. J. T. Hodge, and McKinney, Dr. R. M. S. Jackson and myself did forty years ago, and the work which I have done at different times in subsequent years, along the Beaver waters; to discover why our general section should differ from that of the Ohio Survey, if it really did differ, and thus to prove or disprove its correctness. It is gratifying to find that the minute revision made by Mr. White has demonstrated its correctness, while incidentally bringing to light many new and confirmatory details. In Report V (1879) Mr. Chance, who had previously gone over part of the same ground, and came to the same conclusions, adds a new confirmation to the old work.

It only remains to condense the *proof by intervals* into a single table that the reader may see how impossible it is to go wrong as to the relations of the *Ferriferous Limestone* to the *Mercer Lower Limestone*, and to the *Sharon Coal*, in the following table.—J. P. L.]

* Table.

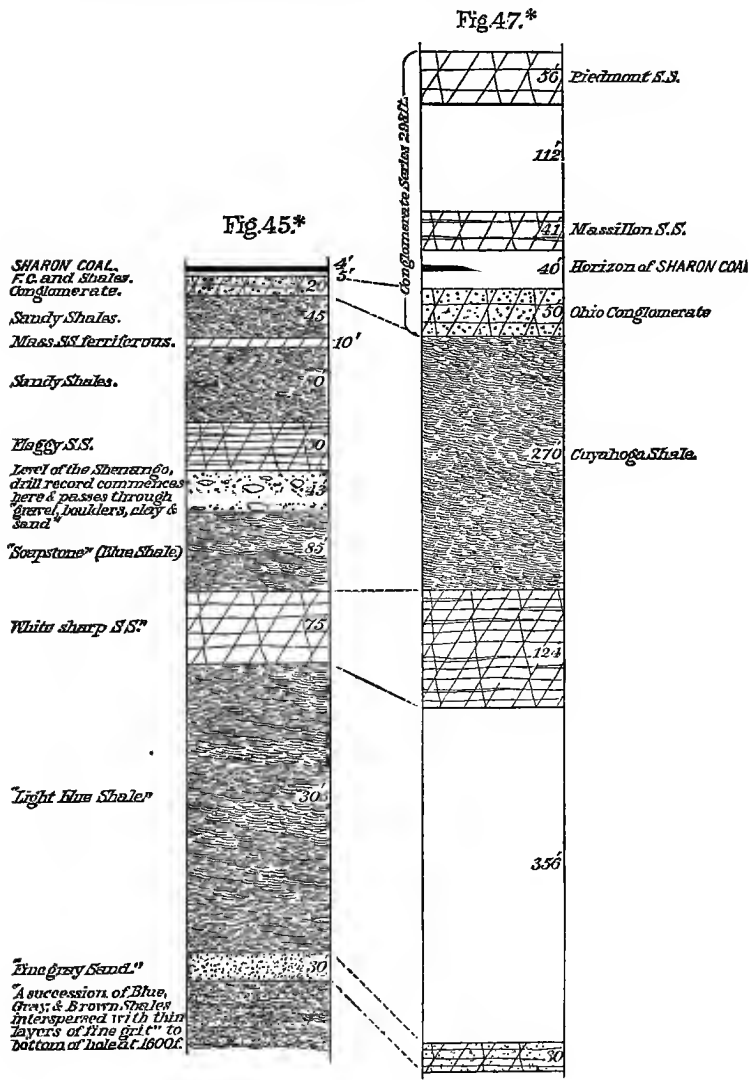
Showing the depth of the Mercer Lower Limestone and of the Sharon Coal bed beneath the top of the Ferriferous Limestone.

<i>In Section</i>	<i>Mercer L. L.</i>	<i>Sharon Coal.</i>
1.*	148' 9''	
2.*	124'	
3.*	116' 3''	307' 7'
4.*	148' 6''	278' ±
5.*	132' 5''	
7.*	138' 8''	
8.* 133' (10' + x) =	144' ±	
10.* Average, .	150'	
13.* 14* combined,	On the	159' 6'' 283'
15.*	Beaver.	150'
16.* x + 155' + X, . .	. . .	220' + (?)
17.* 269 6' + X, . . .	. . .	. . . . . 360' ±
18.* 138' 6'' + X, . . .	. . .	188' (?), 332'
27.* On the Little Beaver, . .	140' 3''	



Fig. 45. Section of the rocks exposed in the vicinity of Sharon, and bored through at Sharon furnace, Mercer County, Pa.

Fig. 47. Section of the rocks passed through in the well boring at Beaver Falls, Beaver County, Pa.





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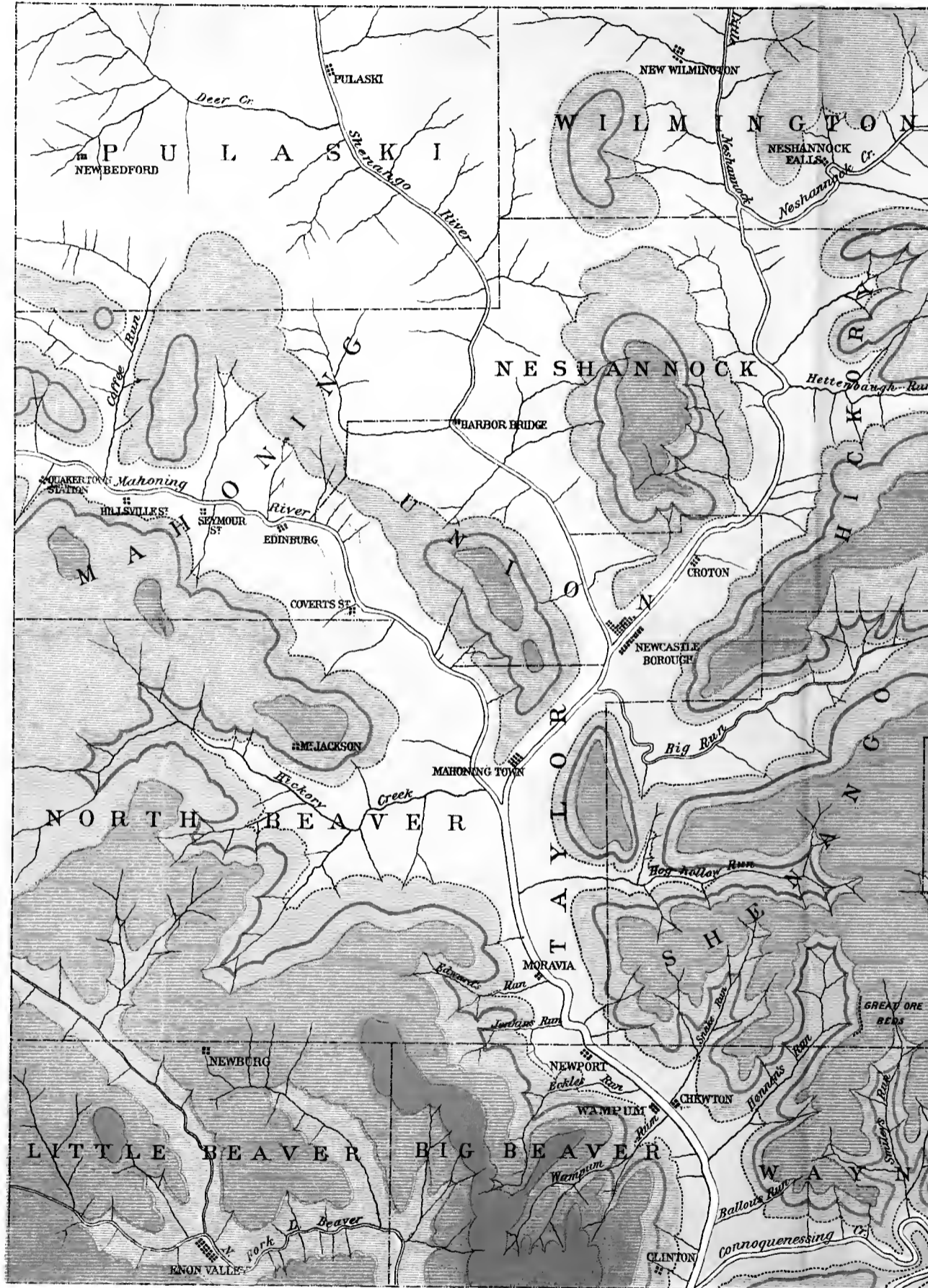
**OLIN
LIBRARY**

LAWRENCE COUNTY.

Q Q

M E R C E R C O








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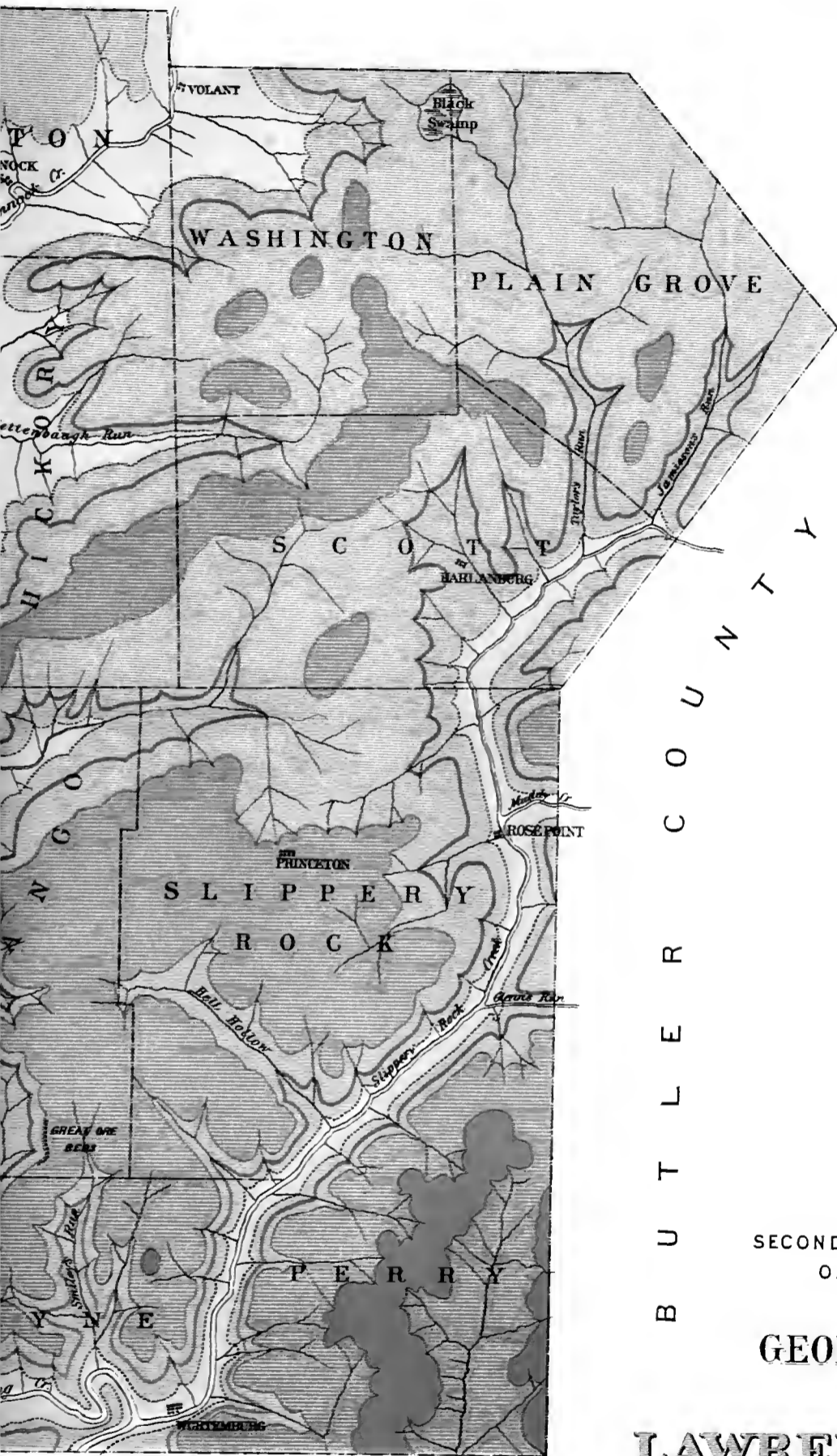


B E A V E R C O U

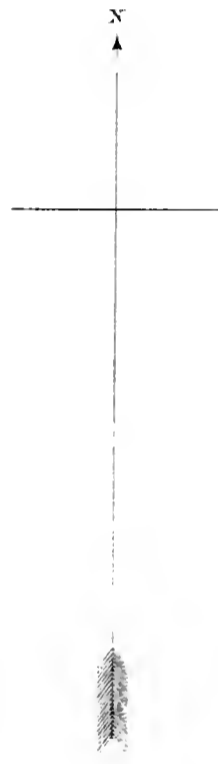
O U N T Y

EXPLANATION OF COLORS.

- Barren Measures 
- Upper Freeport Coal 
- Lower Productive Coal Measures 
- Darlington Coal 
- Ferruginous Limestone 
- Conglomerate Sharon Coal 
- Sharon Shales 



B U T L E R C O U N T Y



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

GEOLOGICAL MAP OF LAWRENCE COUNTY

J.P. LESLEY STATE GEOLOGIST
I.C. White Asst Geologist
1878.

Scale: 2 miles = 1 inch.



U N T Y

