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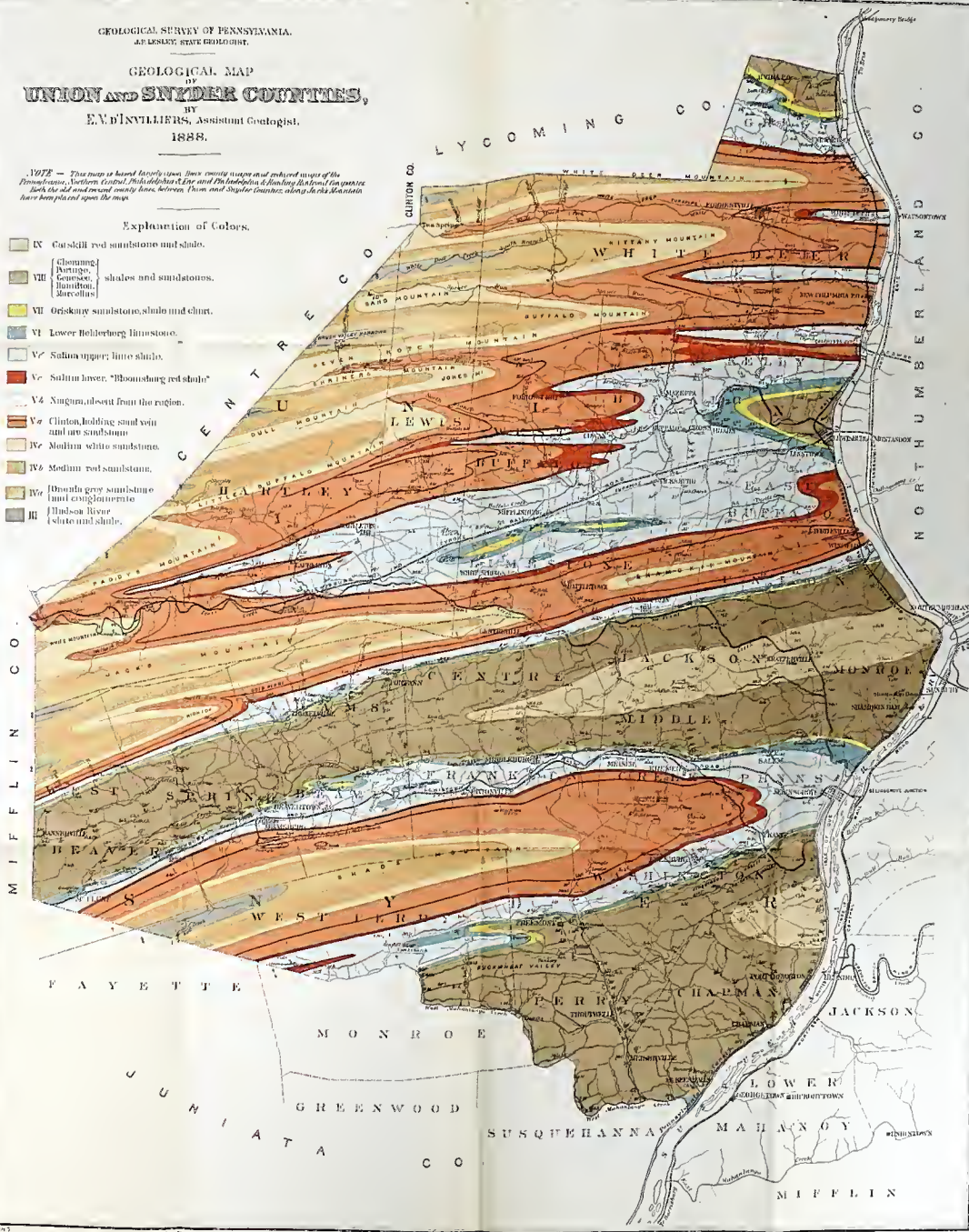
GEOLOGICAL SURVEY OF PENNSYLVANIA.
ALLEGANY STATE GEOLOGIST.

GEOLOGICAL MAP
OF
UNION AND SNIDER COUNTIES,
BY
E. V. D'INVILLIERS, Assistant Geologist,
1888.

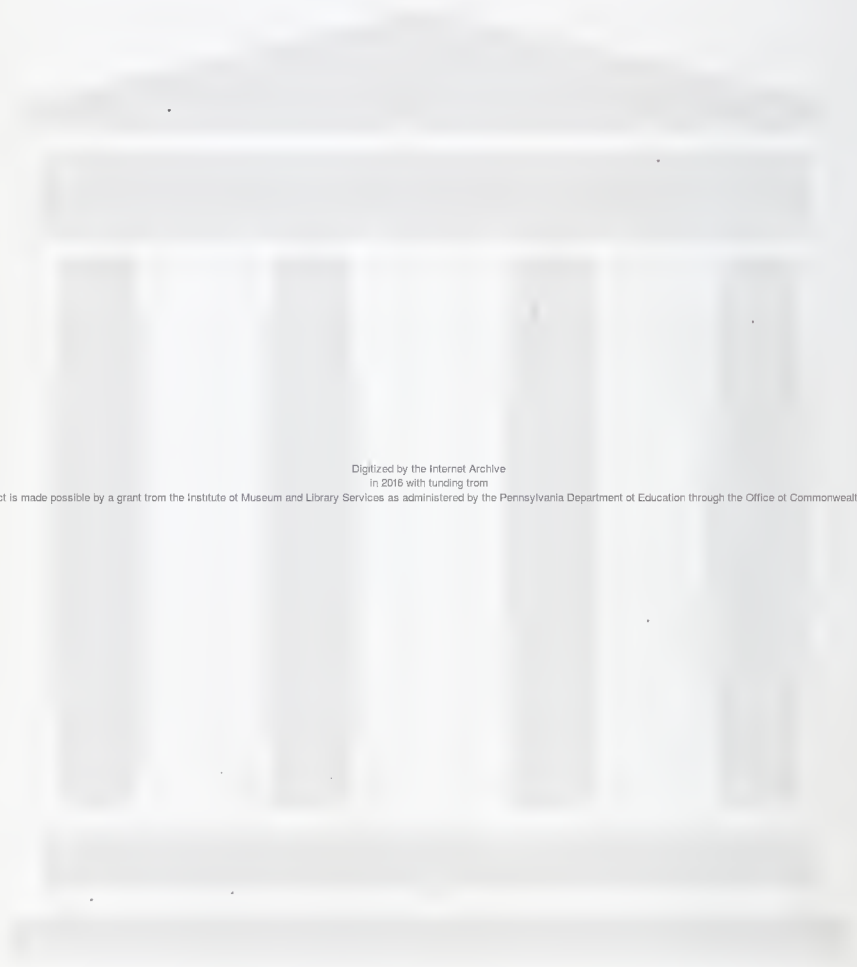
NOTE — This map is based largely upon lines correctly traced and reduced copies of the Pennsylvanian, Northern Carboniferous, Permian, and Triassic, and the Allegheny, Redoubt, and Genesee. Both the old and recent county lines between them and other counties, along with the mountain have been placed upon the map.

Explanation of Colors.

- IX Coarsill red sandstone and shale.
- VIII (Channing, Dartmouth, Genesee, Hamilton, Mercersburg) shales and sandstones.
- VII Oriskany sandstone, shale and chert.
- VI Lower Beclerberg limestone.
- V² Salina upper; lime shale.
- V¹ Salina lower; "Blossburg red shale".
- V⁴ Niagara, absent from the region.
- V³ Clinton, holding sandstone and lime sandstone.
- IV² Middle white sandstone.
- IV¹ Middle red sandstone.
- III² Middle gray sandstone and conglomerate.
- III¹ Hudson River (slate and shale).

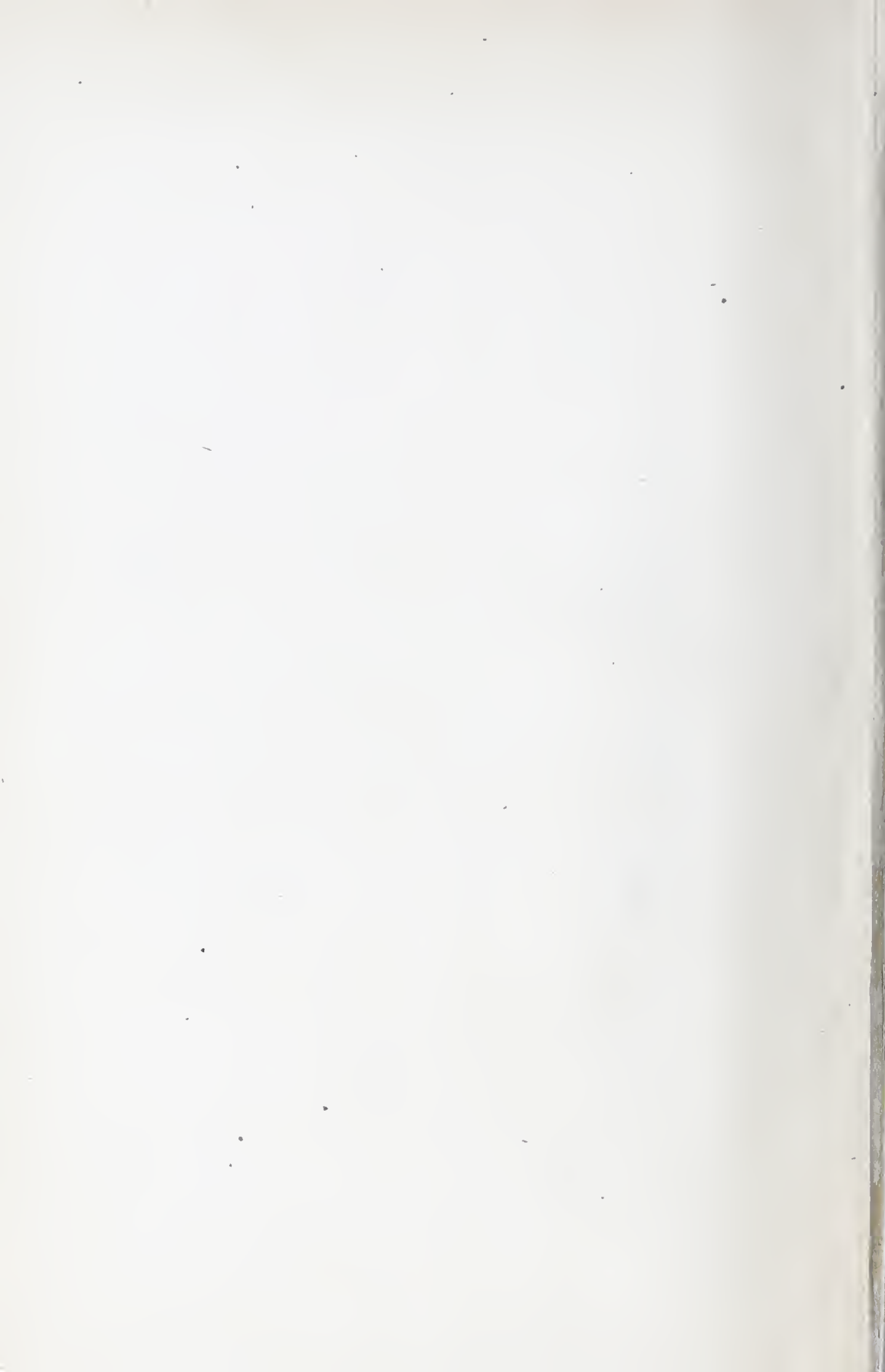


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SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

REPORT OF PROGRESS.

F³.

1888-1889.

REPORT ON THE GEOLOGY OF THE
FOUR COUNTIES
UNION, SNYDER, MIFFLIN AND JUNIATA

WITH DESCRIPTIONS.

OF THE

CLINTON FOSSIL ORE MINES, MARCELLUS CARBONATE IRON
ORE MINES, ORISKANY GLASS SAND MINES, AND LEWIS-
TOWN LIMESTONE QUARRIES.

Illustrated by

A colored geological map of Union and Snyder counties.

A colored geological map of Mifflin and Juniata counties.

BY E. V. D'INVILLIERS.

HARRISBURG :

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

1891.

Entered, for the Commonwealth of Pennsylvania, in the year 1891, according
to acts of Congress,

By WILLIAM A. INGHAM,

Secretary of the Board of Commissioners of the Geological Survey,

In the office of the Librarian of Congress, at

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LETTER OF TRANSMITTAL.

TO HIS EXCELLENCY ROBERT E. PATTISON, *Governor of Pennsylvania, ex-officio Chairman of the Board of Commissioners of the Geological Survey of Pennsylvania.*

SIR:—I have the honor to present the report of my late assistant, Mr. E. V. d'Invilliers, on the four counties of Union, Snyder, Mifflin and Juniata, descriptive of their geological structure, formations, mines and quarries, with notes on their soils and vegetation.

This report was handed to me in May, 1889, and ordered for printing in September, 1890, having to wait its turn among the public documents of the state, in charge of the Superintendent of Public Printing.

Before writing the report Mr. d'Invilliers constructed the two maps which accompany and illustrate its text, one of Union and Snyder, the other of Mifflin and Juniata, on the regular scale of two miles to the inch, and with the regular coloration of the geological outcrops adopted at the beginning of the survey in 1874.

These maps were engraved and printed by Bien & Co. in 1888-9, and have been lying at Harrisburg awaiting the printing of the report. Their beauty will be acknowledged; and every care has been bestowed upon their construction to make them as accurate as possible. In the absence of exact geodetic map-work by the U. S. Coast Survey, the State of Pennsylvania having never made a geodetic survey of its own region inside its boundary lines, the usual difficulties were encountered in adjusting the county lines to each other, and still greater difficulties in adjusting the townships in each county. But the geographical inaccuracies nowhere amount to enough to interfere with a cor-

rect *geological* representation. The outcrop belts of the several formations are sufficiently exact for practical use of the maps by citizens of these counties and students of this wonderfully and beautifully complicated district of middle Pennsylvania.

It is surrounded by other districts which have been described in previous reports, mapped on the same scale, and colored in the same style. Readers of this report are therefore referred to Professor E. W. Claypole's report (F2) and map of PERRY county on the south. Professor I. C. White's report (G7) and map of NORTHUMBERLAND county on the east. Professor I. C. White's report (T3) and map of HUNTINGDON county on the west. r. d'Invilliers' report (T4) and map of CENTRE county and Dr. H. M. Chance's report (G4) and map of CLINTON county on the northwest; and Mr. Franklin Platt's report (G2) and map of LYCOMING county on the north. Adding Professor J. J. Stevenson's published report (T2) and map of BEDFORD and FULTON counties on the Maryland line, and Professor I. C. White's reports (G6, G7) and maps of MONTOUR, COLUMBIA, LUZERNE, PIKE, MONROE and half of CARBON counties on the north branch Susquehanna, Lehigh and Delaware rivers, a nearly complete map of the complicated middle belt of Pennsylvania, on a scale of two miles to the inch, can be put together. Maps of all CARBON and of SCHUYLKILL counties are nearly ready for publication, and will make complete the middle belt of the state.

Such maps of all the counties of the state have been published excepting BUCKS and MONTGOMERY, which will soon be reported for publication by Mr. B. S. Lyman.

No illustrations of the geological structure of the district are given in this report; no local or general cross-sections to show anticlinals and synclinals; no columnar sections to show the sequence and thickness of the formations. For such illustrations the reader of this report is referred to Mr. John Hughes Dewees' report (F, 1878) on the Fossil ore beds of the Juniata district, where he will find a wealth of sections and local maps almost unexampled in the literature of geological science. The instrumental sec-

tions at Logan gap, McVeytown, Mt. Union, etc. there exhibited, constructed by our lamented Charles A. Ashburner, then aid to Mr. Dewees, are of unsurpassed excellence. That report covered part of Snyder county, and carried the geology of the district far across Huntingdon county.

Unfortunately the curious and beautiful map of the contour line survey of the south flank of Jack's mountain from Logan gap to Jack's narrows made in 1875 by Ashburner and Billin has never been published.

But a more important contribution to the geology of the district was Mr. C. E. Billin's contour-line survey map of the Seven mountains made in 1876-77, published partially in Grand Atlas, division V, part 1, and now in a separate atlas. Besides the map itself, more than a dozen elaborately constructed cross-sections show the structure of this mountain mass, the western spurs of which project into Huntingdon and Mifflin, and the eastern spur sink into the red shale plain of Union and Snyder. A special map of the Greenwood furnace or great Stone mountain fault and another of the zigzag outcrop lines of the fossil ore beds in western Huntingdon county are included in the set of sheets.

Mr. d'Inwilliers' field and office work extended over more than a year, and no part of the four counties was slighted. The completeness of his report is as remarkable as its accuracy in detail. It brings down the history of the iron industry of the district almost to date, showing its decline and the cause of it, without reference, however, to the great fact that the concentration of iron-making at great centers of production, the large introduction of northern, western and foreign richer ores, and especially the substitution of Bessemer for cast-iron pig, have combined to change the status of the old iron-ore-producing districts of Pennsylvania.

Readers will notice that Palæontology is excluded from this report. No collections of fossils were made. The reader is therefore referred to Prof. Claypole's and Prof. White's reports on Perry, Huntingdon and Northumberland counties, and to my Dictionary of the Fossils of Penn-

sylvania (P4) for the names and figures of the animal forms to be found in the formations of the district.

I take the opportunity to warn the citizens of the district reported on in this volume not to throw away their money in mining for gold, silver, copper, lead, zinc, bismuth, antimony or tin, for they will never find any workable veins of these metals at depths less than many thousands of feet beneath the surface. The mountains of the district are barren of all precious metals.

With this warning in mind it is well for the people of these counties to know that small deceptive and worthless exhibitions of lead and zinc ores may be expected to present themselves at perhaps more than one point along the very extensive outcrops of the Lewistown or Lower Helderberg limestone formation which are quarried in almost all the forty-seven townships of the four counties; but it is absolutely certain that every dollar spent in trying to open a lead or zinc mine at any such point will be thrown away!

It is well to repeat here that the abundance of iron pyrites or "fool's gold" in the Marcellus shales has deceived many persons and will deceive many more into the belief that these shining little cubical crystals are particles of real gold; whereas they are only a crystalized compound of iron and sulphur, of no value except for the manufacture of vitriol, and then only when they can be mined in large masses cheaply.

Still more earnestly I warn citizens of this district against those who would persuade them to go into boring for *oil* or *gas*. No boring for either an oil or a gas well in this district, or in any part of it, will ever be productive. The Venango oil formation and the Bradford oil formation crop out in belts across the district, but they hold neither oil nor gas. The Trenton rocks of Ohio and Indiana underlie the district, but there is no shadow of probability that they hold either oil or gas. Whatever oil and gas may have existed in these formations originally has long ago been evaporated from them; so folded and cracked was this part of the earth's crust at the rise of the continent at the end of the coal age.

The search for *coal* will be equally vain. Foolish people

have dug into certain black slates which range along the edge of Kishicoquillis valley inside Logan gap, in hope of finding a coal bed ; in hope that the black slate at the surface will turn into coal if followed down beneath the surface. Such hopes are silly. There are also black slate beds in the Marcellus formation and in the Genesee formation ; and sometimes these black slates have a good deal of old animal fat in them, which time has changed and hardened into asphalt, so that specimens put into a blacksmith's fire will fry and flame for a few minutes. But no one has ever seen or heard of a coal bed in these formations. There is not a ton of real coal in the four counties. All the formations of the district are much older than the coal measures, and were deposited before the first coal bed was made. The oldest coal bed is that in Perry county, and that is good for nothing.

Note on the River Drainage.—The two great rivers of this district, the Susquehanna and the Juniata, have had a curiously different history. The Juniata river has had the same water basin from its birth, that is from the elevation of the coal-measure continent out of the sea at the close of the Permo-carboniferous age. The West Branch of the Susquehanna has considerably and the East Branch has greatly enlarged its water basin since the Ice age.

The Terminal moraine (see Report Z) running across Luzerne, Columbia, Lycoming, Potter and McKean counties, across the Susquehanna waters, running far north of the whole Juniata water basin, interfered with none of its branches, and never furnished any glacial sand, gravel or bowlders to its water courses. In this respect the Juniata resembles the Schuylkill river, in whose alluvians no northern drift material is noticeable. The Susquehanna vallies, on the contrary, like the Delaware valley (and for the same reason), are full of secondary northern drift deposits, obtained since the Ice age from the stuff brought southward by the ice as far as the line of the Terminal moraine.

The West Branch Susquehanna flowing past Union county was always a noble river, for it always had Muncy, Loyalsock and Lycoming creeks pouring their waters into it

from the north, the Sinnemahoning and Moshannon waters from the west, and the Bald Eagle waters from the south. But before the ice invaded New York from Canada, and spread over the northeastern counties of Pennsylvania as far south as the Terminal moraine, Kettle creek was a branch of the Genesee river, and Pine creek was a branch of the Tioga river; consequently most of the rainfall of Potter and Tioga counties formerly flowed off into Lake Ontario; whereas now it swells the volume of the West Branch Susquehanna.

The East Branch Susquehanna, which joins the West Branch at Northumberland, and is much the larger river of the two, was formerly as much inferior to it; for it was only fed by the Lackawanna waters in the east, the Fishing creek and Tunkhannock waters on the north, and the Catawissa and Shamokin waters on the south. All the rest—the greater part—of the rainfall of the New York-Pennsylvania state-line region, which now pours its vast volume (often in disastrous floods) down the valley of the North Branch Susquehanna into Chesapeake bay, then—before the Ice age—poured through Canandaigua lake into Lake Ontario at Sodus Point.

Mr. John F. Carll first placed this whole subject of old Lake country drainage on a sound basis by his observations in the oil regions, as referred to in foot-note to page 106, Report I, 1875, and given fully with illustrations in his third report (III, 1880), where he proved that the upper Allegheny river water basin drained through Lake Chautauqua into Lake Erie, and gave reasons for suspecting what is now pretty certain, that the whole Monongahela, Allegheny and upper Ohio water basin was also drained into Lake Erie by the Beaver-Mahoning-Grand River valley

Mr. Carll's summary of his late observations on the Susquehanna waters was given me in a letter dated March 23, 1890, in the following words:

“During the last winter, while doing some field work in central New York, and the counties of Tioga, Bradford and Susquehanna, Pennsylvania, I incidentally made some discoveries in relation to pre-glacial water ways which seem

worthy of record. I intend to embody the facts in a paper to be read before the American Philosophical Society, but my time is so occupied that I cannot do so at present, and, therefore, knowing that you appreciate early information on such subjects, I will state briefly—and perhaps rather dogmatically—what these discoveries are.

“1. An old and deeply-filled river valley exists between Elmira and Seneca lake. The Susquehanna of New York once swept around by Waverly to Elmira and thence passed northward through Seneca lake valley and on, probably through Sodus bay, into the Ontario basin.

“2. The Pine creek waters of Potter county flowed into Tioga river ; thence to the Chemung at Corning ; and thence through Big Flats valley to Horseheads, where they joined the pre-glacial Susquehanna.

“3. Between Corning and Elmira the Chemung river now flows in a new channel, and between it and the old channel (Big Flats) there is a triangular mountain of stratified rock, probably more than 300 feet high.

“4. That part of the Susquehanna between Waverly and Towanda was evidently opened during the Glacial period by the cutting down of two small streams which flowed in opposite directions, and headed on a low point in the pre-glacial divide ; as also was that part of Pine creek between Ansonia and Lloyds in Tioga county.

“In Report 13 I said I suspected the Beaver and Mahoning once flowed into the Lake Erie basin through Grand river valley. Since its publication I have had opportunities of studying the subject further and now feel quite confident of the fact, and that the Allegheny and Monongahela waters went there also.

“I now trace the pre-glacial divide as roughly penciled on the accompanying railroad map, and I think I have sufficient data to warrant doing so.

“Through this divide, three streams—cut during the Glacial period—still continue to deliver southward, viz : Ohio, Pine creek and the Susquehanna.

“It is to be remarked that every glacial cut has its associated glacial fill ; they go in pairs as seen below :

Pre-glacial Divide.

Cut of Ohio River,	. . . Filling in Grand River Valley, Ohio.
Cut of Pine Creek,	. . . Filling in Marsh Creek, Tioga co., Pa.
Cut of Susquehanna,	. . . Filling at Horseheads, N. Y.

North of Pre-glacial Divide.

Cut French Creek,	. . . Filling at Conneaut Lake.
Cut Oil Creek,	. . . . . Filling at Clappsville, Crawford co., Pa.
Cut Allegheny (Thompson's),	. . . . . Filling at Cassadaga Lake.
Cut Allegheny (Big Bend),	. . . . . Filling at Steamburg, N. Y.
Cut Tionesta Creek,	. . . . . Filling at Stoneham.
Cut Chemung,	. . . . . Filling at Big Flats, N. Y.

“There were also temporary drains through the pre-glacial divide during the Ice age: on the west, through the Maumee into the Wabash; on the east, through the Mohawk into the Hudson; and five on the south, as shown in I3, page 373.

“What caused these immensely thick deposits (fills as I have called them) at points which are now the summit divides of modern water-ways, and which always hold either lakes or swamps of considerable dimensions? May it be that, when a southern under-ice drainage had become established, there was a middle ground between the diverging north and south currents where there was little movement in the water, and where all the materials dropped by the ice remained comparatively undisturbed, and thus accumulated rapidly and built up the barrier? At any rate it seems as if quiet conditions prevailed when the barriers were being completed, for the surface deposits always consist of still-water materials.

“The subject is so broad and there are so many complex questions connected with it, that I feel incompetent to deal even with those facts and figures already accumulated. But I enjoy the study, and shall continue to investigate for my own personal gratification, whether it be of any interest to the public at large or not.”

There is a danger to be encountered in this study of glacial topography which must not be ignored—the danger of confounding the old topography with the new; the danger of ascribing to glacial waters the channeling of the great

gorges through which the Susquehanna and Delaware waters now flow. For these must be of *pre-glacial* age, seeing that they are in all respects identical in character with the innumerable gorges and gaps of the great non-glaciated region, where there has never been a change of drainage. For it is only necessary to refer to Tunkhannock creek splitting Elk mountain, Shraeder's creek splitting Towanda mountain, the upper Tioga river splitting Blossburg mountain, Middle creek splitting Tioga mountain, Tangascootac creek splitting the Allegheny mountain, and a score or two more of similar ravines, between vertical walls a thousand feet high, with nothing whatever to do with a glacial change of drainage, to convince any one of the impossibility of ascribing the similar great cross-gorges to glacial water forces, or of limiting their origin at the Ice age. The cross gorge of the Lycoming is precisely like that of Pine creek, and yet it is wholly pre-glacial.

It is plain to any observing eye that the gorges of the upper West Branch, of Pine creek, of Lycoming creek, through which waters now flow south (like the gorges of the Driftwood, the Susquehanna and the Moshannon, in Clearfield county, which waters now flow north) were all and each of them alike made by the general rain-fall descending from the table land through innumerable steep side ravines. The coming of the northern ice found them all substantially completed, and the ice left its burden of terminal moraine upon their steep slopes and bottom beds precisely as it did upon the upland.

It is sufficient to hint at these facts here. They will be more fully discussed in my final report.

J. P. LESLEY.

LETTER OF MR. D'INVILLIERS.

711 WALNUT STREET,
PHILADELPHIA, *May 1, 1889.*

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

DEAR SIR: I have the honor to transmit herewith my report upon the geology of Union, Snyder, Mifflin and Juniata counties, the field work of which was largely carried on during the season of 1888. The high state of cultivation effected through this district between the Susquehanna and Juniata rivers, and its ready accessibility, except in the region of the Seven mountains along the Center county line, made an exploration of its area comparatively easy, while the effective, and in many cases detailed examinations of the field carried on at different times by my predecessors on the First and Second Geological Surveys, had already put on record such a general delineation of its structure and geology as to make extensive repetition of these facts unnecessary.

As the commercial features of the district are confined almost solely to the fossil (Clinton) ore-beds of No. V, the Lower Helderberg limestone of No. VI, and (in the western part of the district) the glass-sand of the Oriskany sandstone formation No. VII, considerable time and attention was given to tracing the outcrops of these three rock-groups; an examination of mines and quarries; and, as far as possible, a correct delineation of their outcrops on the maps. It was hoped that a very complete record of the various ore-mines and the characteristics of the several ore-beds of the Clinton formation might be obtained; but the utter prostration of the iron industry through the Juniata

and Susquehanna valleys for the last two years rendered this impossible.

The two colored geological maps of the four counties.

In the construction of the four county maps accompanying this report every effort was made to use all reliable data which could be obtained during the progress of the survey: but as much valuable material regarding the courses and distances of the various county lines was submitted too late for any practical use, owing to the advanced stage of the map-construction and the conflicting testimony of some of the lines, it was deemed best to use this data only as far as it was possible to do so without doing violence to points already established by railroad surveys and township reductions.

All this material has great relative value however, and in order to preserve it as a record for future compilations and corrections, the correspondence is published below.

The general base for all the county maps was established by reducing to one common scale of one mile to one inch all the railroad maps kindly furnished by the Pennsylvania, Northern Central, Philadelphia and Erie, and the Philadelphia and Reading railroad companies, by which means the location of towns, villages and large streams were fixed with comparative accuracy.

Unfortunately the failure to obtain any good map of the main line of the Pennsylvania Railroad from Rockville, or Marysville, west, along the Juniata to Mt. Union, prevented the establishment of points along that river in Juniata and Mifflin counties with definite accuracy. And while an attempt was made to fix the location of Lewistown Junction by a reduction of right-of-way maps along the main line, with a common point determined by independent plottings of the Sunbury and Lewistown railroad, such violence was done to township maps of Juniata and Mifflin county as to make their use absolutely impossible.

With Rockville and Selinsgrove Junctions as fixed points therefore, the lines of the Sunbury division and main line were each swung slightly to meet at a common point, Lewistown; with the possible effect of slightly warping a por-

tion of the western townships of Snyder county, along the railroad. The integrity of both lines as a whole was maintained, however, in this manner; and the river line west of Lewistown was made to conform as far as possible to the Mifflin county maps, inasmuch as the railroad line was very indefinitely located. Upon the scale used, however, the general position of places cannot be far wrong.

Little or no information could be obtained from the county seats concerning the county lines; but, with the exception of Juniata county, the several letters published below give the best obtainable data bearing upon the courses and distances of the county lines of Mifflin, Union and Snyder. The map of Union and Snyder counties shows both the old and the new dividing line along Jack's mountain.

My thanks are due the following gentlemen for information and assistance kindly rendered during the progress of the survey:

Messrs. R. H. Lee and R. H. Lee, Jr., of Logan; Messrs. Horace Culbertson, W. M. Phillips, of Lewistown; Hon. W. P. Stevenson, of McVeytown; G. R. Jacobs and W. H. Groninger, of Mifflintown; Hon. J. C. Bucher, of Lewisburg; Dr. Levi P. Rook, of Winfield; Mr. A. C. Simpson, of Selinsgrove; Dr. A. M. Smith, of Adamsburg; Mr. James M. Middelsworth, of Troxellville; Mr. Levi Kepler, of Mt. Pleasant Mills; Mr. John Swartzell, of Siglerville, and Mr. A. K. Gift, of Middleburg; and to the Pennsylvania railroad, Northern Central railroad, and Philadelphia and Reading railroad companies.

Thanking you very much for the courteous assistance you have always rendered me in connection with this report,

I am, very respectfully, yours,

E. V. d'INVILLIERS.

Letter of Mr. John Swartzell relative to Mifflin County boundaries.

SIGLERVILLE, September 29, 1888.

MR. E. V. d'INVILLIERS

DEAR SIR: Inclosed you will find the courses and distances of the several lines bounding the county of Mifflin, which I have collected from various sources since I received your letter. Some of the lines between

Mifflin and Juniata are not very reliable; and the lines having been surveyed at various dates, and some of them with adjusted compasses, you may find considerable difficulty in bringing your lines to close.

The following courses and distances begin at a Buttonwood on the northeast side of the Juniata river 160 perches below Drake's old ferry house thence across the said river, south 2° east 26 perches to a post on the Huntingdon county side of river. Thence along the shore of same, giving the river to Mifflin county by the following courses and distances, including the line across the river already given from the Buttonwood tree:

COURSES AND DISTANCES OF MIFFLIN COUNTY LINES.

	<i>Course.</i>	<i>Perches.</i>		<i>Course.</i>	<i>Perches.</i>
0,	S. 2° E.	26	49,	N. 76° E.	7.5
1,	N. 80½ E.	17	50,	N. 88 E.	29
2,	N. 61 E.	12	51,	N. 86½ E.	15
3,	N. 80 E.	10.4	52,	N. 81 E.	26
4,	S. 83½ E.	12.8	53,	S. 71¾ E.	23
5,	N. 75½ E.	16	54,	S. 52¾ E.	22
6,	N. 68¼ E.	12.2	55,	S. 51 E.	26
7,	N. 58 E.	80	56,	S. 38½ E.	37.3
8,	N. 70 E.	28	57,	S. 23¼ E.	19
9,	N. 85½ E.	16	58,	S. 35 W.	17.7
10,	S. 79½ E.	18	59,	S. 11 E.	12
11,	S. 75 E.	26	60,	S. 36½ E.	14.5
12,	S. 58½ E.	21.2	61,	S. 69 E.	12
13,	S. 54 E.	11.5	62,	N. 48¾ E.	10.4
14,	S. 23 E.	11.5	63,	N. 62 E.	32
15,	S. 1½ W.	18	64,	S. 87½ E.	22.4
16,	S. 15½ W.	26	65,	S. 63 E.	64
17,	S. 24½ W.	34	66,	S. 47¼ E.	22
18,	S. 29 W.	47.8	67,	S. 55½ E.	22.3
19,	S. 16½ W.	33.2	68,	S. 66 E.	28.8
20,	S. 4½ W.	27.8	69,	S. 71½ E.	38.5
21,	S. 11 E.	25	70,	S. 88 E.	23
22,	S. 19¼ E.	143	71,	N. 73 E.	22
23,	S. 20 E.	28	72,	N. 55 E.	76
24,	S. 15½ E.	14.6	73,	N. 34½ E.	22
25,	S. 24 E.	16	74,	N. 25 E.	27
26,	S. 32 E.	27	75,	N. 33¼ E.	52
27,	S. 43 E.	33	76,	N. 18 E.	10.5
28,	S. 32 E.	26.4	77,	North	11 to
29,	S. 24½ E.	12.4	pine. This closes the river lines.		
30,	S. 19 E.	13.2	Thence by Blue Rock hill.		
31,	S. 28 E.	11.2	78,	East	844.7 to
32,	S. 41 E.	18	stones on top of Black Log mountain. Thence along the summit.		
33,	S. 60 E.	21	79,	N. 37 E.	107
34,	S. 72½ E.	38.8	80,	N. 25 E.	46.5
35,	S. 31 E.	10	81,	N. 37 E.	121 to
36,	S. 40 E.	13.2	stones, across Aughwick, in old county line, abandoned. Continued along summit.		
37,	S. 53 E.	36	82,	N. 37 E.	122.7 to
38,	S. 68¼ E.	13.5	stones near a red oak marked M. & J., which is the place where David Hough, I. W. Allen and R. G. Hays began the line of Mifflin and Juniata counties the 12th day of June, 1845.		
39,	S. 78 E.	33	See continuation on next page.		
40,	N. 82 E.	26.8	Mifflin and Juniata.		
41,	N. 87 E.	13.8			
42,	N. 59½ E.	22			
43,	N. 73 E.	20			
44,	N. 77½ E.	10.5			
45,	N. 42 E.	48			
46,	N. 50 E.	23.5			
47,	N. 54 E.	18.2			
48,	N. 58 E.	12			

The foregoing lines all adjoin Huntingdon county, except the 122.7 rod line which is a line of Mifflin and Juniata. The following are the lines between Mifflin and Juniata counties, beginning at the east end of the 122.7 rods, thence along the summit of Black Log mountain, N. 30° E. 62 ps. to Chestnut, N. 45° E. 178, N. 40° E. 220, N. 45° E. 882, N. 47° E. 1240, N. 45° E. 820, thence across Licking Creek valley N. 20° E. 752 to top of mountain, thence by same, N. 55° E. 2816 ps. to stones, thence north at 420 across the Juniata river, in all 700 ps. to top of Shade mountain, thence along the summit of same, N. 50 E. 200, N. 55 E. 100, N. 60 E. 1346, N. 65 E. 680, N. 68 E. 1317, to the pine corner in line of Snyder county. Thence along the line of said Snyder county N. 79 W. 3 miles 179 perches to a chestnut-oak, thence north 10 miles 7 ps. on North side of Penn's creek to a stone, thence N. 55½ W. 114 to old gum, corner of Centre and Union counties. Thence by line of Centre county S. 83½ W. 99 to old hemlock corner.

I now leave this point and go back to the buttonwood on the northeast side of the Juniata river 160 perches below Drake's old ferry house, thence by line of Huntingdon county, N. 72½ W. 270 to stones on top of Jack's mountain, thence along the summit of same, N. 1° W. 448, N. 65 E. 128, N. 40 E. 91, N. 20 E. 114, N. 40 E. 86, N. 45 E. 122, N. 35 E. 122, N. 40 E. 264, N. 32 E. 91, N. 38 E. 130, N. 32½ E. 68, N. 39½ E. 61, N. 34 E. 230, N. 31 E. 136, N. 37½ E. 54, N. 11½ E. 15, N. 31 E. 32, N. 38¼ E. 162, N. 50 E. 36, N. 40 E. 30, N. 48½ E. 194, N. 45½ E. 44.6 to a Juneberry, thence N. 27 E. 15, N. 42 E. 224, N. 52 E. 132, N. 50 E. 558 (the line across Kishacoquillas valley has never been definitely settled and remains a disputed question), thence across Kishacoquillas valley, N. 48 W. 1092 perches to top of Stone mountain, thence along the same, N. 30 E. 758, N. 38 E. 742, N. 40 E. 200, N. 45 E. 530, N. 58 E. 178, N. 54 E. 249, N. 50 E. 202, N. 60 E. 84, N. 50 E. 192, N. 45 E. 78, north 72, N. 60 E. 298, N. 47 E. 326 to maple, N. 43 W. 940 to corner of Centre county, thence by line of same N. 60° E. 2 miles, N. 65 E. 1 mile, N. 60 E. 73 perches, N. 45 E. 247 perches, N. 70 E. 4 miles, N. 60 E. 1 mile, N. 65 E. 9 miles, N. 72 E. 3 miles, to the old hemlock corner, being the place at which I stopped in above notes at west end of line, S. 83½ W. 99 rods.

The foregoing field notes I have copied from the work of various surveyors, and from other sources. I am unable to give you any information respecting the lines of Juniata county.

Very respectfully,

JOHN SWARTZELL.

Description of Courses and Distances of Union County Lines.

Submitted by Mr. R. F. BROWN, *Lewisburgh, Union, Co., Pa.*

Beginning at a marked marble stone, on the west bank of the West Branch of the Susquehanna river, thence along Lycoming county, N. 74¼ W. 3 mi. 122 ps. to a marked stone, by same, S. 16¼ W. 4 mi. 112 ps. to a stone heap on the summit of White Deer mountain. Thence by same, N. 88 W. 4 mi. 252 ps. to a stone—by same, S. 72¼

W. 2 *mi.* 212 *ps.* to stones—by same, *N.* 88 *W.* 1 *mi.* 139 *ps.* to a marked stone in the Lycoming county line. Thence along Clinton county, *S.* 2 *W.* 1 *mi.* 151 *ps.* to Tea Spring—on the Sugar Valley Turnpike. Thence along Centre Co. *S.* 44 $\frac{1}{4}$ *W.* 5 *mi.* to a marked stone in the Brush Valley Narrows. Thence by same, *S.* 38 $\frac{3}{4}$ *W.* 7 *mi.* to a marked stone on the Penn's Valley turnpike. Thence by same, *S.* 49 $\frac{1}{2}$ *W.* 6 *mi.* 40 *ps.* to a gum corner-tree, of Union, Centre and Mifflin counties. Thence along Mifflin county *S.* 53 $\frac{1}{2}$ *E.* 119 *ps.* to a stone on the north side of Penn's Creek.—Thence along said Mifflin county, *S.* 2 $\frac{1}{2}$ *W.* 2 *mi.* 203 *ps.* to a marked stone on the summit of Jack's mountain, and corner of Snyder county. Thence along Snyder Co. *N.* 74 *E.* 1 *mi.* 306 *ps.* to a pitch pine. Thence along the summit of the said Jack's Mountain and Snyder Co. *N.* 80 *E.* 10 *mi.* 128 *ps.* to a pitch pine; along same, *N.* 75 *E.* 3 *mi.* 25 *ps.* to a white pine; along same, *S.* 89 $\frac{1}{2}$ *E.* 1 *mi.* 41 *ps.* to a marked stone on the west side of Penn's Creek. Thence down along the south side of Penn's Creek, *S.* 57 $\frac{1}{2}$ *E.* 27 *ps.*—*S.* 43 $\frac{1}{2}$ *E.* 22 *ps.*—*S.* 34 $\frac{1}{2}$ *E.* 32 *ps.*—*S.* 48 *E.* 18—*S.* 71 *E.* 43—*S.* 57 $\frac{1}{2}$ *E.* 22—*S.* 20 *E.* 26—*S.* 25 *E.* 24—*S.* 65 *E.* 24—*S.* 55 *E.* 13—*S.* 78 *E.* 36—*N.* 72 *E.* 41—*N.* 30 *E.* 27—*S.* 70 *E.* 30—*S.* 84 *E.* 40—*S.* 34 $\frac{1}{2}$ *E.* 68—*S.* 31 *E.* 124—*S.* 83 *E.* 22—*N.* 80 *E.* 26—*N.* 88 *E.* 35—*S.* 51 $\frac{1}{2}$ *E.* 135—*N.* 6 $\frac{1}{2}$ *E.* 61—*N.* 51 $\frac{1}{2}$ *E.* 36—*N.* 25 *E.* 53—*N.* 27 *E.* 18—*N.* 69 $\frac{1}{2}$ *E.* 32—*N.* 56 *E.* 30—*N.* 61 $\frac{1}{2}$ *E.* 48—*N.* 74 $\frac{3}{4}$ *E.* 26—*S.* 89 *E.* 43—*S.* 77 *E.* 15—*S.* 65 *E.* 31—*N.* 87 $\frac{1}{2}$ *E.* 24—*N.* 60 $\frac{1}{2}$ *E.* 27—*N.* 17 $\frac{1}{2}$ *E.* 41—*N.* 50 *E.* 8—*N.* 70 *E.* 10—*S.* 83 $\frac{3}{4}$ *E.* 26—*N.* 82 $\frac{3}{4}$ *E.* 58.—*N.* 89 $\frac{1}{2}$ *E.* 9—*S.* 79 $\frac{1}{2}$ *E.* 30—*S.* 72 $\frac{1}{2}$ *E.* 23.5—*N.* 78 *E.* 34—*N.* 83 *E.* 46—*S.* 81 *E.* 40—*N.* 75 *E.* 55—*N.* 83 $\frac{1}{2}$ *E.* 27—*N.* 55 *E.* 52—*N.* 59 *E.* 12.2—*N.* 21 *E.* 36—*N.* 56 *E.* 16—*N.* 76 $\frac{1}{2}$ *E.* 31—*N.* 88 *E.* 17—*N.* 78 *E.* 84—*N.* 82 *E.* 34—to a marked stone on the south side of Penn's Creek. Thence across said Penn's Creek, *N.* 45 $\frac{1}{2}$ *E.* 32, to a marked stone on the north side of Penn's Creek, and on the south side of the public road leading from New Berlin to Northumberland. Thence along the south side of said road *N.* 71 $\frac{1}{4}$ *E.* 22—*N.* 78 $\frac{1}{4}$ *E.* 14—*N.* 80 $\frac{1}{2}$ *E.* 68—*N.* 77 $\frac{1}{2}$ *E.* 41.2—*N.* 83 $\frac{1}{2}$ *E.* 34—*N.* 76 $\frac{1}{2}$ *E.* 27—*N.* 45 *E.* 15.5—*N.* 57 *E.* 20—*N.* 61 $\frac{1}{2}$ *E.*

12—N. 74 E. 29—S. $81\frac{1}{2}$ E. 33.5—S. 74 E. 42—S. 72 E. 32—S. $81\frac{1}{2}$ E. 16—E. 69—S. $85\frac{1}{2}$ E. 48—S. $67\frac{1}{2}$ E. 52—S. 60 E. 13—S. 68 E. 40.4—S. 65 E. 42—S. $74\frac{1}{2}$ E. 55—S. 80 E. 52.5—S. 88 E. 28—N. $86\frac{1}{2}$ E. 42—S. 88 E. 26—N. $89\frac{1}{2}$ E. 43—N. $77\frac{1}{2}$ E. 38—N. 79 E. 129.5—N. 76, E. 20—N. $62\frac{1}{2}$ E. 7—N. 59 E. 33—N. 65 E. 25—N. 85 E. 6—N. 64 E. 82—S. $77\frac{1}{2}$ E. 14—S. $65\frac{1}{2}$ E. 13.5—S. 69 E. 67.3—S. $41\frac{1}{2}$ E. 18—S. 62 E. 38—N. 89 E. 21—N. $80\frac{1}{2}$ E. 27—N. 68 E. 57.5—N. $74\frac{1}{2}$ E. 47.5 to a post on the south side of the road. Thence across the aforesaid road N. 15 W. 2 to chestnut on north side of the road. Thence along north side of said road, N. 75 E. 51—N. 77 E. 69.5—N. 82 E. 35.5—N. 77, E. 31—E. 31.5—S. 83 E. 24—S. 69 E. 28—S. $71\frac{1}{2}$ E. 23.7—S. 24 W. 8.2—S. 49 E. 29.6—S. 50 E. 6—S. 20 E. 16.4—S. 89 E. 42—E. 106.5—N. 78 E. 30—N. 75 E. 58—N. 64 E. 19—N. 51 E. 17—N. $29\frac{1}{4}$ E. 18—N. 86 E. 4—S. $59\frac{1}{2}$ E. 16—S. $52\frac{1}{2}$ E. 26—S. $55\frac{1}{2}$ E. 28—S. 59 E. 26—S. 87 E. 11.2—N. $79\frac{1}{2}$ E. 27.2—N. 87 E. 29—S. 69 E. 13—S. $28\frac{1}{2}$ E. 24—S. $58\frac{1}{2}$ E. 37—S. $56\frac{1}{2}$ E. 42—S. 52 E. 23—S. 46 E. 81—S. 50 E. 20—S. 44 E. 24—S. 34 E. 25.5—S. $60\frac{1}{4}$ E. 24—N. $89\frac{1}{2}$ —E. 12—N. $77\frac{1}{2}$ E. 9—N. $88\frac{1}{2}$ E. 36—N. 82 E. 16—N. 77 E. 24—S. 84 E. 14—S. $58\frac{1}{2}$ E. 11—N. 58 E. 6—N. $4\frac{1}{2}$ W. 14—N. 11 W. 36—N. 19 W. 18—to the Northumberland Bridge, across the West Branch of the Susquehanna at the mouth of the North Branch. Total distance from the end of Jack's mountain to said bridge 15 mi. 87.9 perches. Thence up along the west bank of the West Branch of the Susquehanna, its several courses and distances to the place of beginning.

NOTE.—The above manuscripts are plainly written, and have been carefully proof read. If they fail to plot correctly it will be from (1) errors in running the lines, (2) errors in the running notes, or (3) errors in copying (or re-copying) from the note books. (J. P. L.)

CHAPTER I.

Area, Topography and Drainage.

The region treated of in this report, comprising the counties of Union and Snyder on the east, Mifflin and Juniata on the west, lies between the West Branch of the Susquehanna river and the Juniata river at Mt. Union, bounded generally north and south by mountain walls of the Seven mountains (under various local names) and the Tuscarora mountain.

It makes a belt of valley and mountain land with extreme dimensions of 64 miles east and west, and 30 miles north and south, but with a total area, according to the tenth census, of only about 1,410 square miles, divided as follows: Union, 310; Snyder, 320; Mifflin, 380, and Juniata, 400.

Union and Snyder Counties.

The *Susquehanna river* forms the eastern line of both Union and Snyder counties for 33 miles, 22 miles in Union down to Sunbury, and 16 miles in Snyder to Mahantango creek.

The *Lycoming county line* on the north runs west from the river for about 3 miles and then S. S. W. over 4 miles across the valley of White Deer Hole creek to the summit of White Deer mountain, and west along this mountain for 8 miles to the Clinton county corner.

The *Clinton county line* is nearly north and south, 2 miles long from the mountain to the Tea spring in Sugar valley.

The *Centre county line* cuts diagonally southwest across the several ridges of the Buffalo mountains for 18 miles to a common corner of Union, Centre and Mifflin.

The dividing line between Mifflin, and Union and Snyder counties, bears nearly north and south for about 9 miles,

crossing Jack's mountain and the valleys of Penns and Middle creeks. The south line of Snyder is largely a common one with Juniata, running along the west branch of Mahantango creek for about 10 miles, and then a straight line for 10 miles across the Shade mountain.

Jack's mountain forms a common divide between the two counties for 16 miles west of Centerville and Penns creek, and a county road for an equal distance to Sunbury, so that the Union-Snyder line is about 32 miles in length. The two counties together form a roughly trapezoid shape, with its long base along the river for 38 miles and its shorter parallel line along Mifflin county only 9 miles long.

Straight lines drawn from either end of this shorter line to the extremities of the river line would be about 31 miles on the north or Centre county side and 22 miles on the south or Juniata county side.

Mifflin and Juniata Counties.

Mifflin and Juniata counties together form a block of somewhat larger area than Union and Snyder, and lie immediately west of these two counties. Their eastern boundary line is a common one with the western line of the two smaller counties.

The northern or Centre-Huntingdon county line is an irregular one extending west along the different spurs of the Seven mountains from the gum-tree corner in Penns valley to a buttonwood on the northeast side of the Juniata river, 160 rods below Drake's old ferry house, an air line distance of about 40 miles, but 48 miles long by measurement along the different mountain offsets. Nine miles of the west end of the line is along the crest of Jack's mountain, after which it crosses the Kishacoquillas valley in the vicinity of Allenville to Stone mountain, keeping that crest to the Centre county corner.

The western boundary of these two counties is formed by the Juniata river to a pine at the neck of the big bend near the mouth of Sugar valley; thence east for about 2½ miles to the summit of Black Log mountain, a common corner of Mifflin, Juniata and Huntingdon. From here the

west line of Juniata runs a few degrees west of south for about $8\frac{1}{2}$ miles, across the Tuscarora valley to the summit of Tuscarora mountain. This mountain crest forms the south boundary all the way to the Juniata, about 35 miles, with but one prominent offset across Liberty valley, south of Honey Grove.

At the Juniata the line is again offset northwards $1\frac{1}{2}$ miles to the crest of the Flint ridge, from whence it courses eastward for a mile to the crest of Turkey ridge, along which it runs for something over 12 miles to the Susquehanna river, $1\frac{1}{2}$ miles south of the west branch of the Mahantango creek.

Black Log mountain forms the dividing line between Mifflin and Juniata counties for $10\frac{1}{2}$ miles, where the line crosses northeast across Licking Creek valley to the summit of the Blue ridge, and along that crest $8\frac{1}{2}$ miles to the spur facing the Juniata river at the "Narrows;" crosses the river $1\frac{3}{4}$ miles to the crest of East Shade mountain and east along that crest for 12 miles to the Snyder county line.

Topography.

The four county maps accompanying this report will, with the aid of the scheme of colors on their margin, readily explain the prominent topographical features of the district and the cause for much of the drainage. Bearing in mind the fact that the brown and yellow colors on the map indicate in a general way the mountain and ridge areas of the district, while the red and blue tints show the valleys, the general position of farm and hill land can be readily located. This statement may be farther modified in speaking of the eastern and western divisions of the district.

In *Union and Snyder counties*, for instance, the blue tints, representing areas covered by the upper Salina and Lower Helderberg shales, marls and limestones, contain the best farming lands and generally create a gently undulating country, well adapted for cultivation and almost entirely cleared of its timber.

The light red and dark brown tints show respectively the Clinton and Marcellus, Hamilton, Chemung, etc., areas, not

so fertile ; contain more sandstone, very little limestone and are more cut up into narrow ridges and deep valleys, making farming more difficult and less remunerative.

The bright red bands of color curving sinuously through these two counties, represent the *Bloomsburg red shale* or lower Salina formation, making almost everywhere a low ridge, conspicuous for its light soil of a deep red color, and the peculiar cleavage of the rocks, and all through these two counties is an unerring dividing line between the richer limestone soils above and the leaner shale soils below and closer to the sandstone mountains.

In *Mifflin and Juniata counties*, owing to the occurrence of other dark red bands in the Clinton formation, and the difficulty, if not impossibility, of always determining their relative geological horizon, *all* the land between the mountain sandstone rock No. IV and the Lower Helderberg (Lewistown) limestone belt No. VI, has been colored a uniform light red ; and therefore in this portion of the district the large farming areas will be indicated by this red tint and of course by the blue limestone tints in the Lewistown, Kishacoquillas and Tuscarora valleys.

It must not be supposed that this western area is devoid of the valuable marls and shales occurring just beneath the Lewistown limestone, which cover so large an area in the Buffalo, Penns and Middle Creek valleys further east. These same rocks are present in Mifflin and Juniata in as great or greater thickness ; but, as will be presently explained, they outcrop with steeper dips and frequent repetitions here instead of lying nearly flat as they do along the Susquehanna ; hence the fertile valleys are narrow and extend for long distances east and west, but without much breadth of surface north and south.

The district as a whole presents an exceedingly diversified topography, due to a series of generally parallel mountain ranges of the Oneida and Medina sandstone No. IV, curving gently to the southwest with a crescent shape, and between whose high sandstone walls beautiful and fertile valleys have been eroded in the softer shales and limestones of the Clinton, Salina and Marcellus measures. In-

intermediate ridges, formed of the sharp sand and chert rocks of the Oriskany No. VII, Chemung No. VIII, and the Catskill No. IX sandstone, help to further modify the topography of the large valleys; but the Buffalo and Penns creek valleys on the east, and the Lewistown, Kishacoquillas and Tuscarora valleys on the west are preëminently garden spots in an agricultural sense, and rendered all the more beautiful and conspicuous by reason of the rugged mountain walls enclosing them.

Along the western line of Union county the map will show seven spurs of the Buffalo mountains, occurring *en échelon* like the fingers of a hand, each one from the south northward projecting a little further eastward into the Buffalo valley and nearer the Susquehanna river. All of these anticlinal spurs are composed of the same sand rocks, Oneida and Medina Nos. IV a, IVb and IVc, brought up by repeated folds in the rocks, and between them occur synclinal valleys of the lower Clinton rocks No. V.

There is still considerable confusion regarding the names of these mountain spurs owing to the many local names they have been given; but leaving out their sub-divisions, enclosing narrow anticlinal valleys of Hudson river slate No. III, their generally accepted names are as follows, from north to south:

- | | | |
|---|--------------------------------|--------------------|
| | 1—White Deer Mountain. | |
| | a— <i>White Deer Valley.</i> | |
| | 3—Nittany Mountain. | |
| | b— <i>Spruce Run Valley.</i> | |
| | Sand Mountain. | |
| 3 | Buffalo Mountain. | |
| | Seven Notch Mt. | |
| | c— <i>Rapid Run Valley.</i> | |
| | Shriner's Mountain. | |
| 4 | Jones Mountain. | |
| | Dull Mountain. | |
| | d— <i>North Branch Valley.</i> | |
| 5 | Little Buffalo Mountain. | |
| | e— <i>Laurel Run Valley.</i> | |
| 6 | Paddy's Mountain. | |
| | f— <i>Penns Creek Valley.</i> | |
| 7 | White Mountain. | |
| | g— <i>Weikert Run Valley.</i> | |
| 8 | Jack's Mountain. | Shamokin Mountain. |

Of all these mountain ridges only Nos. 6, 7 and 8 pass into Mifflin county.

Paddy's mountain, closing around the head of Panther Run valley, forms the Mifflin-Centre county line, and is here best known as *Long mountain*.

White mountain, split in two by the northern anticlinal axis of the Kishacoquillas valley, divides to admit the Havise valley, about 4 miles west of the Union county line, and its southern half extends west about 8 miles into Mifflin county, where it dies away in the Kishacoquillas valley at Strong's Knob.

Triester Valley, to the south of Strong's Knob, occupies the eroded crest of the middle anticlinal of the Kishacoquillas valley, and is shut in at its eastern end between opposing walls of the Jack's mountain anticlinal, about a mile inside the Union county line, the mountain itself running eastward and gradually declining in height and breadth 14 miles to Centerville, where it is cut off by Penns creek. *Shamokin mountain*, about $4\frac{1}{2}$ miles long, is a direct continuation of Jack's mountain. It is composed of the same rocks and occupies an intermediate position between Centerville and the Susquehanna river.

Beatty's Knob, in Mifflin county, between Triester and New Lancaster valleys, extends a short distance further west than Strong's Knob, and like it is a synclinal spur formed by the northern sub-division of Jack's mountain. The New Lancaster valley to the south heads up about one-half a mile into Snyder county; and 5 miles further east the opposing sandstone walls come together in High Top on the south side of Swift run, creating a spur *topographically* like Strong's and Beatty's knobs, but *structurally* an anticlinal instead of a synclinal.

The south wall of Jack's mountain overlooking the Lewis-town valley courses west in a high straight monoclinical ridge for 14 miles to the Logan gap, and for 30 miles further west to the Mt. Union gap of the Juniata. Throughout the entire length of this remarkably straight and noble mountain, nearly 60 miles long between Centerville and Mt. Union, there are but two water gaps, at Logan and Mt.

Union, giving access from the south to the beautiful Kishacoquillas valley.

This equally remarkable valley, composed of an undulating floor of Lower Silurian limestone, and flanked on either side by the Hudson River slates No. III, hemmed in by Standing Stone, Long and Paddy's mountains on the north and Jack's mountain on the south, is about 30 miles long and 4 miles wide at its widest part in Mifflin county; but its western extremity, about 5 miles long, is in Huntingdon county, giving about 25 miles to Mifflin county. Like the mountain enclosing it, it is not straight, but curves southwest in a crescent shape, with the bow or apex of the curve pointing northwards.

At its eastern end it is sub-divided by the spurs already mentioned into three separate and narrow valleys: *Havise valley* on the north, *Triester valley* in the center and *New Lancaster valley* on the south, each having its own anticlinal axis.

Standing Stone mountain, the main northern boundary wall of the main valley west of Milroy, terminates eastward in a synclinal spur known as *Straley's* or *Baird's Knob*, immediately in line with Strong's Knob, forming part of the Broad mountain range. Further east Long or Paddy mountain bounds the valley on the north.

Buffalo valley, in Union county, is similarly modified by a series of anticlinal and synclinal flexures, none of which, however, have any special names. The anticlinal mountain prongs of the Buffalo mountains, coming in from Centre and Mifflin counties, narrow the valley considerably along the northwest county line.

Geologically the deepest part of the valley lies just north of Lewisburg, where, as the map will show, there is a canoe-shaped trough of the Marcellus and Hamilton shales and slates, encircled by the Oriskany and Lower Helderberg limestone.

Two other detached areas of these latter groups are shown on the Union county map south of Mifflinburg; but the greater part of Buffalo valley is composed of the Salina marls and shales and the Clinton rocks, spreading out over

all that portion of the county east of the Buffalo mountain and north of Jack's mountain, and at once accounting for the singularly fertile nature of its soil.

Jack's mountain forms a natural geographical and topographical division of the district under review, and to a large extent, as will be presently seen, a geological division as well.

The southern district of Snyder, Juniata and the lower half of Mifflin county form together a belt of country about 56 miles long between the Susquehanna and Huntingdon county lines, and from 20 miles wide on the east to 13 or 15 miles wide on the west. Jack's mountain forms its northern boundary wall; Tuscarora mountain and Turkey ridge its southern boundary.

Shade mountain further divides it into two nearly equal parts. This great mountain, second only in importance to Jack's mountain in its effects upon the topography and economical geology of the district, is really divisible into three divisions, arranged somewhat *en échelon* as follows:

1st. *East Shade mountain*, extending from a point about 8 miles west of Selinsgrove for 25 miles to the Juniata river below Lewistown; an anticlinal ridge shaped like an up-turned canoe, its two sandstone rims forced apart in the center to admit of a slate valley about 10 miles long, and closing up at either end to form sandstone knobs like those seen at the ends of the spurs of the Buffalo mountain group.

2d. *The Blue Ridge mountain*, another double-crested anticlinal ridge of the Oneida and Medina sandstones, which extends from the Juniata river at Grahamville west for nearly 25 miles to the Big Bend of the same river south of Newton Hamilton. For the first 10 miles, as far west as Minehart's gap, it marks the county line between Mifflin and Juniata. Unlike the East and West Shade mountains, its crest is not split open, and being without water gaps or roads, it practically forms a rugged barrier to communication between the two counties.

3d. *West Shade and Black Log mountain*, which rises about 4 miles west of the river at Mifflintown, and extends for 20 miles through the district to the Huntingdon line.

The map coloring will show how this mountain is a single anticlinal range of Medina sandstone for the first $3\frac{1}{2}$ miles of its course westward. The increasing strength of the anticlinal uplift then begins to part its crest to admit of the red Medina sandstone, and from this point the northern division is known as the *Black Log mountain* and the southern as the *Shade* or *West Shade mountain*. Both are composed of the same rocks with opposing dips, and in 8 miles have been shoved far enough apart to admit of a high knob of the Oneida sandstone, on to which the county line runs from Blue Ridge at Minehart's gap.

This Oneida range in turn becomes divided, just as was the case in the East Shade mountain, to admit first of the Hudson River slates and finally the Trenton limestone of the Black Log valley.

Licking Creek valley intervenes between the Blue Ridge and the West Shade mountains, forming a narrow basin of the Clinton rocks, while to the south of the last-named mountain the Tuscarora valley stretches from the Juniata river into Huntingdon county.

The Lewistown valley, facing the West Shade mountain range on the north, and extending north to the base of Jack's mountain, is surpassingly beautiful and highly cultivated, and being watered for more than half its length by the Juniata river, which flows through it longitudinally from Mt. Union to the "Juniata Narrows," it has commended itself to the attention of agriculturists for many years.

Between mountain and mountain, north and south, and the Snyder county line and the Juniata river below Mt. Union, the valley is about 6 miles wide and 36 miles long, entirely within Mifflin county, but with proper allowance for the mountain slope and the interior ridges of the Oriskany sandstone which stretch in long parallel lines from end to end, the arable portion of the valley will not average more than 4 miles in width.

Its rocks consist of Clinton, Salina, Lower Helderberg, Oriskany and Devonian formations. Structurally it is a wide synclinal trough, deeper at the two ends than in the middle, and, therefore, having the largest areas of the

Devonian rocks on the east and west, but containing numerous subordinate rolls near the center, which duplicate the rock outcrops and cut the main valley into several narrow troughs, bearing local names.

It is almost everywhere highly cultivated, except along the barren Oriskany sandstone ridges, which, however, in this county yield large quantities of sand useful for glass manufacture.

The Tuscarora valley, to the south of West Shade mountain range, is watered throughout its length by the Tuscarora creek and its branches; but by reason of its prevailing rock strata, the shales, slates and sandstones of No. VIII, it is by no means as fertile and largely cultivated as the Buffalo and Lewistown valleys.

The maps will show how these No. VIII rocks, scarcely a mile wide on the Juniata at Port Royal, gradually increase to 3 miles in width westward on the Huntingdon county line, and in the same proportion reduce the amount of arable lands between the Shade and Tuscarora mountains. Much of this land will of course be reclaimed in time for farming purposes by the liberal use of lime and fertilizers, but at present it is quite densely wooded, and its many steep hillsides and narrow valleys do not invite cultivation to the same extent as more favorable land near by. On either side of it, forming as it were interior boundary walls of much less height than the main mountains, runs a ridge of Oriskany sandstone or chert, producing a still more barren soil, and from its physical condition everywhere unfit for use as glass sand.

The best farming land lies between these ridges and the foot of the mountains, and the cause for it is readily discerned. These belts of land, though somewhat narrow, are underlaid by the same limestones, marls and shales which make the Lewistown, Buffalo and Penns creek valleys, and as frequent water gaps cut through them into the Tuscarora valley, it is to be expected that the limestone rocks which outcrop so favorably for quarrying will soon be utilized to repair and improve the harsher soil of the main valley.

Tuscarora mountain forms the south wall of this valley from the Juniata east of Thompsontown to the Huntingdon county line. Composed of the same No. IV rocks as the various other mountain ranges of the district, it produces similar topographical effects. From the river west to the Liberty Valley gap south of Honey Grove it forms a comparatively straight wall without a single water gap for about 22 miles. It is of anticlinal structure, one-half of the mountain being in Juniata and the other half in Perry.

South of Honey Grove it is offset southwards, enclosing the Liberty valley of Clinton rocks between its two divisions, and extends for 12 miles more in the district to Huntingdon county.

Turkey ridge forms the north wall of the Tuscarora valley and the Juniata-Perry county line east of the Pennsylvania railroad all the way to the Susquehanna river; but it is composed of Hamilton sandstone No. VIII, a much higher geological formation than the Medina No. IV and here forming a ridge almost as high as the mountain.

The Oriskany sandstone, colored yellow on the map, makes a series of zigzag ridges through the eastern portion of Juniata county enclosing the valley of the Cocolamus and Mahantango creeks, composed of the Marcellus, Hamilton, Portage and Chemung rocks of No. VIII, a valley in many respects like the Tuscarora further west. Like it, its width is only a mile between Port Royal and New Mexico on the Juniata; along the Mahantango, south of Rickfield, 7 or 8 miles wide; and on the Susquehanna 10 to 12 miles wide, where it deepens to receive a small boat-shaped area of the Catskill rocks north of Port Trevorton.

For reasons already fully explained in treating of the Tuscarora valley, the choice farming lands of eastern Juniata and southern Snyder all lie behind the Oriskany sandstone ridges, and owing to the repeated folds in these rocks and the elevation of the main basin going towards the Juniata, large areas are occupied there by the Lower Helderberg limestone and Salina marls and shales, so that magnificent farms occupy most of the territory between the Tuscarora and East Shade mountains.

The farming land narrows conspicuously along the south side of Shade mountain in Snyder county, although in this portion of the district, owing to superior facilities for marketing the product, the country occupied by the No. VIII rocks is more largely cleared and tilled and with encouraging results.

Rivers and Streams.

The *Susquehanna river* forms the eastern boundary line of the district and the county line of Union and Snyder from a point below the Montgomery bridge to McKee's Half Falls at the mouth of Mahantango creek. Its air line length is about 33 miles, but measured by the meanderings of the stream this distance is increased to about 42 miles; 22 miles to a junction with the North branch at Sunbury, and 20 miles from there to Mahantango.

The river is everywhere quite shallow, and from one-half to one mile in width, flowing over a rocky channel of various formations, with a comparatively slight dip.

From the northern extremity of the district in Gregg township, of Union county, to Sunbury, the West Branch keeps a S. S. E. course with two prominent bends at White Deers Mills and Lewisburg. From Sunbury the course is S. S. W. with a western bend at Selinsgrove and an eastern bend at Port Trevorton. Numerous islands obstruct the channel throughout its course in the district, increasing the picturesque beauty of the river.

Reference to the table in Report N will at once indicate the very gentle fall of the river. Thus in the 24 miles between Montgomery and Sunbury (see table 129 Philadelphia and Erie railroad) the total fall is $490 - 444 = 46'$, or scarcely 2' per mile. From Sunbury to Mahantango creek (see table 110 Northern Central R. R.) the fall is $444 - 404 = 40'$, or just about 2' per mile. From that point to Harrisburg the fall is even less, or about 1.82' per mile.'

The entire drainage of Union and Snyder counties is eastward, directly into the Susquehanna, the principal branch streams being as follows from north southwards:

1st, *White Deer Hole creek*, which with its tributaries

Spring creek and South creek, waters nearly the whole of Gregg township. Black creek, a smaller stream to the north, flows directly to the river and drains the slate area north of the Oriskany sandstone ridge in this township.

2d. *White Deer creek*, rising near the Centre county line, flows eastward between White Deer and Nittany mountains to White Deer Mills, through a valley of Clinton and Salina rocks.

3d. *Buffalo creek*, entering the river at Lewisburg, drains through its tributaries, Little Buffalo, Spruce run and Rapid run, a large portion of the Buffalo valley in Union county, its branches rising between spurs of the Buffalo mountains and watering the fertile plain to the west of Lewisburg.

4th. *Turtle creek*, a small stream draining the region between Lewisburg and the Shamokin mountain, and entering the river at Turtleville, 4 miles below Lewisburg.

5th. *Penns creek*, the largest stream in the district, which, after watering a large portion of Centre county, breaks through Paddy's mountain about 3 miles west of the Union county line in a beautiful horse-shoe bend, and flows for 16 miles through Union county, along the north base of Jack's mountain to Centerville. From here it forms the line between Union and Snyder counties for about 7 miles, where it cuts diagonally across the Devonian and Catskill areas of Snyder county, to the river at Selinsgrove. It has many branches in both counties, but they are small. In its flow of about 36 miles from the gap in Paddy's mountain to Selinsgrove, it falls about 540', or an average of 15' per mile.

6th. *Middle creek*, rising along the Mifflin county line, drains all that portion of Snyder county between Jack's and Shade mountains, and empties into the river only about 2 miles below Penns creek at Selinsgrove. Through much of its course in Snyder county it furnishes the avenue for the Sunbury and Lewistown railroad, breaking south at Kremer Station across the expiring end of the Shade mountain anticlinal and making a wide loop in the Devonian slates east of Freeburg before reaching the river.

7th. *Mahantango creek*, forming the line between Snyder and eastern Juniata, and reaching the river at McKee's Half Falls. The North branch is its main tributary, heading up towards Freemont and draining the Hiester and Buckwheat valleys and the southern township of Snyder county. A small area of eastern Juniata is likewise drained through this creek, which is the most important stream in this portion of the district, though comparatively small.

The *Juniata river* plays the same rôle in Mifflin and Juniata counties as the Susquehanna does in the more eastern portion of the district. Indeed its importance is relatively greater, as it enters more largely into the economical development of the district through which it flows and gives access through its canal and the main line of the Pennsylvania railroad to the product of its farms and mines in widely separated areas.

Its course through these two counties, from Mt. Union to the nose of the Tuscarora mountain, the Perry county line, is made exceedingly sinuous and irregular by the variety of rock formations through which it flows. By the line of the Pennsylvania railroad this distance is about 52 miles, and the fall (see Table I, Report N) $597-416=181'$ or $3.5'$ per mile.

From its point of entrance into Mifflin county at Mt. Union, below the great gap in Jack's mountain, the river flows south for nearly 5 miles to the base of the Blue Ridge, where, failing to cut its way through that high rock barrier of Medina sandstone, it is turned directly backward in its course to Newton Hamilton. Here it makes another wide curve towards the southeast and gradually eats its way back into the softer Lower Helderberg and Salina rocks, keeping thence a general northeast course to Lewistown, though with several broad curves in the Salina and Clinton shales.

At Lewistown it is deflected towards the south again, and after passing around the spur of the East Shade mountain anticlinal it glides southeast rapidly through the "Narrows" between East Shade and Blue mountains, a narrow washed out basin of Clinton rocks No. V. Entering Juni-

ata county in this gap it soon cuts off a small end of the Blue Ridge spur, and turns southeast to Mifflintown, across a plain of Clinton and Salina rocks. In the 12 miles between Lewistown and Mifflintown, as indicated by railroad levels, the river falls nearly 60', or at a rate of 5' per mile; but a large part of this fall is made through the "Narrows."

From Mifflintown southeast it meets with nothing to seriously obstruct its flow until the base of Tuscarora mountain is reached, where it is again deflected eastward and finally passes around the end of the mountain east of Thompsontown and into Perry county.

1. *The Kishacoquillas creek* is its most important tributary in Mifflin county, which with its main branch Honey creek, drains all the Kishacoquillas valley, and a large portion of the Seven mountains area southward to the river at Lewistown. This creek is one of the most beautiful in the district, and by its grand gap in Jack's mountain south of Reedsville, has afforded a natural location for the Milroy branch railroad and the Bellefonte turnpike.

2. *Jack's creek* is another prominent tributary in Mifflin county, rising near the Snyder county line and draining all the upper Lewistown valley between Jack's and East Shade mountain to the Juniata about a mile below Lewistown.

3. *Lost creek, in Juniata county*, is the next large stream going south, entering the river from the east about $1\frac{1}{4}$ miles above Mifflintown. Like Jack's creek on the north side of the East Shade mountain, Lost creek waters a very large area of southern Juniata south of the mountain to the flintstone ridge of Oriskany No. VII sandstone. One branch really takes its rise in Snyder county in the Spigelmeyer anticlinal slate valley of No. III between the two crests of Shade mountain, and cutting down through the south crest, enters the Clinton rocks in the valley north of McAllisterville. In a few miles it receives another branch at Oakland Mills, and then flows west along the north base of Lost Creek ridge to the Juniata at the Ciba grist mill.

4. *Delaware run* is a small stream flowing southwards through East Salem and Thompsontown to the river.

5. *Cocalamus creek*, a larger tributary entering the river in Perry county below Millerstown, after cutting through Turkey Ridge in Greenwood township, completes the list of principal streams in eastern Juniata, except, of course, *West Mahantango creek*, which has already been mentioned in connection with the Susquehanna river drainage.

6. *Tuscarora creek* is by far the largest and most important branch of the Juniata river on the west side of the county. Its source lies well up the Tuscarora valley in Huntingdon county, and after entering the district near Waterloo, it practically drains all eastern Juniata county between the Blue Ridge and Tuscarora mountain, except the narrow Black Log valley, which is drained westward to Augwick creek at Orbisonia in Huntingdon county.

The main Tuscarora creek is over 30 miles long in Juniata county, and for the first ten miles of its course it flows largely in the upper Salina lime shales, outside of the main valley, which, rising to greater elevations and yielding less to erosion, furnishes many small tributaries to the main creek back of the Oriskany and Lower Helderberg ridge. Near Waterford the creek breaks down the limestone and sandstone wall but only to immediately return again after meeting the Hamilton sandstone rocks.

In two miles more a second attempt was more successful and the creek turns northeast and north across the main slate valley. Here, a little below McCollough's mill, it receives its Willow run branch, which waters the north side of the valley and Shade mountain through openings at Peru Mills and Reed's gap.

For the next 6 or 7 miles the creek keeps a general east course through the gradually contracting No. VIII slate valley, until northeast of Pleasant View it pursues a most remarkable course. Unable apparently to break through the high limestone wall south of Academia, it turns directly south and cuts completely across the valley it had almost left, breaks down both the sandstone and limestone barriers on the south and passes well into the Salina shales west of Spruce Hill. Here a local anticlinal evidently obstructs its further passage and turns it again northward to an equal

distance north of the north wall of the valley, which it had failed to cut through only about a mile further west.

For the next 8 or 10 miles its course is exceedingly sinuous, being alternately inside and outside of the Oriskany ridge, which however, is here largely obliterated, finally entering the Juniata at Port Royal. Throughout its course it is a rather narrow and shallow stream with a gentle and nearly uniform fall.

Lick creek, its principal tributary, is of only secondary importance to the parent stream. Rising in Mifflin county in the narrow Clinton valley between the Blue Ridge and Black Log mountains, its course for 16 or 18 miles is naturally well defined by these two mountain walls. It first enters an area of Upper Salina lime shales about 6 miles from the Juniata, but instead of continuing its course in this valley to the river, it turns abruptly south at the Licking Creek church, $1\frac{1}{2}$ miles from the river, cuts through Lost Creek ridge, across the Shade mountain anticlinal, and the South ridge at the Germania Mills, presenting excellent exposures of the Clinton rocks down to the Iron sandstone; across the Mifflintown-Johnstown limestone valley to Farmdale; gaps both limbs of the succeeding anticlinal in the Ore sandstone and Lower Clinton rocks, and enters the Tuscarora creek about a mile west of Port Royal.

Various tributaries of Licking creek and Tuscarora creek, too numerous and unimportant to call for special mention, are shown on the map.



CHAPTER II.

Geological Structure of the District.

The general structural features of this district are in the main simple and well defined, and as they have been so well described, both by assistants of the First Survey and in Report F of the Second Survey, it will be sufficient merely to summarize the main results here, which indeed are made plain by the map coloring and dip arrows.

Between the main anticlinal and synclinal rolls, extending in broad concentric curves through the district from east to west, there are many subordinate minor flexures, of short extension, local importance, and frequently without names, but which effect, to an important degree, the economical features of the district in which they occur.

Union County.

Beginning on the east side along the Susquehanna and from the north southward, the most strongly marked structural lines are those of the Buffalo mountain range.

1. *The Black run synclinal*, a trough of No. VIII shale and sandstone, one-half of which lies in Lycoming county, so that the general dip of all the formations south to White Deer mountain is northward.

2. *The White Deer mountain anticlinal*, touching the river at the Gregg-White Deer township line about a mile above White Deer Mills, and splitting the mountain crest westward in Clinton county. This is the *Watsonstown axis* of Northumberland.

3. *The White Deer Valley synclinal*, which, crossing the river at White Deer Mills in upper Salina rocks, courses westward through White Deer valley, lifting successively to daylight the Bloomsburg red shales of the lower Salina division; the Clinton, and near the Centre county line, the Medina rocks of No. IV.

4. The *Nittany mountain anticlinal*, reaching the river a little over a mile below the last described synclinal, and keeping a nearly parallel course westward, lifts first the Ore sandstone and then the Medina white sandstone No. IV of the mountain, about 5 miles from the river; then in turn the lower Medina and Oneida, until the increasing strength of the axis is sufficient to part asunder the opposing walls of the mountain and admit of an enclosed valley of Hudson river slate No. III along the upper White Deer creek, and extending 4 miles long to the Centre county line.

5. The *New Columbia synclinal*, a trough whose axial line crosses the Susquehanna about a mile north of New Columbia, and being somewhat deeper than the White Deer Mills basin, contains a greater thickness of the upper Salina shales and marls, and does not elevate the Bloomsburg shale along its axis until at $6\frac{1}{2}$ miles from the river. From here westward its rise is more rapid, so that before reaching the Centre county line it holds in its trough a synclinal ridge, *Sand mountain*, 4 miles long, composed of upper Medina sandstone, and occupying the valley of Spruce run.

6. *Buffalo mountain anticlinal*, touching the river a little south of New Columbia with comparatively flat dips, elevates the Ore sandstone in $1\frac{1}{2}$ miles, with opposing dips of 40° , and in $5\frac{1}{2}$ miles more brings up the Medina sandstone in the Buffalo mountain spur. This mountain bears a close analogy to Nittany mountain on the north, but, like it, its anticlinal axis going westward gradually forces its walls apart to admit of still lower rocks, until they finally enclose a slate valley of No. III nearly 3 miles long in Union, known as the *Brush Valley Narrows* in Centre.

South of Buffalo mountain the structure becomes slightly more complicated. At the river opposite Milton there is a narrow synclinal and anticlinal roll in the rocks within a mile of each other in the upper and lower Salina rocks, making long narrow tongues of the Bloomsburg red shale, as shown on the map, extending for some 6 or 8 miles from the river.

7. The *Rapid run synclinal* is the western extension of

the double basin at the river, occupying the valley of that name between the Seven Notch mountain on the north and Shriner's mountain on the south, and carrying the Clinton rocks in its trough to within $1\frac{1}{2}$ miles of the county line.

8. *The Jones mountain anticlinal* may, in the same manner, be considered the westward prolongation of the river axis, splitting lengthwise into Shriner and Dull mountains, containing between them a small valley of No. III slates.

9. *The Lewisburg synclinal*, as the map coloring indicates, is the deepest trough in Union, as it contains north of Lewisburg a belt of No. VIII Marcellus slate and Hamilton sandstone 2 miles wide on the river, narrowing to a point about 3 miles west of Lewisburg. Here it is concentrically encircled by the Oriskany sandstone No. VII and the Lower Helderberg limestone No. VI of the Limestone Ridge, in a single simple synclinal fold, $1\frac{1}{2}$ miles wide, on Buffalo creek. This is the *Lackawanna basin* of Northumberland.

Still further west a large area of the upper Salina lime shales and marls succeed, which create the fertile Buffalo valley; but while seemingly a wide smooth plane, its structure becomes more confused by the presence hereabouts of several small anticlinals and synclinals; whose growing strength as they are followed westward lead to the elevation of mountain rocks like those already described to the north, between which occur synclinal valleys of Clinton rocks. The chief of them are:

10. *The Forrest Hill synclinal*, first detected north of Mazeppa in the valley of Armstrong run, elevating the Bloomsburg shale at Forrest Hill, then the Clinton rocks further west and finally at the head of North Branch valley holding the sand rocks of No. IV of the Dull and Little Buffalo mountains.

11. *The Little Buffalo mountain anticlinal*, next south, first well seen west of Mazeppa in lower Salina and Clinton rocks, in time elevates its mountain sand-rock spur in Lewis township, and finally brings to daylight a narrow tongue of No. III slate along the Centre county line.

12. The *Cowan synclinal* is the next trough south, first making its appearance at Cowan in Buffalo township, and easily traced westward as a narrow fold of Salina and Clinton rocks, closely hugging the south base of the Little Buffalo mountain, and crossing the Lewisburg and Bellefonte turnpike near the old hotel on Laurel run.

13. *Paddy's mountain anticlinal*, a double flat roll of Bloomsburg red shale where first seen south of Cowan, but showing only a single fold of Clinton rocks at Pleasant Grove church in Lewis township; crossing the Bellefonte turnpike at the forks of the road to Laurelton with dips of 10° and 20° in the Iron sandstone, and soon elevating the Medina sandstone in the Paddy mountain spur in Hartley.

Thus far it has been seen that each succeeding trough south of White Deer mountain has deepened slightly along the river, to contain geologically higher and more recent rocks. The Mifflinburg synclinal however, to be soon described, is an exception to this rule, for it is geologically deepest near the center and contains in its trough a synclinal ridge of Lower Helderberg limestone 7 miles long, south of Mifflinburg, capped in places with Oriskany sandstone.

14. The *Hartleton sub-division* of the Buffalo Valley synclinal, the first basin south of Paddy's mountain, is largely local in this county. It is overshadowed by the deeper basin at Mifflinburg further east, but it can be traced west of Hartleton for 8 miles as a narrow valley of upper Salina lime shale land, flanked on either side with bands of Bloomsburg red shale with converging dips of 30° - 35° , and by the shoaling up of the succeeding Clinton valley along Penn's creek further west, begins to assume new prominence in Mifflin and Centre counties as the *Long mountain synclinal*.

15. The *Vicksburg anticlinal* is of almost equal insignificance, although it can be more or less distinctly traced from the river about $1\frac{1}{2}$ miles below Lewisburg. This is the expiring end of the great *Montour axis* of Montour and Columbia counties.

Its crest is there composed of the top layers of the Clinton formation, and as the axis sinks towards the west it

carries down first the Bloomsburg or lower Salina red shale, and then a portion of the upper Salina shale. Its axial line curves north to Vicksburg and then south towards Buffalo creek, where it again begins to increase gradually in strength, until east of Laurelton it brings up the Bloomsburg shale, and the Clinton west of Laurelton. Here it again declines and dies away against the north flank of the White mountain.

16. The *Mifflinburg synclinal* is shaped like a canoe, its deepest central point being south of Mifflinburg and rising in both directions; eastward to the Susquehanna about a mile north of Turtleville and extending westward, north of Milmont and south of Laurelton, to shoal up along the Lewisburg and Tyrone railroad.

17. The *White mountain anticlinal*, next south, is of only slight importance in Union county, extending for about 4 miles east of the Mifflin county line, but subsiding so rapidly eastward that the red and white Medina No. IV, the lower Clinton and Ore sandstone are all carried under water level on the railroad east of Weikert station.

18. The *Jack's mountain anticlinal* is by far the grandest and most important axis in the county, extending from the river at Turtleville west through Shamokin mountain; crossing Sweitzer run about half a mile below Battletown, where the sand rock has sunk beneath the Clinton shales for about two miles; thence extending along the Union-Snyder line to Mifflin county, where the walls of the mountain have been pushed far enough apart to admit of the east end of the Spiegelmeyer slate valley No. III.

For $3\frac{1}{2}$ miles west of Turtleville the axis carries on its crest only the Clinton rocks; the two opposing outcrops of the Ore sandstone are scarcely one-fourth of a mile apart on the river. The crest of the anticlinal however, is here sunken, causing two anticlinal rolls of the Ore sandstone which come together about a mile from the river, and form a basin shoaling westward, from which a large quantity of ore has been mined.

Where the axis has become strong enough to elevate the Medina sandstone of Shamokin mountain, the same strata,

on opposing dips, are nearly $1\frac{1}{2}$ miles apart. The crest then remains nearly steady, preserving a strip of sandstone for about 5 miles in length, known as *Shamokin mountain*, but highest opposite New Berlin, where the Medina red sandstone shows on the crest.

At the west end of the ridge it again subsides, so that on both sides of Sweitzer run valley, the lower Clinton shales arch over its crest, until north of Centerville the axis again rises rapidly, raising the Medina sandstone a couple of hundred feet above Penns creek, which cuts diagonally through the mountain, eroding the south dip. The rise west is then more gradual, lifting the Oneida sandstone to daylight about 6 miles from Centerville, and finally the No. III Hudson river slate just before reaching the Mifflin county line.

Snyder county.

1. *Jack's mountain*, of anticlinal structure, forming one half of the north county line has just been described; but in Spring township of Snyder county, west and south of Swift run, and about 3 miles west of Troxelville, the southern division of the mountain has elevated at the High Top an anticlinal spur of Medina sandstone IVc, between which and the northern division of the mountain occurs the synclinal trough of *Swift run*, composed of the lower Clinton measures and the Oneida sandstone along the Mifflin line. High Top mountain is soon parted by the increasing strength of the anticlinal going westward, admitting of an elevated plateau of the red Medina IVb, and in turn a second interior spur or knob of the Oneida IV at the Spring and West Beaver township line. This interior ridge is similarly parted in the next mile, and Hudson river slates No. III appear close to the county line, forming the head of the New Lancaster anticlinal valley of Mifflin county.

2. *The Northumberland synclinal.* The whole central tier of townships in Snyder county to the south of Jack's mountain is occupied by one broad synclinal of Catskill and Devonian rocks, which may be conveniently called the "Northumberland Synclinal," forming the center of the

main Juniata trough, and crossing the Susquehanna river at the junction of the North and West branches at Northumberland, in Catskill red sandstone No. IX, with converging dips of 10° - 15° .

The line of this great trough is distinctly marked through Snyder county, and is generally occupied by high land. It carries the Catskill measures for 15 miles in its basin, which shoals and contracts westward from the river, as is indicated by the map coloring. From a point northwest of Middleburg to the Juniata county line, its rocks are everywhere Devonian, with only the lower members of No. VIII, or the Marcellus and Hamilton slates in the western townships.

The axis is well seen on Penns creek near Kratzerville, with dips in Catskill rocks of 10° - 15° ; passing thence westward a little north of the Lutheran church in Jackson township to the M. E. church and school in Centre township; then north of Zion church to Adams township, with dips in Chemung rocks of 25° and 30° , where it curves slightly southwest with the valley, keeping a little north of the Centre line and the Lutheran and Methodist churches in West Beaver, until it finally passes out of the county south of Bannerville. It is everywhere an exceedingly regular and normal synclinal, apparently without any subordinate rolls, and gradually deepens toward the river.

There are one or two small anticlinal rolls in the limestone and lime shales of the valley between Beavertown and Paxtonville, and one economically important dimple in the Clinton measures south of Adamsburg, which will be mentioned in detail later.

3. The *Shade mountain anticlinal* is the next prominent structural feature, running through the great mountain range of that name to Juniata county, and crossing the river above Selinsgrove into Northumberland county, where it has subsided to such an extent as to barely carry on its crest the Lower Helderberg No. VI and Oriskany No. VII for about 2 miles from the river, beyond which point the Marcellus and Hamilton rocks come in and extend to the Columbia county line.

West of the river however, the axis is constantly growing stronger towards the Juniata line; but the flat dip in both legs of the arch on the river has served to spread the Lower Helderberg and upper Salina limestone and shale over a very large area west of Selinsgrove, to the direct advantage of the farming interests, and with the effect of creating a most beautiful and thickly settled valley.

The Bloomsburg red shales are brought to daylight about $2\frac{1}{2}$ miles west of Selinsgrove, showing a slight synclinal dimple along the crest of the anticlinal, and soon followed by the Ore sandstone outcrop, which just crosses to the east side of Middle creek.

The anticlinal at this point, below Kantz's mill on Middle creek, throws off dips of only 10° . The crest of the arch flattens even more to the west of this point, showing dips of only 5° and keeping the lower Clinton red and brown shales on the surface for 5 miles. It is due to this flatness that the ore-beds germane to the lower part of the Clinton group *below* the horizon of the Ore sandstone have been worked very extensively in this vicinity; for the beds, though thin, have been thoroughly leached and remain above water level over wide areas, presenting many favorable points for development.

About 8 miles from the river and south from Middleburg the Medina sandstone No. IVc of Shade mountain is brought up, and as it rises quickly and is the only mountain spur in the vicinity, it can be seen for miles around. From this point westward Shade mountain and its anticlinal topographically divides Snyder county into two parts. Its white Medina sandstone crest soon splits to receive the red Medina sandstone, and the latter in turn divides to receive the Oneida sandstone No. IVa, between whose walls is included a No. III slate valley, about one-half a mile wide, and in this county nearly 4 miles long.

This valley, whose floor is a couple of hundred feet beneath the crests of the bounding mountain walls, but over 2000' A. T., is locally known as "*Spiegelmeier's valley*."

Shade mountain itself, whose central anticlinal line is marked by this slate valley, is about 30 miles long from

where it rises in the knob south of Middleburg, until it subsides again as it rose, below Jack's creek on the Juniata.

4. The *Shamokin synclinal* enters Snyder county at Pine island, about 2 miles above Port Trevorton, holding the Catskill rocks in its trough for about 3 miles west of the river. Its dips are generally steeper than in the Northumberland basin, so that in Northumberland county the basin separates rapidly to finally admit of the coal measures at Trevorton and Mt. Carmel.

So on the west side of the river the basin shoals up and contracts. The Catskill rocks No. IX are succeeded by the Devonian No. VIII. The axial line passes through the southern part of Washington township to Mt. Pleasant Mill and Freemont in Perry, where only the Marcellus black slates are held in its trough, until at 2½ miles west of Freemont the Oriskany sandstone No. VII is brought to daylight, making a wall around the slate valley which is continued as a tightly compressed synclinal ridge of Lower Helderberg limestone No. VI, 2 miles long to a point north of Richfield. Beyond this the synclinal approaches more nearly to the base of the East Shade mountain, marked by a fertile valley of Clinton and Salina lime shales and slates.

5. The *Slenderdale anticlinal* axis of Juniata county is represented in Snyder immediately south of the Shamokin synclinal, carrying the upper Salina lime shales on its crest, north of Richfield, east to the line of Perry and West Perry townships. Here the Lower Helderberg limestone and Oriskany sandstone in turn fold over the dying axis, the sandstone disappearing beneath a plain of Marcellus No. VIII black slate, just southwest of Freemont. The axis cannot be traced far east of this point.

All the southern part of Snyder county is composed of the different members of No. VIII, which along both forks of Mahantango creek, as well as along the river, show two subordinate anticlinals and synclinals of no great importance, and only serving to duplicate and spread the outcrops of these rocks.

6. The *Tuscarora mountain anticlinal* of Juniata county, after passing through Perry county, makes itself felt in the

extreme south corner of Snyder county by elevating the Oriskany sandstone and Lewistown limestone to daylight at McKee's Half-Falls, passing through Georgetown in Northumberland and making a fertile little limestone valley two miles in length. It is of comparatively small importance in Snyder county.

Mifflin County.

The structural features of Mifflin county are virtually a westward extension of those described in Union, just as those of Juniata have corresponding folds in Snyder county.

The Buffalo mountain range however, which makes so prominent a feature of the topography and geology of northern Union, is largely absent in Mifflin county, the most of its component ridges extended into Centre county on the north to form the classic "Seven Mountain Range" so beautifully described in the Final Report of the First Survey and delineated in the contour line maps of Mr. C. E. Billing, accompanying this report.

1. The *Long mountain synclinal*, corresponding to the Hartleton synclinal of Union, continues that axis west from Penns creek along the valley of Panther run, first in lower Clinton shales, and finally in a closely compressed fold of white Medina sandstone. IVc.

Paddy's mountain, to the north of this in Mifflin county, is a monoclinical, its rocks dipping southeast towards Panther creek and flanked north by the Poe valley of No. III slate in Centre county, whose anticlinal extends westward into Mifflin county again in the northern corner of Armagh township, where it has sunk to carry on its crest only the red Medina at the head of Laurel run. Long mountain synclinal deepens again along a right hand fork of Laurel creek, enclosing a considerable area of the lower Clinton rocks No. V. The elevated area west of Laurel creek, associated with the Broad mountain range of Huntingdon county is somewhat complicated by a Z-shaped fault in Brown township.

2. The *Broad mountain anticlinal*, of Huntingdon county, increasing in strength coming eastward, carries the

high knob of Oneida sandstone No. IV on its crest at the Mifflin county line, made by the union of Brush and Lingle mountains. composed of the same rocks, but having opposing dips north and south.

A slate valley of No. III, here so high as to have received the name of *Slate ridge*, forms as usual behind this sandstone dome, and in a mile from its western apex it is cut off by the fault just mentioned. The Oneida terrace of Lingle mountain in the south is not apparently disturbed at all, and it carries even a considerable thickness of the underlying No. III slates along the north flank, as is shown by the map coloring. But the center of the valley east of the fault line is occupied by the mountain makers, the Oneida and Medina sandstones, in direct continuation with Paddy mountain, which has been cut off abruptly here, shoved first forward (north), then sideways (east) and then forward (north) again in a parallel direction to the first break. Here then is a compound fracture.

The throw of the fault north and south is about 2500', or the mountain crests, really a part of the same ridge, are out of line with each other about one-half a mile. The thrust amounts to about 1.3 miles, or the two crests have slid past one another 6800'.

The Oneida ridge which flanks Lingle valley on the north, and seems to come to an end at the fault in Slate ridge, is the Brush ridge of the map to the north.

This fault, situated in an exceedingly wild and mountainous country and difficult of access, is however well shown on Mr. Billin's topographical sheets, where it is located with more accuracy, and can be studied with the aid of topography to much better advantage than upon the county map.

The north limb of the Broad mountain-Havise valley anticlinal is represented between the Huntingdon county line and Laurel creek only by vertical or overturned southeast dips. East of Laurel creek, however, the line of the axis is well marked by the elevation of a slender limestone ridge of No. II, 2½ miles long, the more conspicuous as it is isolated in a plain of Hudson River and Utica slates No.

III, everywhere else filling up the *Havise valley* * to within 4 miles of the Union county line, into which county it is prolonged in the White mountain anticlinal. It is scarcely traceable beyond Penns creek at the base of White mountain in Union county.

3. The *Milroy synclinal* is a distinct and well-marked basin in Mifflin county, though scarcely discernable in Union county, along Weikert run back of the White mountain. Passing west from there it holds the red and white Medina sandstone in its trough for about 6 miles, the mountain finally terminating in a high spur of the Oneida sandstone No. IVa, known as *Strong's Knob* † just northeast of Siglerville in Armagh township. At Moore's grist mill, just west of the end of the spur, the synclinal is seen in the Hudson River slates No. III, with converging dips along the axis of only 10°, which however stiffen rapidly within short distances on either side of the axial line.

The trough keeps about the same elevation for the next 5 miles, holding only the slates, and passing about a mile north of Milroy with north and south dips of 10° and 20°, until west of Laurel creek it begins to deepen again to admit *Straley's Knob*, ‡ a high spur of Oneida sandstone, and the counterpart of Strong's knob to the east.

On the road passing north through Cooper's Gap to Greenwood Furnace, north and south dips of 35° and 60° are exposed in the red Medina sandstone No. IVb, indicating the compressed character of the fold, and about 1½ miles west the white Medina sandstone of Millikin's Knob marks the basin line, which passes thence west into Huntingdon county as the Greenwood basin.

4. The *Jack's mountain anticlinal* of Union county succeeds this basin on the south, though represented in Mifflin county by the valley rocks Nos. III and II. This is the central one of the three anticlinals of the Kishacoquillas valley, passing through the Triester Valley § to Sig-

* Christman's valley of the First Survey, Rep. H. D. Rogers.

† Stewart's Knob of the First Survey.

‡ Baird's Knob of the First Survey.

§ Orr's Valley of the First Survey.

lersville, with the Havise valley on the north and the New Lancaster valley axis on the south.

The slates of No. III occupy the Triester valley and crest of the axis from the Union county line west for $6\frac{1}{2}$ miles, where the Siluro-Cambrian limestone No. II is elevated to the surface, about $2\frac{1}{2}$ miles east of Siglerville. At the latter village the axis throws off dips in this limestone of 60° north and 70° south. The axis shows on the Lewistown and Bellefonte turnpike, about a mile below Milroy, with dips of 40° and 60° , therefore flattening gradually westward. On Tea creek in Brown township, less than 3 miles further west, the axis is normal and shows dips of but 30° .

A little south of Barr's P. O. in the same township, the axis is represented by a close fold in the limestone with dips of 80° each way; but the south dips almost immediately flatten down to 5° while the north dips hold up to 50° and 60° . This point is almost immediately south of the fracture in the mountain, which results in the faulting and shoving of the mountain rocks as already described.

The anticlinal can be traced four miles further, into Union township, making a hook in the outline of the slate outcrop north of Mechanicsville. West of this point it is overridden by the greater strength and effect of the Stone Mountain fault. This fault, unlike that of Brush ridge in Brown township, shows only a lateral thrust, causing a breaking in the Stone mountain along a N. 33 E. line, which has swung the two ends of the mountain past each other for about a mile in distance, duplicating the rock measures on either side of this fault so that in going in a northwest direction from Mechanicsville to Huntingdon county, one passes over four ridges instead of two, Standing Stone mountain being a double monoclinical ridge with north dips. This great fault, one of the most interesting in Pennsylvania, is distinctly shown on Mr. Billin's map and has been minutely and graphically described by Prof. Lesley in the Huntingdon county report, Vol. T3, p. 337.

The coloring of the county map will also sufficiently show the effect of this fault, as well as the curious modifications of dips near the line of thrust, displayed in the

east mountain, where the rocks of the Oneida sandstone terrace and the underlying slate have both apparently been overturned and dip southward at steep angles, 35° – 50° . The effects of the fault are hardly visible along the stream issuing from Allison's gap, where it probably coalesces with the prolongation of the Jack's mountain anticlinal, last well observed north of Mechanicsville.

It has already been described how Jack's mountain, in Union and Snyder counties, consists of two anticlinals holding the slate of No. III at the heads of Triester and New Lancaster valleys along the Mifflin line, with the synclinal of Swift run between. This will appear more distinctly on joining the two maps together.

5. The *Swift Run synclinal* of the east develops westward into the Beatty's Knob synclinal, creating a bold mountain spur of Oneida sandstone, north and east of Locke's Mills. Continued westward the line of this trough elevates first the Hudson river slate of III; passes through Naginney's cave near the railroad station of this name on the Milroy branch of the Pennsylvania railroad in limestone, beyond which the synclinal is not traceable.

It is comparatively obliterated along Tea creek, where the rocks have a south dip all the way from the Triester valley axis to the slate at Reedsville.

6. The *New Lancaster Valley* anticlinal*, corresponding to the southern roll of Jack's mountain in Snyder county, is similarly obscured after passing through Locke's Mills and Honey Creek station, although it is probable that it bears a direct relation to the axis, which first appearing along the pike in the vicinity of the village of Kishacoquillas, passes a little north of the Union Mills and through the old Greenwood hematite ore-banks south of Belleville, and forms the main axis of the valley, a little south of the pike all the way to the Huntingdon county line. At all events the western end of the Kishacoquillas valley in Mifflin county seems to everywhere show a breadth of about 2 miles of limestone, with but a single anticlinal axis, throwing off comparatively gentle dips.

* Swartzel Valley of the First Survey.

Jack's mountain in this county, always forming the southern boundary wall of the Kishacoquillas valley, shows a straight monoclinal ridge, whose summits rise to the elevation of 2000' above tide. This remarkable mountain creates a complete topographical and geological barrier between the Kishacoquillas valley on the north and the Lewistown valley on the south, two totally different valleys in their topography, geology and structure.

Topographically both have high bounding walls north and south. The *Kishacoquillas valley* however, is largely an open plain from 2 to 4 miles wide, broken at its eastern end by mountain spurs, but open on the west. The *Lewistown valley*, stretching similarly from one end of the county to the other, is broken by many slender ridges and narrow subordinate valleys, presenting a fairly smooth and homogeneous appearance from the summit of Jack's or Shade mountain, but in reality very deeply cut up longitudinally. The effect produced in both valleys is directly due to their geology and structure.

The Kishacoquillas valley is composed of the Lower Silurian limestone and slate *below* the mountain sand rocks No. IV; the Lewistown valley contains only rocks *above* the Oneida and Medina sandstone, the upper Silurian and Devonian Nos. V, VI, VII and VIII, and both groups of rocks have a more or less characteristic topography.

Then again the structure of the northern valley is normally a great anticlinal: the southern valley is synclinal: and while both are modified by subordinate axes, the Lewistown valley is crumpled into a dozen rock waves, duplicating and repeating the same rocks several times, and consequently accounting for the diversified topography due to the successive elevation and depression of such rocks as tend to create the ridges and valleys.

The detailed structure of the Lewistown valley has been so thoroughly delineated in Report F, page 47 *et seq.*, that it would seem useless to repeat the description here. The map coloring and the dip arrows will sufficiently explain the structure, even without the aid of the several carefully drawn cross-sections of Report F along the Kishacoquillas

creek at Logan ; the Lewistown section, $2\frac{1}{2}$ miles further west ; and the section at McVeytown, besides numerous local sections of the subordinate rock waves between Lewistown and Mt. Union.

7. The *Lewistown synclinal valley*, viewed as a whole, is deeper geologically at either end than in the center, and therefore contains at its ends in Mifflin county a much greater thickness of the No. VIII slates and sandstones than in the central portion. Moreover, several of the tightly compressed anticlinals and synclinals which occur between McVeytown and Lewistown die away east and west, making one broad valley of the Lower Devonian measures.

The seeming irregularity of the central portion of the belt is reduced to perfect order and clearness once that this key to the structure has been applied. The structural features of the valley have largely increased its commercial wealth; for had the basin been simply a *normal* one there would have been only a single series of outcrops on each side of the valley, the ores, limestone and sandstone of the north half towards Jack's mountain descending far beneath the Juniata river to appear but once again along the south half of the valley against the Blue Ridge. Instead of that the outcrops these ores and limestones, whose extraction has added so much to the wealth of the county in the past, are repeated several times, producing the zigzag appearance of color on the map, and presenting the iron ores, limestone and glass-sand to more advantageous and cheaper development. The local features of the district will be described later in the Township Geology.

8. The *East Shade mountain anticlinal* has already been partly described, passing through the mountain of that name and its slate valley of No. III, and touching the Juniata at the mouth of Jack's creek here in Mifflin county. The plane of this axis is like a bow, subsiding towards both ends from the Snyder county line, until on the Juniata the Medina crest of the mountain sinks completely beneath a plain of the lower Clinton rocks, which show on the west and south side of the river.

It seems to rapidly expire westward towards Granville as a distinct roll, unless indeed it be associated with the Chestnut ridge axis, which from the neighborhood of Lockport southwest to Matawan, opposite McVeytown, has elevated the Ore sandstone above the surface in a double ridge, carrying on its flank a double outcrop of the overlying "Sand Vein" ore bed for a distance of about 7 miles. It is quite probable, however, that this is a distinct flexure.

9. The *Blue Ridge-Slenderdale anticlinal*, the next south, gets its strength and importance from the western side of the district—the reverse to the East Shade mountain. It is not nearly so strong an axis either, for it has only managed to push apart the Medina sandstone wall, making an interior elevated plateau of the red Medina sandstone and shale between the two opposing walls—Blue Ridge and Licking Creek mountains—both of which when coming together take the former name where the subsidence of the anticlinal has closed up the break and united the ridges.

This axis steadily increases in strength from the Huntingdon county line to Minehart's gap and with opposing dips of from 40° to 55°. East of the gap it subsides gradually to the Juniata at Grahamville, one small knob of the white Medina sandstone, IVc, being left on the east side of the river to more closely mark the course of the axis. A mile further east it carries the Ore sandstone down on its crest, with dips of 60° north and south, and for a space of 3 miles, through the valley of Horning's run, that sandstone and its fossil ore-bed are beneath water level.

The axis however reappears with increased strength in Slenderdale ridge, making a double ore outcrop at its western end, crossing Lost creek north of McAllisterville and Cocalamus creek a mile north of the village of that name, east of which the axis steadily subsides, first carrying down the fossil ore-bed about 2 miles from the Snyder county line, and there coalescing with the small roll already described in Snyder county, north of Richfield.

10. A narrow and tightly compressed synclinal trough exists between the East Shade mountain and the Blue Ridge, marked by the channel of the Juniata river for 6

miles through the "Narrows,"² but scarcely discernible for any distance on either side of the river. It carries only the lower Clinton measures, which have been largely eroded from the flank of both mountains through the gap.

11. The *Licking creek synclinal*, lying south of the Blue Ridge, is a long narrow trough watered by Licking creek, and occupied largely by the lower Clinton rocks in Mifflin and part of Juniata county.

Approaching the river however, the basin deepens and widens out, receiving the Ore sandstone at about 8 miles from the Juniata in Mifflin township, and a thin strip of the upper Salina marls, with some Lower Helderberg (?) limestone about 4 miles long, which closely marks the axial line. East of the river it is not so well defined, passing through Fermanagh township a little north of Lost creek, and into Fayette a little north of Oakland Mills.

East of McAllisterville it takes new importance by deepening to include the lower Helderberg No. VI and Oriskany sandstone (chert) No. VII; but it soon flattens and dies out east in lower Devonian measures which occupy so large a part of the four eastern townships of Juniata.

12. The *East Shade mountain anticlinal* must also be taken up at the Huntingdon county line, where it is most conspicuous and has produced the greatest effect. Under the name of the *Black Log mountain anticlinal* in Huntingdon county it traverses lengthwise that beautiful valley for nearly 18 miles, with the Black Log mountain on the north and Shade mountain on the south, itself a fertile floor of limestone No. II and slate No. III.

Juniata county.

This description answers in Juniata county, although the axis has already begun to subside, carrying down the limestone first in 3 miles, then the slate in 10 miles, and finally brings together successively the three divisions of the mountain rock No. IV, until the uppermost of these, the white Medina IVc, sinks beneath the Clinton measures in Milford township, about 4 miles from the river. It is only on the

crest of this axis that the lower Silurian limestone has been brought to daylight in Juniata county, the same limestone which makes the floor of the Kishacoquillas valley, and in but one other place, in the Spiegelmeier valley in the northeast corner of the county, on the summit of the East Shade mountain, has the next higher formation—the slate No. III—being exposed. This brings about a significant point of difference geologically between Juniata and Mifflin counties, and the effect is largely due to the structure.

The Black Log or West Shade mountain axis crosses the river a mile above Mifflintown, still carrying the Ore sandstone on either side with dips of 15° and 30° , and as it gradually subsides on the west side of the river its crest becomes dimpled with a small synclinal roll making four outcrops of the Ore sandstone and Sand vein as far east as the Fayette township line.

Beyond this point it can only be identified by the indented outcrops of Lower Helderberg limestone and Oriskany sandstone in Flintstone ridge, where east of the Presbyterian church it shows north dips of 15° and south dips of 40° – 50° . Its presence was not noted on Cocalamus creek at all.

13. The *Mifflintown synclinal*, which succeeds on the south, is the main axis of the northern part of the Juniata valley. It crosses the run a short distance below the county seat with converging dips of only 10° and 15° , and for 8 miles west to Allenville its course is marked by a trough of upper Salina marls and perhaps the lowest members of the Lewistown limestone, which have added so largely to the fertility of the valley.

Further west it dies away against Shade mountain. It is not continued directly eastward from Mifflintown, but is offset a little to the south *en échelon* with the line first described, and then passes on through Flintstone ridge gradually deepening until it receives the Marcellus slate No. VIII about $4\frac{1}{2}$ miles from the river.

This trough line crosses Delaware run just north of East Salem with dips of 30° – 35° in Marcellus slate, and Cocalamus creek about midway between the cemetery and the

school house. It was likewise noticed on Little Cocalamus creek near the forks of the stream in Monroe township, about $2\frac{1}{2}$ miles south of Evandale, beyond which it is obscure to Troutwell in Snyder county.

It is one of the two principal synclinals in Juniata county, the second and more southern one being that of the Tuscarora valley, to be presently described.

14. The *Academia anticlinal* is a saddle of Clinton rocks extending from Reed's gap on the west to Cocalamus creek on the east, and passing just north of the village of Academia in Beale township.

It is first noticed by lifting to daylight the Ore sandstone and accompanying measures just northeast of Reed's gap, and eastward gradually spreading the opposing ore outcrops still further apart. Thus at Academia the two outcrops are just a mile apart, the south dip being 40° and the north one 60° , with the crest of the axis midway, exposing much flatter dips. The outcrops are even slightly more apart on Licking creek, where the dips are 30° and 40° ; but the subsidence is then more rapid, the Ore sandstone being carried under between the river and the turnpike, beyond which successively higher measures straddle the crest of the anticlinal.

At Van Wert the dips are 40° north and 30° south, and the opposing outcrops of Lower Helderberg limestone are now only about a mile apart and then finally come together on Delaware run, after slightly crimping along the crest of the axis. Still further east the axis is lost in the wide slate valley of No. VIII, where the exposures are scarce, unless perhaps it be merged with the Georgetown axis seen at the extreme end of the county, elevating the limestone No. VI and sandstone No. VII at the mouth of Mahantango creek for nearly 2 miles from the river and passing through Oriental and towards the Seven Stars Hotel.

15. The *Tuscarora synclinal*, like the main trough of the Lewistown valley, is more shallow and narrow in the middle of the county on the river, and deepens gradually towards both ends, its basin always occupied by Devonian rocks, and in the main a simple and regular synclinal.

The axis crosses the river at Mexico, where the two outcrops of Oriskany sandstone, enclosing the slate valley, are scarcely one-half mile apart. A mile west of the river they are even closer, but there gradually begin to diverge, the valley meanwhile filling up with a greater thickness of slate. The axis is well seen at the first bend in Tuscarora creek, with dips of 40°, and again just where the road from McCoyville south crosses the creek, with dips of 25° south and 10° north. The trough line then bends a little south, passes through the high ridge south of Willow run, and keeps about midway between the two sandstone and limestone ridges flanking the valley all the way to Huntingdon county.

East of Mexico the trough likewise widens and deepens, crossing Delaware run north of Thompsontown, swerving to the southeast slightly to become indistinct along Dutchman's run.

16. The *Tuscarora mountain anticlinal* forms the south wall of this basin from Huntingdon county to the Juniata river gap above Millerstown. It is really monoclinal in Juniata county, one-half of the roll being in Perry county. Its course is broken by the synclinal Liberty valley in Tuscarora township, from which the mountain rocks of No. IV rise both ways. It is in every respect like the other mountain ranges of this district.

CHAPTER III.

Stratigraphical Geology.

The Palaeozoic Formations.—By reference to almost any one of the published reports of the Geological Survey, it will be seen that the Palaeozoic rocks of Pennsylvania have been divided into 17 general groups, numbered from No. I, Potsdam sandstone at the bottom, to No. XVII, the Permo-Carboniferous rocks on top.

Of these 17 general divisions, which have been sub-divided in many of the reports, the rocks of the "*Juniata District*," through Juniata, Mifflin, Union and Snyder counties, are all comprised between the middle of the Siluro-Cambrian limestone No. II at the base and the middle of the Catskill formation No. IX at the top; consequently the Potsdam sandstone and part of the Lower Silurian limestone are hidden from view everywhere in this district, and all the formations, Nos. X to XVII, including all the carboniferous rocks and part of the Catskill No. IX are absent from the surface of these four counties.

As a direct result of this condition of affairs no coal-bed of merchantable quality or thickness that is to-day mined at any point in the state can ever possibly be found in this district, for the rocks in which such coal-beds occur do not exist here, and it is more than doubtful whether any attempt to find coal in the Devonian slates No. VIII will ever prove successful or of the slightest economical importance. Certain it is that its search in those rocks and in the still lower Hudson River No. III slates, which, despite every warning to the contrary, goes on time and again in many parts of the state, will entail much disappointment and loss of money to those foolish enough to engage in it.

Without uselessly going into detailed mention of vertical sections and descriptions of the various rock groups, the following general summary has been compiled from previous reports, to show at a glance the relative average thick-

ness and character of the Palaeozoic rock-column in the Juniata district.

It must be remembered however that there is no sharp line or plane of division between the various groups, the one imperceptibly grading into another, and their planes of contact often concealed by *débris*, so that the thickness assigned to the successive groups are only approximately and relatively correct.

And it can never be otherwise, from the very nature of their deposition. The constant thickening and thinning of the various rock groups make it impossible to fix absolute measurements, so that too great stress must not be put upon the figures subtended below.

Two complete vertical sections are given to explain the map coloring and give an idea of the approximate thickness of the different rockgroups:

(A) *Section of Mifflin and Juniata county*, mainly from reports F and F² and from personal surveys.

(B) *Section of Union and Snyder counties* from reports G⁷, T⁴ and from personal surveys.

A. General section in Mifflin and Juniata.

No. VIII 3300'±	{ Chemung, g. 800' Portage, f. 1000' Genesee, e. 200' Hamilton, c. 600' Marcellus, b. 700'	In western Juniata county, including only a portion of the Chemung rocks. In eastern Mifflin, about 2500'; and at Lewistown only Marcellus division.
No. VII 50-200'	{ Oriskany sandstone. Stormville shale.	Sandstone is 160' in Long Hollow; 140' at McVeytown; 110' at Lewistown and 95' at Mt. Union. In Juniata it is 25'-40' thick; chert. Oriskany shale varies from 50'-200' in western Mifflin county.
No. VI 300'±	{ Lewistown limeshale; Lewistown limestone.	Lewistown, 140'; McVeytown 130; in places only 50'. From 30'-200' thick; average about 90'.
No. V. 2500'	{ Salina upper Vc. Salina lower Vc. Niagara Vb (absent) Clinton Va	2500' thick at Lewiston; 2500' at Mt. Union; 2700' at McVeytown; average about 2500' in district.

No. IV. 2700'	{	Medina white sandstone IVc.	} 820'
		Medina red sandstone and shale IV b.	
		Oneida gray SS. and Congl. IVa	
No. III. 2300'	{	Hudson river slate IIIb	} 937'
		Utica black slate IIIa		Kishicoquillis cr. } 1367'
No. II. 300'±	{	Trenton limestone,	Part of No. II, about 300' in Kishicoquillis valley, 150' in Black Log valley.

The above scale represents all the rocks found in the two western counties. There is very little of No. VIII in Mifflin county, except towards the east side along the Union county line, and very little of Nos. II and III in Juniata except in the Black Log valley ; so that no one section will fit all parts of this district.

B. General section in Union and Snyder.

No. IX 3500'±	Catskill shale and sandstone.	{	Not represented in Union ; partly in Snyder, including 1000' of Transition beds IX-VIII.	
No. VIII 5300'	{	Chemung,	} 2500' Measurements along N. C. R. R. opposite Selinsgrove.	
		Portage,		
		Genessee,		} 300' At Georgetown the same rocks are only 4000' thick, owing to thinning of Hamilton and Marcellus. Only Marcellus in Union county.
		Hamilton,		
No. VII 150'	{	Oriskany sandstone,	} 50' The sandstone varies from 20'-60' ; the shale from 75'-125'	
		Oriskany (Stormville) shale		
No. VI 250'-350'	{	Lower Helderberg or	} An upper limestone-shale series 120'-150' fossiliferous.	
		Lewistown limestone.		A middle bastard limestone and shale series 25'-75'
No. V 2000'-2300'	{	Upper Salina Vc'.	} 700' marls and lime shales.	
		Lower Salina, (Bloomsburg) red shale Vc.		
		Clinton, Va.		
No. IV 2400'±	{	Medina white sandstone IVc	} Nowhere well exposed for measurement in Union and Snyder.	
		Medina red sandstone IVb		
		Oneida gray SS. and Congl. IVa		
No. III 300'±	Hudson river slate,	{	Only partially exposed in secluded mountain valleys of Buffalo mountain range ; Jack's and Shade mountains.	

There still exists some uncertainty as to the limitation of several of these rock-groups, and though much advance has been made by the study of them in different parts of the state, many difficulties constantly arise in the way of correlation. In this report it has been thought best to group the formations and color them on the map as they would appear to the ordinary field observer without doing violence to any particular system of nomenclature, and mainly with a view of graphically representing the economical features.

The Catskill Rocks. No. IX.

This formation, which is colored a pinkish-red on the map, only exists in Snyder county, occupying the troughs of the two main synclinal basins. Only a portion of the formation has been preserved there, the greatest thickness of rocks showing along the Susquehanna river opposite Northumberland, in all about 3500' thick, including about 1000' of the "Transition Rocks" at the base.

Some geologists prefer to separate this lower group, having fossil types common to both the Catskill and Chemung formations; but it will suffice to know that they have been included here in the Catskill, whose base has been fixed at the lowest *red bed*, for no other red beds are seen until we descend the geological column to No. Vc, the lower Salina rocks. These red beds therefore seem to offer a fairly good lithological division between No. IX and No. VIII, and the map has been colored accordingly.

The *Catskill rocks*, so considered, show in Snyder county an upper series of red sandstone and shales, with some few greenish-gray beds, in all about 2500' thick and well exposed in the cuts of the Sunbury, Lewisburg and Williamsport (P. and R.) railroad, on the west side of the river opposite Northumberland. The bottom portion of the formation, 1000' thick, whose red beds are not so prominent and have a less vivid hue, contain much olive-green shale and brownish-red sandstone. These rocks are well exposed along the public road from Northumberland to Shamokin Dam, and

to a more limited extent along the river in Chapman township north of Port Treverton.

The Catskill rocks nowhere furnish minerals or substances of economical value. The country occupied by them is rugged and considerably cut up by small and narrow ravines, eroded out of the softer shaly members. It furnishes a fairly good soil where cleared, but it is not largely farmed in Snyder county.

Chemung, Portage, Genessee, etc., No. VIII.

The next underlying group of rocks is designated collectively as No. VIII on the map, and is colored brown. No attempt was made to differentiate the formation into its several members, Chemung, Portage, Genessee, Hamilton and Marcellus; for in places the rocks of some one division cannot be recognized at all, and with the exception of the Marcellus, which carries a limestone and a bed of carbonate ore at its base, and the two lower Selinsgrove limestone beds in Snyder county, no valuable mineral deposit has been found in them.

Along the Susquehanna in Snyder county the Chemung and Portage cannot be separated, mainly owing to the absence of the flaggy structure of the Portage, which characterizes this formation along the Juniata and the Pennsylvania railroad cuts between Newton Hamilton and Mt. Union, in Mifflin county.

The *Chemung* and *Portage* rocks combined (*VIII g, f*), can be fairly well distinguished through Snyder county from the underlying Genessee and Hamilton by their lithological character and different type of topography they make. The former here consists of a top series of green, gray and olive shales, with some few thin splintery sandstones, grading downwards into harder sandstone beds, dark gray and brown, with very little slate, weathering into irregular but small fragments, which ring like a bell when struck, and are very splintery.

The whole double group, 2500' thick, contains many fossil

beds and is essentially a ridge-maker, whose soil is mostly barren and unproductive and very little cleared anywhere in the district.

The *Genesee rocks*, (*VIII e*.) largely a series of dark blue, brown and black shale, weathering yellow, are essentially valley-makers, everywhere following the base of the Chemung ridges, and sharply distinguished from those rocks by the totally different topography produced. They are about 300' thick in Snyder county.

The *Hamilton proper*, (*VIII c*.) on both sides of the Shade mountain anticlinal, carries about 1000' of slate and brownish shale on top, which assist in widening the Genesee slate valleys; but the lower part, 1000' thick, is much more massive, containing several beds of sandstone, which create a second line of ridges separated from the higher Chemung ridges by the Genesee and Hamilton valleys. Prof. I. C. White in Report G7, p. 79, gives a very interesting section of the entire series, measured along the Northern Central railroad below Selinsgrove Junction. He shows the lower part of the Hamilton above mentioned to consist of:

(a) Selinsgrove upper sandstone,	202'
(b) Dark olive shales, sandy,	125
(c) Selinsgrove lower sandstone,	5'
(d) Olive brown shale,	200'
(e) Dark shale and slate, with cleavage,	600'
(f) Selinsgrove upper limestone and impure limestone with shale beds,	40'

The *Marcellus black slate*, (*VIII b*) the base of the Hamilton group, is a valley-maker, being readily eroded and decomposed. It is a dark black fissile slate, breaking in small, thin irregular pieces, and yielding a somewhat gray clay soil. Thickness about 300'. Beneath it Prof. White finds, along the railroad where the measures are well exposed for measurement in a bluff:—(a) *Selinsgrove lower limestone*, a hard light gray impure rock, in thin layers, interstratified with gray shale 65' thick. (b) *Selinsgrove shale*, light gray impure limestone at top, 140' thick. This would make the Marcellus slate division, therefore, about 500' thick.

The different members could not be as well seen on the Snyder county side of the river as in Northumberland

county, owing to greater erosion and concealment; but the above fairly represents the character of the formation, typically developed. Varying sections of these rocks of No. VIII may be seen on Mahantango creek in southern Snyder, and along Penns creek and upper Middle creek between Jack's and Shade mountains. Their exposed thickness decreases somewhat going west from the river, owing to erosion and the western rise of the Northumberland synclinal, so that in Spring and West Beaver townships nearly the whole valley between the two Oriskany sandstone ridges is occupied by the black Marcellus slate, and Hamilton, here largely shale, and perhaps some Genessee beds.

The *Marcellus black slate* has been a very fruitful source of disaster to many coal mining companies throughout the district, which have labored long and earnestly to find coal in them. Every effort has proved a failure, as well as similar operations in the Hudson River and Utica slate formations No. III.

Union county contains only a very small amount of the No. VIII formation, caught in the Buffalo valley synclinal north of Lewisburg, where perhaps the whole of the Marcellus formation exists, but little if any of the overlying Hamilton.

Mifflin county contains a fair section through the Lewistown valley of Marcellus and Hamilton rocks, and the Portage group is especially well developed in Wayne township along the Juniata river. There does not appear to be any representation of the Chemung rocks at all in this county, so that those portions of the Lewistown valley occupied by the rocks of No. VIII present a very different topographical aspect to land so occupied in Snyder county.

The valley between Jack's and Shade mountains, which is deep enough along the Susquehanna to contain Catskill rocks No. IX, shoals up rapidly, until in Decatur township of Mifflin county the Chemung group is entirely wanting; the Portage is represented by a series of thin flags and sandy shales, making a sharp synclinal (double) ridge along the center of the valley; the Genessee and Hamilton slates, shales and sandstones making valleys on either side of the

central ridge, and a little high land near the bottom of the formation; and finally the Marcellus slate, following the line of the Oriskany sandstone ridges, and extending in long narrow belts between the folded synclinals in Derry township.

The greatest thickness of the entire series cannot be over 2500', near the Snyder county line. The series has somewhat the same character as at the Susquehanna, with rather less sandstone and limestone however in the Hamilton and Marcellus groups.

The *Marcellus iron ore*, a dull colored ash-gray pyritous carbonate when freshly broken, is well exposed in Derry township along the north side of the valley, at the Towns- end mines of the Logan I. and S. Co. The Marcellus here shows about 30' of black slate between the Oriskany sandstone No. VII (making a ridge behind the outcrop) and the ore-bed. The limestone in some places underlying this ore is generally absent here or decomposed to a clay. The mine will be referred to in the chapter on Township Geology. The bed is from 6' to 9' thick in the present workings, capped with a smooth black slate hanging wall.

Perhaps 300' of black slate overlies it throughout the narrow valley between the ridges, all belonging to the Marcellus. In the neighborhood of Lewistown only part of the Marcellus formation is held within the tightly compressed synclinals, the largest area and greatest thickness being found in the trough of the first synclinal north of Lewistown. Some few attempts have been made to find the Marcellus ore in different parts of this valley and in Granville township, but no ore is being mined at present. Near its horizon however, the Marcellus or Upper Helderberg limestone was seen at several points, at its greatest development showing 40' of impure greenish limestone, weathering rapidly into unctuous green shales.

At McVeytown the same rock is developed 40' thick, darker in color and consisting of numerous thin layers separated by clay slate.

The *McCoy, Ross, and the Dull & Bradley mines* are located in three different Marcellus slate synclinals north

of McVeytown, and have formerly furnished a great deal of ore from the Marcellus bed. From 80' to 100' of black slate intervenes here between the Oriskany sandstone and the lowest ore-bed, which is immediately underlaid by limestone. The ore-bed is from 2½' to 8' thick, overlaid by black slate.

West of McVeytown the synclinal and anticlinal crimples flatten out into one broad basin along the Juniata west of Newton Hamilton. Here the Portage flags are excellently exposed in the railroad cuts north of Newton Hamilton, lying perfectly flat in the trough of the synclinal. The whole group here is about 2000' thick.

The Marcellus limestone has been quarried on the river just east of Newton Hamilton, at the Norton quarry, where it is 40' thick and shows a hard gray crystalline and siliceous limestone in flat beds 2' to 4' thick, almost directly in contact with the Oriskany No. VII, which shows plainly on the river. The same limestone has been quarried and burned at several other points here, showing the same characteristics.

In Juniata county the No. VIII rocks west of the river are confined to the immediate valley of the Tuscarora, and east of the river occupy the synclinal made by successive rolls of the Oriskany sandstone spreading out along Mahantango creek to the Susquehanna. Several anticlinal axes, originating in the eastern belt 5 or 6 miles wide, increase in strength westward, and as they pass out into lower formations they throw the Devonian rocks into a series of folds and narrow triangular basins, which terminate westward.

Along the Susquehanna these rocks partake largely of the character displayed on both sides of the Shade mountain anticlinal at Selinsgrove; except that both the Marcellus and Hamilton groups thin somewhat. There is very little limestone in the series.

The country is generally one of poor soils, and topographically consists of a series of long narrow ridges enclos-

ing broader valleys. All the ridges however die out westward as the basin shoals up, confining the No. VIII rocks to a narrow tongue on both sides of the Juniata, mainly filled up with the Marcellus rocks.

Turkey ridge, limiting the district and the county on the south, is composed mainly of the Hamilton sandstone. It rises perhaps 150' above the valley, and runs for about 11 miles, decreasing in height towards the Juniata. Southwest of the Juniata the lower members of the formation are contained in a regular synclinal valley about half a mile wide, gradually widening to the southwest to receive higher strata along its center.

At *Honey Grove* the valley is nearly 3 miles wide, and about here the Chemung rocks first make their appearance, creating the typical narrow straight ridges due to the hard sandstone strata composing them.

The *Marcellus limestone* is exposed at various places in the Tuscarora valley, notably at Peru Mills, where the top layer is a good limestone 2' thick, underlaid by an impure greenish calcareous rock, and a considerable thickness of lime-shales, probably 100' thick.

Along the Huntingdon county line the whole group is about 3300' thick. The Marcellus division at the bottom is largely black slate with some gray and buff calcareous shales and thin argillaceous limestone, and grading upwards into more or less massive white sandstone strata separated by dark shales, the whole being 600' or 700' thick. The Hamilton and Genesee are largely olive and bluish-black slates, with some brown layers and thin sandstones, 800'. The Portage rocks are not so easily distinguished as on the Juniata, but are quite massive along the flanks of the Chemung ridges, and generally of a smooth texture and dark in color, and about 1000' thick. The Chemung rocks on top and along the center of the valley are composed of thin but very hard gray sandstone, breaking into long flat layers and show a decided cleavage. There is some shale also, reddish-brown in color, and fissile, the whole producing a lean soil, so that the ridges in western Juniata are very little cleared for farming purposes.

Oriskany Sandstone and Shale No. VII.

This double formation, colored yellow on the map, forms a most important geological and topographical break all through the district, occurring between comparatively softer measures, the Marcellus slate above and the Lewistown limestone strata below.

The *Oriskany sandstone* can be traced everywhere by the sharp low ridge it forms, no less than by the character of the soil made by the disintegration of its rocks. It is perhaps the most variable and uncertain formation of the Palaeozoic series of Pennsylvania; but it is well developed in this central district of the state. Sometimes the rough weathering sandstone has dwindled down so much in thickness that the underlying Lewistown limestone makes the crest of the ridge, with the Oriskany (Stormville) shales and a little broken down sandstone making the outer flank. Elsewhere, especially in Mifflin county, the sandstone swells out to 125'-150' in thickness; creates high and rough ridges, with the limestone making a valley at the base.

The *Oriskany* (or *Stormville*) shales are rarely well exposed, being generally covered with *débris* from the overlying sandstone, and their thickness is equally as variable. Through the larger part of the district the Oriskany sandstone No. VII exists as a hard flint or chert rock, breaking up into sharp irregular pieces, which cover the crests and slopes of the ridges, and assist in locating this formation. When in such a condition this sandstone is useless and creates a hard dry soil, very light and but rarely farmed. But the typical sandstone is made up of grains of sharp quartz, loosely cemented together and quarried in many places for use as glass-sand.

In *Union county* the Oriskany sandstone has but a slight representation. It makes a thin band of loose sand through Gregg township in the north end of the county, where the low dip of the measures has spread its outcrop considerably; but its thickness is not great.

It is also found encircling the Buffalo valley synclinal at Lewisburg, though nowhere well exposed, and consisting of a mass of yellowish-brown sand lying on the flank of the limestone ridge.

It is again enclosed in the Mifflinburg synclinal, occurring in three slender detached patches on the crest of the long limestone ridge south of Mifflinburg. Its sand has no commercial value here, being discolored and shaly. The formation cannot be over 25' or 30' thick; and the underlying flint shales do not seem to occur at all.

In *Snyder county* the formation is more widely distributed but, nearly everywhere, a chert, and of no economical importance. It occurs on both sides of the main Northumberland synclinal from the Susquehanna to the Juniata line; but in many places along the north side of the valley it is wanting, and always indistinct and very thin. It is slightly more distinct on the south side of this synclinal, and sometimes shows a good, but thin, bed of sand; but it is practically worthless for glass purposes.

In *Flinstone ridge*, extending from the river below Selinsgrove towards Freeburg and Freemont, its chert beds form the crest and give the name to this conspicuous hill. The thickness of the formation could not be well determined; but it falls within 40'; and is everywhere a hard chert.

In *Mifflin county* the formation shows its best development, especially from the neighborhood of Lewistown west to Mt. Union. It is variable here too, both in thickness and character, but augments gradually towards the south west. The Oriskany sandstone is about 50' thick in Decatur township, being well exposed on the flanks of the two subordinate anticlinals which jut out into the Devonian slate valley from the Kishacoquillas creek.

In the ridge north of Lewistown the same formation is 110' thick, but it is not particularly massive, showing a rather soft sandstone 40' thick, between layers of shaly sandstone, and the Oriskany shales beneath it are put at

205' in thickness in the Lewistown section. (See Report F, p. 49.)

At the *Juniata Sand Works*, $3\frac{1}{2}$ miles west of Lewistown, the sandstone is about 100' thick and yields a high grade quality of glass-sand. The sandy shales underlying the sandstone are 200' thick. At McVeytown the sandstone has increased to 140'-150' in thickness, and is here again largely quarried for glass manufacture.

At the *Enterprise Sand Works* at Vineyard station on the Pennsylvania railroad $3\frac{1}{2}$ miles east of Newton Hamilton, this rock is again splendidly developed and largely quarried. It seems to be about 125' thick, although this measurement may be somewhat increased by including an impure sand bed not worked by the company.

In *Wayne township*, east of Newton Hamilton, the formation is spread over a wide area by reason of the flattening out of several anticlinal rolls, creating a large sand flat, out of which project small ridges made by the harder members of the series; but the sand does not seem as suitable for glass purposes here, as in the more steeply-tilted rocks along the south leg of the synclinal, from Lewistown west. At Mt. Union, on the north side of the Lewistown valley, the formation is about 100' thick; but 150'-160' in Long hollow, a few miles to the east.

Along the north flank of Shade mountain, east of Lewistown, the rock is not as persistent in character, nor so easily traced, as it dwindles down in thickness towards Union county, where, as already stated, it is only 30' thick. Many places, no doubt, besides those enumerated in this county could furnish an excellent sand to the glassmakers, but lack of railroad facilities has retarded the search for and development of it. As it is, the quarrying, preparation and shipment of the quartz sand makes a most interesting and important industry, and one which is bound to develop and augment the county's material wealth. The occurrence and duplication of this remarkable deposit by rolls and basins is clearly set forth by color on the county map, and does not call for special mention here. The sandstone is usually very fossiliferous, and can be readily rec-

ognized by this means, no less than from the glistening white and lemon-yellow color of its sand.

In *Juniata county* the formation again deteriorates, and, where present at all, it is usually in the form of flint or chert rocks, in which condition it is unfit for glass purposes.

The *Flintstone ridge* before spoken of, in Snyder county, carries the same name here, and shows a zigzag course east of the Juniata, in obedience to the structural laws governing its exposure, from Richfield to Port Royal. Large accumulations of sand take place at the extremity of the canoe-shaped basins, where the two opposing dips meet, but the formation is not thick, averaging perhaps 40' in this part of the district, with perhaps an equal thickness of sandy shale below it. This latter is both calcareous and siliceous; and usually quite hard, breaking into small square pieces, with sharp edges and quite as resisting to atmospheric influences as the more massive members of the formation.

On the south side of the main Tuscarora synclinal, along the foot of Turkey ridge, No. VII is scarcely perceptible. West of the Juniata two low Oriskany chert ridges flank the main valley all the way into Huntingdon county, their rocks the same but dipping toward each other, creating hills which are rarely farmed now but given up to the cultivation of peaches, to which their sandy soil seems very well adapted. The sandstone is here 20–25' thick, the shale perhaps twice as thick. This formation is also exposed on the crest of the Tuscarora mountain anticlinal, at McKee's Half Falls, in the extreme southeastern corner of the county.

Some little iron ore has been mined from the upper sandstone members in one or two places in Mifflin county, and in Juniata county and other points the Oriskany ridges are covered with a mass of siliceous hematite ore, which has never yet repaid the amount of money spent in its development, and is in fact worthless.

The Lower Helderberg (Lewistown) Limestone No. VI.

This formation has been given a deep blue tint on the map for the two-fold purpose of distinguishing it from

Siluro-Cambrian limestone No. II, of the Kishacoquillas and Black Log valleys, a much lower formation, and to accent strongly the position of these important limestone beds, to which the Lewistown valley owes much of its fertility and charming scenery. The group is so well developed here that the formation often carries the name of the "*Lewistown Limestone*," and to follow its course through the Juniata is only to pick out the most fertile and the most highly cultivated portion of the region lying contiguous to it.

It may be conveniently divided for description into two sub-divisions, (a) *an upper lime-shale division*, and (b) *a lower massive limestone division*. The upper of these two divisions abounds in fossils; the lower furnishes but few. Again the upper is rarely burned for lime unless the lower member is covered up or difficult to reach, while the massive member furnishes nearly everywhere one or more beds of most excellent quality, some of it good pure stone, free from siliceous matter, suitable for furnace use, plastering and all purposes where high grade lime is required.

In *Perry county* (see Rep. F³, p. 60) Prof. Claypole divides this formation as follows:

1. White flint shales,	10'	
2. Yellow flint shales,	80'	
3. Black cherty limestone,	8'	
4. Clark's Mill lime shale,	150'	
5. Lewistown limestone, massive, 100'		
		<i>Lower Helderberg No. VI</i> 348' thick.

Nos. 1, 2, 3, in which Prof. Claypole has found fossils of the Lower Helderberg type, have been included in the Oriskany (Stormville) shale division of No. VII in this report, not upon palaeontological grounds, but because of the general character of the group, which consists of sandy slate and calcareous-siliceous shales, forming really a transition series between the coarse friable sandstone No. VII and the upper lime-shales of No. VI. With a view of representing the economical features of the district as far as possible, these flint-shales have been colored yellow, and included in No. VII, leaving the lower members of the section, Nos. 4 and 5 about 250' thick, to represent No. VI.

In *Huntingdon county*, (Rep. T³, p. 123,) Prof. White divides No. VI as follows :

1. *An upper division*, consisting of impure and shaly limestone and containing a 25' massive layer with *Stromatopora fossils* 133'.

2. *A middle division*, dark blue massive limestone, not fossiliferous, and containing mostly good limestone beds, 90'.

3. *A lower division of shaly*, impure limestone . . 170'.

The total thickness of the formation is thus about 300', varying from that up to 400' in other parts of the county. All the good beds, most quarried, are confined to the middle division, 90'-100' thick.

Along the Susquehanna the series is from 250'-300' in Union county and may be conveniently divided into—

1. *An upper limestone-shale series*, fossiliferous containing the *Stromatopora bed* near the center and with some good limestone near the base, } 100'-150'.
2. *A middle bastard limestone series*, carrying tough, impure limestone beds, very hard and weathering with difficulty; magnesian and never burned, } 25'-75'.
3. *A lower massive limestone series*, known east of the river as the "*Bossardville limestone*" and containing most of the good quarry beds; dark blue, non-fossiliferous, with impure bands, 20'-30' thick at center, } 100'.

The total thickness of the group averages about 250' as against 350' in Huntingdon, and 250' in Perry. It must be remembered in comparing these sections that the "*Bossardville limestone*" group of the Susquehanna, corresponds to No. 5 of the Perry county section and to No. 2 of the Huntingdon county section, the lower division of the latter 170' thick, consisting of impure limestone, and in this report considered a part of the next lower group—the *Upper Salina*, Vc'.

The practical point brought out by this comparison is the fact that the *Lower Helderberg* (Lewistown) *formation* in this central district furnishes a series of limestone beds, non-fossiliferous and massive, and about 100' thick, which contains nearly all of the pure stone of the series, probably averaging 50 per cent. of the entire group thickness, and that the good burning beds are to be sought in this series

alone all through the Juniata district. The position of this series is shown on the map by a deep blue tint.

In *Union county* the rocks of formation VI outcrop through Gregg township, where the beds are thin, and are nowhere opened over 50' in thickness.

The Lower Helderberg limestones are next seen in the Buffalo Valley synclinal at Lewisburg, making the boat-shaped "*Limestone ridge*," in which several quarries have been opened. Here, and along the Mifflinburg limestone ridge, the lower massive "*Bossardville*" beds of the group have been opened, without exhibiting any complete section. This division, however, with its usual shale partings, is fully 80' thick and yields an excellent quality of limestone. The upper lime shales are about 110' thick, and are very fossiliferous, but nowhere quarried.

The *Winfield quarries*, in the extreme southeast corner of the county, belonging to the Union Furnace Company, perhaps exhibited the best section of the lower Bossardville beds, as they have been more extensively quarried here than elsewhere, both for furnace flux and the general market.

The series can be conveniently divided into two divisions, *an upper* (immediately under the shaly beds) 50'-55' thick and furnishing some good beds; *and a lower*, 48' thick, holding several massive beds, and yielding both fine grade paper-lime and furnace flux. A bed, 6' thick, of shelly porous rock, very hard and lean, divides the two groups; the whole forming a series practically 100' thick.

In *Snyder county* a double outcrop of limestone flanks the Northumberland synclinal, following the line of the Oriskany sandstone already described, and often replacing that rock as the crest of the ridge.

The *Winfield beds* are opened on the north side of the basin in many places as far west as New Berlin; but not as completely as on the river. There is another group of quarries in Kline's ridge, along the same belt as Troxelville; but they are small and show no better sequence of

beds. Almost every mile of the south belt, from Selinsgrove to Middleburg, Adamsburg and McClure, shows one or more quarries, and while the sections exposed in them are not very extensive, they all substantiate the general persistency and good quality of the lower division of No. VI, as a series of beds of varying thicknesses, aggregating close upon 100'.

The *Lower Helderberg series* is perhaps best exposed opposite Selinsgrove on the N. C. R. R. on both sides of the Selinsgrove or Shade mountain anticlinal, where they are much thicker apparently than farther north, showing 343' thick on the north side of the axis and 413' thick on the south side, of which about 125' represents the massive *Bossardville beds*.

On the south side of the Shade mountain anticlinal these same measures may be traced uninterruptedly from below Selinsgrove on the Susquehanna west past Freeburg and Freemont to within 3 miles of the county line, where they form a narrow synclinal basin and high ridge and return to within a mile of Freemont. Here they lap over the Slenderdale axis, and retreat westward again to the Cocalamus creek at Richfield.

Quarries of considerable size are opened in them west of Middle creek and west of Freemont; but only a portion of the massive division, 30'-60' thick, has been developed in them, and the lime burning industry languishes for lack of railroad communications. A limited amount of No. VI is also exposed in the south-east corner of the county, near McKee's Half Falls, on the crest of the Georgetown axis; but there are no quarries there to show the character of the measures.

In *Mifflin county*, the Lower Helderberg measures are very well developed, showing a somewhat amplified section near the central portion of the belt between Lewistown and McVeytown. It enters the county in a double line of ridges, capped with Oriskany sandstone No. VII, on either side of the slate valley of Decatur township.

The northern belt runs pretty straight through Decatur

to Derry township where it makes a synclinal and returns eastward about a mile in an anticlinal ridge with north and south dips of 85° and 50° . Here it turns back again westward to the next synclinal at Logan on the Kishacoquillas, west of which point it extends in an unbroken synclinal of No. VI, in places deepening to receive No. VII and a little of No. VIII, to within 4 miles of the Juniata. East of Logan the basin splits and widens to receive No. VII and No. VIII, folding over again in another anticlinal, entering into Decatur township before returning again westward to the grist mill on the pike north of Lewistown.

The *southern belt* enters the county from McClure and makes a prominent ridge facing the Sunbury and Lewistown railroad all the way to Lewistown, from whence it passes west to the Juniata Sand Works, Strode's Mill and McVeytown. Here the belt and ridge bend southwest and make several small anticlinal and synclinal rolls north of Vineyard station, crossing the river and passing into Huntingdon county about $1\frac{1}{2}$ miles west of Newton Hamilton.

The eastern end of the county is rather sparingly developed; that is to say the quarries are all comparatively small and the section of No. VI limited. Perhaps the best exposure is at the Maitland gap, where the upper division shows about 20' of shaly and somewhat siliceous limestone, and a lower, more massive division of good limestone 70' thick.

At *Lewistown*, along the Kishacoquillas creek, the character of the Lower Helderberg limestone is well seen. The *upper division* here consists largely of flaggy argillaceous limestone, somewhat quarried for building purposes, but not yielding a good burning-lime. It is about 140' thick. The Lewistown limestone is about 185' thick here, showing several massive beds of blue limestone, largely quarried for lime and furnace flux. But the good portion of the deposit does not comprise more than 60' at the top of the division.

The Logan Iron Company quarry furnace flux from this middle division of No. VI, and further divide it into three members :

1. *An upper argillaceous and fossiliferous member*, 10'.
2. *A middle good, pure, fluxing limestone-bed*, 50'–60'.
3. *A lower highly silicious member*, not used. 20'.

The company get all their furnace stone from the middle beds 50'–60' thick, here opened just at the arch of the synclinal. The total combined thickness of the Lewistown shale and limestone in the vicinity of Lewistown, as measured instrumentally for Report F, p. 49 (Logan section), is $140+185=325'$; and 300' may be taken as a fair average for the group in the three synclinals which occur between Lewistown and Ferguson valley. The group holds about the same thickness at McVeytown, although measured sections in Report F show the upper shaly limestone to be 215' thick and lower massive portion about 100', 50' being good stone in beds of varying thickness from 1 to 8'.

On the Juniata below Mt. Union nearly 100' of stone are exposed in the quarry of the Lucy Furnace Co., about $\frac{1}{2}$ mile from the bridge, the central portion of which, 40' thick, is a good blue furnace stone.

In Juniata county, the Lower Helderberg limestone formation is somewhat thin. Entering the county on the east at Richfield, its course to the Juniata is practically that of the Flintstone Ridge No. VII, already described, sometimes rising to form the crest of the ridge where the Oriskany sandstone becomes shaly or is absent. A number of quarries have been opened between Richfield and McAllisterville, and south of the latter village; none of great size or importance, but all showing a good stone of uniform general excellence. None of these quarries show over 50' of stone exposure, and the beds making up this mass are never very thick, 1 to 4', except in some few instances which will be mentioned in Township Geology. West of East Salem in the north leg of the synclinal, an additional series of quarry openings show about the same thing, but not so well exposed.

The outcrop of No. VI, after nearly reaching the river in the synclinal, turns back eastward to East Salem, folds over the Academia anticlinal in a double wrinkle, and finally

turns westward again as the north leg of the main Tuscarora synclinal to Port Royal. Along the basin there are in places as high as 60' of No. VI exposed; but the individual beds are never over 3' or 4' thick, and the good burning portion of the series will not aggregate over 40' in thickness.

West of the Juniata the outcrop of No. VI on the north side of the Tuscarora synclinal, shows but a single line, passing through McCoysville and back of Peru Mills to Huntingdon county.

The best exposures are at McCoysville and Peru Mills, at both of which places the limestone beds have been quarried. At McCoysville No. VI shows about 150' thick, including the upper shaly members, the massive pure limestone at the bottom occurring in a series of thin beds about 40' thick. At Peru Mills the exposure measures about 50', with but few large beds.

The south outcrop of limestone in Juniata county forming the south leg of the Tuscarora synclinal, extends from the base of Turkey ridge, in front of the Tuscarora mountain gap in Delaware township, through Thompsontown to Mexico on the Juniata. There are few good exposures here. At the Hamilton quarries all the good lime is quarried from 60' of measures, none of the individual beds being more than 3' thick.

About the same thickness is exposed in Bennei's quarry, 1½ miles further west, and on the river below Mexico, where, however, the upper shaly limestone increase the section by 80'. West of the river the limestone belt makes nearly a straight line past Pleasant View to Bealetown, where it makes a synclinal loop, and at Allen's quarry shows about 60' thick, dipping N. 30° W. 35°. The stone is evenly bedded and has a sub-crystalline structure, greyish-blue in color, and rather silicious at the base. The upper portion is fossiliferous, the good limestone being about 40' thick.

West from here to Huntingdon county the Tuscarora creek partially cuts out the section of No. VI, which has evidently decreased in thickness, so that a complete section would scarcely show more than 150'-200' of measures.

Salina and Clinton formations, No. V.

Various names have been given by different geologists in their different districts of Pennsylvania to the measures underlying massive beds of the Lewistown (Lower Helderberg) Limestone No. VI.

Pof. Rogers included in his Scalent and Surgent series all the rocks between the No. VI limestone, and the top of the white Medina sandstone No. IVc, which forms the crests of so many of the mountain ridges of the district. The *Scalent series* he made triple: 1. The *Scalent limestone* on top, corresponding to the *Water Lime* formation of New York; 2. The *Scalent grey marls*, and, 3. The *Scalent variegated marls*, both of which he correlated with the *Onondaga Salt group* of New York.

The *Surgent series*, underlying the Scalent, he divided as follows, from above downward:

*Pennsylvania.**New York.*

- | | |
|---------------------------------------|--|
| Scalent series, | The Water Lime and Onondaga formation. |
| 1. Surgent red marl, | = Clinton group. |
| 2. Surgent upper ore shale, | = Upper Green shale of Clinton group. |
| 3. Surgent ore sandstone, | } Probably part of the upper Green shale of Clinton. |
| 4. Surgent lower ore shale, | |
| 5. Surgent upper slate. | |
| 6. Surgent Iron Sandstone. | |
| 7. Surgent lower slate, | = Probably the lower Green shale of Clinton. |
| Levant white sandstone, | = Medina of New York. |

Mr. Dewees, in Report F, further subdivided these groups, and in the measured sections by Messrs. Ashburner and Billin, given in that report at Lewistown, McVeytown and Mt. Union, the following nomenclature was adopted:

Logan and Lewistown Sections, Combined, Report F.

VI.	}	Lewistown (Lower Helderberg) limestone,	
		1. Water lime shale,	470'
		2. Salina shales,	350'

V.	{	3. Niagara limestone?	3½' to 4'	} 2137'		
		4. Niagara shales?	70'			
		5. Upper Clinton variegated shales,	432'			
		6. Variegated shales,	326'			
		7. Clinton lower red shales,	260'			
		8. Upper Clinton fossil ore shales.				
		9. Clinton lower lime shales,	251'			
		10. Clinton upper olive shales.				
		11. Ore sandstone, including fossil-ore beds, . . .	38'			
		12. Clinton middle olive shales,	175'			
		13. Iron sandstone (block-ore),	7'			
		14. Lower Clinton shales,	571'			
		IV. Medina white sandstone.				

Nos. 1 and 2 of the section being regarded as part of the Lower Helderberg limestone formation No. VI; and Nos. 3 to 14 are incorporated in the Clinton 2137' thick.

The *Mifflin and Juniata county maps* have in this report been colored *red* for the *Salina* and *Clinton groups*, it not being possible to separate them here, as in *Union* and *Snyder counties*, by the outcrop of the "*Bloomsburg red shale*" or *lower Salina Vc*; and therefore everything in the above section from 1 to 14 inclusive, with an average total thickness of about 2500' has been included under the following subdivisions:

- Vc' 1. The Salina upper lime shales, Nos. 1 to 4, 900' thick.
- Ve 2. Salina lower variegated shale, red predominating, }
- Vb 3. Niagara, wanting, } 1600'-1800'
- Va 4. Clinton red and brown shales and fossil-ore, . . }

According to this view the Salina upper division would correspond to Prof. Roger's *Scalent series*, and the Salina lower and Clinton to his *Surgent series*; but there are no sharp lines of division, whether lithologically or palaeontologically between the different members of these groups; and all attempts to use the red color of the *Bloomsburg red shale* in these two counties, to separate the upper and lower Salina, signally failed by reason of the numerous red bands in the upper Salina series there.

In *Union and Snyder counties*, the *Bloomsburg red shale* division was much more distinctly marked, and consequently the *maps of these two counties* depict this red band, by whose zig-zag windings the structure is emphasized and a reliable key-rock established for dividing the upper

Salina lime shales above (colored blue in bars) from the lower Salina (deep red) and Clinton groups (light red) below.

At the same time the coloring adopted, while doing no violence to geological nomenclature affords a graphic method for locating the best and most fertile farm lands of the district.

The whole group in these two counties is from 2000' to 2300' thick, the upper Salina Vc' 700'; the lower Salina Vc, or "Bloomsburg red shale," 400', and the Clinton Va the balance.

In *Union and Snyder counties*, the *upper Salina* group* is represented by a series of buff-colored and greenish magnesian limestone and lime-shales, readily yielding to atmospheric influences and therefore creating most excellent farming lands. Very little, if any, of the limestone is pure enough to burn or make suitable lime for farm fertilizers; and as a usual thing they are so soft and yielding as to present but few outcrops and a very limited means for measurement.

Some few thin bands of red shale occur in the lower part of the formation; but they can readily be distinguished here from the *Bloomsburg red shale* which is usually rather sandy, has a deep and quite uniform red color, and nearly everywhere makes low ridges and bluffs. It is moreover characterized by cleavage, which serves to break the rock into irregular small blocks, creating a rough surface.

All the area with blue bars on the Union and Snyder maps is occupied by the *upper Salina* rocks; and a glance at the map better than any description will show the large proportion of the land so occupied in both counties. To its presence is largely due the fertility and charm of the beautiful Buffalo valley in Union; while in Snyder county two equally famous belts of farming land occur on either side of the Shade mountain anticlinal.

The *Clinton division* in these two counties is of equal

*Comprising the Upper and Middle Salina groups of Northumberland, Columbia, etc. (see G⁷).

importance in another sense; for, while yielding a good soil along the line of strike of its shales and thin limestone strata, its chief value lies in the fact of its being the repository of the series of fossil-ore beds from which large quantities of iron ore have been mined in the past, and upon which the good reputation of the Juniata iron was founded. The erection of much larger furnaces at the present day, the demand for purer raw materials, large outputs and cheap ores to mine, combined with the comparatively low price of iron, have tended to almost paralyze the ore mining industry in this region, although hundreds of abandoned drifts and slopes bear testimony to the large amount of ore that was once mined from these beds.

The *Clinton division* may be further sub-divided thus:

Bloomsburg red shales—Lower Salina group No. Vc.

- | | |
|---|---------|
| 1. Upper olive and greenish, sandy and limy beds, | 175' ± |
| 2. Ore sandstone and fossil-ore beds, | 10'-25' |
| 3. Middle olive shales and thin limestone, | 150' |
| 4. Iron sandstone and block-ore, | 10' |
| 5. Lower olive and brown fossil shales and slate, | 600' |

Total thickness of Clinton Va, 950' ±

The various members of the group necessarily vary greatly and gradually thicken up towards the west to about 1200' in all.

In *Union county* the *Clinton* rocks are found in the numerous synclinals and anticlinals of the Buffalo mountains, between outcrops of the Medina sandstone and the Bloomsburg red shales, and along both flanks of Jack's mountain, and its continuation in Shamokin mountain, finally curving over the whole crest of the latter axis before reaching the river at Turtle creek.

In *Snyder county* these rocks make a triangular-shaped area, narrowing eastward on both flanks of the Shade mountain axis.

The Ore Sandstone.

The *Ore sandstone* member of this formation, No. 2 of the general section, is perhaps the most readily identified

as it certainly is the most important economically from the fact of its being a key or guide-rock to the location of the "Sand Vein" fossil-ore bed immediately above, and the Danville fossil-ore beds which underlie it anywhere from 10'-25'.

This remarkable sandstone is hard to describe, but once seen can rarely be mistaken for anything else. It has a dull brown to whitish-red cast, is frequently full of fossils, has a square but rugged, fracture, and sometimes is made up wholly of fragile layers only a few inches thick. It is only about 8' to 10' thick in Union and Snyder counties along the river, though increasing to 30' in western Snyder, where it makes a very prominent ridge wherever it outcrops.

It occurs at an interval of 150' to 200', say 175' below the Bloomsburg red shale group, and about the same distance above the Iron sandstone, and as in a large part of Union and Snyder counties its dips are moderate, it creates a ridge, always quite prominent in such cases, at some distance from the base of the Medina mountains.

The Sand Vein Ore.

The *Sand vein ore* occurs on top of it, usually separated from the Ore sandstone by the "Sand Rock," a coarse brownish ferruginous sandstone, evenly bedded in places 3' or 4' thick, elsewhere absent. This ore bed has furnished by far the largest bulk of the ore mined in these four counties, although by no means a persistent bed, either in bed section or character. Frequently it is altogether absent and again often so lean and siliceous as to be a mere ferruginous and-sandy limestone, fossiliferous and not mined at all. However, where the ore is good it shows from 2' to 3' thick, usually divided in the center by a band of "Jack" or hard slate from 0' to 10' thick. It is impossible to give any typical section of this bed, for it varies greatly and within comparatively short distances. Above water level it furnishes a good quality of soft fossil ore, with 45-47 per cent. of iron in the furnace, and from .2 to .5 per cent. of phosphorus. The silica varies anywhere from 10 to 30 per cent., the percentage of iron running down accordingly.

The narrow red band on the map represents the outcrop of the Ore sandstone approximately.

The Danville ore.

The *Danville ore bed*, so called from its large development at Danville in Montour county (where the Sand Vein is worthless) is usually separated from the Ore sandstone above by from 10' to 30' of purplish-red and calcareous shale. It is from 16" to 18" thick at Danville, where it has been most wrought, and shows a triple character, separated by thin slate seams. These beds are spread through 6' or 8' of measures in Union county, are usually merely thin ferruginous limestone, but in places, as between Turtleville and New Berlin, the partings are thinner, and the different ore benches 4" to 6" thick are worked in the same gangways.

This is the principal bed along the south side of the Longstown ridge, and near Union Furnace at Turtleville the lowest of the three Danville beds is said to have yielded from 20" to 3' of ore.

The *Middle olive shales*, 150' ±, intervene between the Danville ore rocks and the Iron sandstone.

The Iron Sandstone.

The latter rock is a hard dark red brittle sandstone, where typically developed, but it varies greatly. A series of sandstones and hard slates 60' to 70' thick occurring at this horizon is sometimes given the name; elsewhere a single bed 8' to 10' thick is called the *Iron sandstone*. It occasionally carries a little ore on top, known as the *Block ore bed*, and is itself frequently ferruginous enough to come within the term "iron ore." But there is no demand for such ore as it can furnish now, and no ore was taken from this horizon at all during 1888.

The Lower Olive shales.

The lower olive shales, 500' to 600' thick, intervene between the Iron sandstone and the Medina sandstone, and it is largely these rocks which fill up the narrow valleys.

between the Buffalo mountain spurs and the outcrops on the flanks of Jack's and Shade mountains.

The Bird's Eye fossil ore.

The *Bird's Eye fossil-ore bed* occurs in the center of these lower Clinton shales, once largely mined along the crest of the Shade mountain anticlinal in eastern Snyder county.

These rocks weather readily, and when not covered by loose bowlders of Medina sandstone on the side of the mountain, they furnish a good natural soil, largely argillaceous, but subject to improvement. Its rocks, however, are usually more siliceous than the Middle olive shales.

The *Bird's Eye fossil-ore bed* is the most important feature of this division, occurring about 150' above the base or top of Medina sandstone, and extensively wrought at one time towards the eastern end of Shade mountain in Snyder. Its flat dip and good quality invites development. It is 8'' -10'' thick, breaks out in blocks just the thickness of the bed, due to cleavage planes running at acute angles to the strike of the measures. Usually its outcrops occur so high in the mountains, wherever the dip becomes stiff, that it is impracticable to reach it for economical development, so that it is very little known in Mifflin and Juniata counties, and is nowhere mined in Union.

Boyer block, and Shot block ores.

Two other beds have been found locally in Snyder county, although they may be found elsewhere.

1st. The *Boyer block-ore*, which Mr. Dewees describes as "occurring 250' to 300' beneath the Iron sandstone and 100' to 150' above the Bird's Eye fossil-bed." It is 6' thick and part of it furnishes good ore where opened in Mahantango Gap northeast of Freemont in Snyder county.

2d. The *Shot-block fossil* lying below the Bird's Eye; 6'' to 8'' thick and contains shot-like argillaceous pebbles. It has been wrought in the Lost Creek ridge and Paxtonville quarries in Snyder county.

No. V, in Mifflin and Juniata.

In *Mifflin and Juniata county*, very little in addition need be said to describe the Salina and Clinton formations. These rocks occupy wide belts through the Lewistown valley in Mifflin county, flanking Jack's and Shade mountains; and the lower Clinton rocks also show in the Laurel Creek valley between Paddy and Long mountains.

The *Salina rocks* will be found close to the blue belt representing the Lower Helderberg limestone, because in this part of the district the dips are steeper and the breadth of the outcrop lessened. On the north side of the Lewistown valley, the *Ore sandstone* makes a high terrace on the south flank of Jack's mountain until approaching the Juniata near Mt. Union, its dip decreases and throws the outcrop more to the south and towards the valley. From Union county to the Kishacoquillas, very little is known of the condition and thickness of this rock or the fossil-ore beds above and below it.

The outcrop of the "*Sand Vein*" is rather silicious in this part of the range; but the ore bed has never been regularly opened and therefore nothing is absolutely known of its character. Vast quantities of uncleared land belonging to the Logan Iron Company occupy this part of Jack's mountain, in which explorations for ore have never been systematically carried on. The *Ore sandstone* is, however, quite massive and about 30' thick, and dips about 60° south, so that these circumstances favor the occurrence of considerable bodies of soft ore here.

At *Logan Gap*, in Jack's mountain, the *Ore sandstone* is about 20' thick and dips 55° S. E.

The *Danville ore beds* have been found here, 3 in number, through a section of 15', the upper bed being 15' beneath the Ore sandstone. The largest is scarcely more than a foot thick, and the small pits have long since been closed. An analysis of the ore given in Report F, p 17, shows:

Iron,	26.100 per cent.
Sulphur, . . . . .	.051
Phosphorus, . . . . .	.544

Carbonate of lime,	47.018
Carbonate of magnesia,	2.240
Insoluble residue,	9.610

At the same place the *Sand Vein* was once opened by the Messrs. Mann, 18'' thick, the underlying sand rock being 3' thick. An old opening on this bed, by a gangway 140 yards long, showing 12'' of good rich ore in the 16'' or 18'', with the following analysis :

Iron,	46.950 per cent.
Sulphur, . . . . .	.005
Phosphorus, . . . . .	.310
Insoluble residue,	22.880

At the *Lucy Furnace*, at Mt. Union, the *Ore sandstone* 30' (?) thick dips 25° S, and the *Sand Vein* about 16'' thick ; and over it here are several beds, 2'' to 6'' thick of fossiliferous limestone.

The *Danville beds* also show here, the two upper beds being separated by 6' of rock. The upper bed is said to be 18'' to 24'' thick, and the two others 10'' to 12''. They could not be well seen or measured, and have never been mined to any extent.

No. V. in Ferguson valley.

Ferguson Valley is a name given to all that belt of country occupied by the Clinton and Salina rocks, lying between Jack's mountain and the Lewistown ridge, and between Kishacoquillas creek and north of Meveytown.

It is an anticlinal valley, the crest of whose arch is indented with a synclinal roll, so that the map shows four outcrops of the *Ore sandstone* and accompanying fossil-ore beds about 8 miles long. This has been the scene of many individual ore operations, although during the season of inspection (1888) but one mine, the Phillip's bank, was actually worked.

The *Ore sandstone* is first brought up in this anticlinal about 2 miles west of Kishacoquillas, and for 2½ miles the ridge shows only a double outcrop of this rock, about ¼ of a mile apart, with opposing dips and including between them a portion of the lower Clinton rocks. The arch here

becomes dimpled, and for the next 5 miles shows four outcrops of the Ore sandstone, in two parallel anticlinals, separated by a narrow synclinal. Throughout the entire ridge, frequent ravines cut through the Ore sandstone and form good opportunities for reaching the ore beds by drifts driven east and west along the line of strike. The dips are of medium strength, 30° to 40° , and the ore of the *Sand Vein* is largely a soft fossil above drainage level, varying from 12" to 18" in thickness including the "Jack" or impure ore shale at the bottom.

At *Graham's bank* $3\frac{1}{2}$ miles west of Yeagertown, the Sand Vein above the Ore sandstone is double, the upper bed being about 20" thick, and the lower, separated by a few feet of shale, is 14" to 18" thick with 4" of barren "Jack."

The Danville bed, below the Ore sandstone was also shafted upon here on the north dip, and found to be a hard fossil about 16" thick.

At the *Philip's bank*, on the old Cuppels property, about 6 miles southwest of Yeagertown, two openings have been made on the outcrops of the central synclinal. The bed here is about 16" thick, the north dip being about vertical and the south dip about 60° .

In the south dip of the anticlinal the same *Sand Vein* is from 20" to 24" thick, but not opened. At McKee's $\frac{1}{2}$ mile further west both dips of both anticlinals have been formerly opened on the Sand Vein. The Ore sandstone is here 15' to 20' thick, and the Sand rock, immediately under the ore beds about 3' thick. The Sand Vein is 16" to 18" thick here.

At *McCord & Rothrock's bank*, $8\frac{1}{2}$ miles west of Yeagertown, the two anticlinals are sinking. The base of the ridge, containing the two anticlinals is nearly half a mile wide. The lower Clinton shales, decomposing into a yellow clay at the surface, form the crest of the south anticlinal, and the Ore sandstone the crest of the north axis, which therefore subsides less rapidly than its south one. The ore bed here is 14" thick, and the Sand rock is quite ferruginous. The Ore sandstone is from 20' to 25' thick

and between it and the Sand rock there is a bed of good porous light ore, 4" to 6" thick. The same bed occurs at Keever's & Phillip's banks.

North flank of Shade mountain.

On the south side of the Lewistown valley, along the north flank of the Shade mountain and Blue Ridge, the ore developments are very meager, owing both to the steep dip of the Ore sandstone which carries the outcrop of the fossil-ore bed high up the mountain flank, and to the uncertain quality and thickness of the ore. Through this part of the field the Ore sandstone and Iron sandstone pass into the high terrace of the mountain, and no longer form separate ridges as in Union and Snyder counties.

East Shade mountain ore

On *East Shade mountain*, south of Painterville, the Ore sandstone is about 25" thick and dips 50° to 60° N. W. The Sand Vein was found here 12" thick in an old tunnel, but hard fossil and lean. The Ore sandstone is about the same thickness south of Wagner Station at Oswell's Gap, and in an old shaft here the "Sand Vein" is found 10" to 12" thick, yielding the following analysis :

Iron,	42.700 per cent.
Sulphur,	trace.
Phosphorus, . . . . .	.138
Insoluble residue,	28.680

The Sand Rock, beneath the Ore sandstone, is a coarse, sandy ferruginous rock, from 2' to 3' thick, and the Danville beds, though not opened, show a considerable quantity of soft fossil-ore at the outcrop. At Mowry's Gap, next west, and about 10 miles east of Lewistown, both the Sand Vein and Danville beds show outcrops of good soft fossil ore.

South of Maitland Station, the Sand Vein is said to have once been opened in a shaft sunk by William How, and showed a soft fossil 16" to 18" thick. The dip here has flattened to 40° N. W. The Ore sandstone continues to make a high terrace ridge from here as far as Jack's creek and

crosses the Juniata on a 60° N. W. dip about a mile south of Lewistown.

It apparently folds over the Shade mountain anticlinal before reaching the ridge again on the west side of the big bend, where two exposures of it on the public road south of the school house show north and south dips of 60° and 70°. Here the outcrop is turned east into the synclinal between Shade and Blue Ridge; but the position of the Ore sandstone is obscured here by reason of erosion. The outcrop apparently turns westward again before reaching the river, as the basin shallows up in that direction and thence makes a straight line along the north base of the Blue Ridge.

North base of Blue ridge.

Comparatively little is known of the ore beds along this part of the range, as no developments have ever been made. At Bixler's Gap, 1½ miles south of Lewistown, the "Bird's Eye" fossil ore was once opened 7" thick, but of inferior quality.

One mile west of Granville Gap, an old shaft sunk on the Sand Vein developed a thin seam of hard fossil. The Ore sandstone is 16' thick and dips 30° N. W. At Minehart's Gap, south of Granville Station, P. R. R., the Ore sandstone shows the same. Mr. Dewees, Report F, p. 88, reports "the argillaceous sand rock under the Ore sandstone and above the Danville ore beds 28' thick. The Danville ore bed rock, above the ore bed is 4' thick, making the whole thickness from the top of the Ore sandstone to the upper Danville beds 50'". He also found the upper Danville bed 12" thick, but lean and calcareous. The Sand Vein is reported "thin and of poor quality," which is apparently true of this bed all the way to Huntingdon county line.

East of Jenkin's Gap, which is south east of McVeytown, a shaft was sunk on the Danville bed on George Hoffman's property and a considerable quantity of altered fossil taken from it.

Near Shank's Gap a number of shafts were once put

down on the Danville beds, and one of them 10' deep, showed the bed 2' thick, from which, it is said, a considerable quantity of altered fossil ore was mined.

The Ore sandstone is massive and 15' thick; but the Sand Vein is not proven. The same authority (Report F, p. 89) reports the Danville ore beds opened at water level in a ravine on property of Charles Bratton, near Shank's Gap, south of Manayunk Station, where the bed is a hematite (altered fossil) 3' thick, and from which over 50 tons of ore have been mined.

Near *Galloway's Gap*, 3½ miles southeast of Newton Hamilton, on property of George Wharton, the Sand Vein bed was proven 10" thick, soft ore. At the Ochre Mill, on the east bank of the Juniata, near the Huntingdon county line, the Sand Vein is not well exposed; but the Ore sandstone is 15' thick and dips 36' N. N. W., underlaid by about 500' of the Clinton lower shales, mostly in Huntingdon county, at the extreme south bend of the river. The Danville ore-bed rock is calcareous, and about 4' thick. The upper Danville ore is 14" thick, calcareous and lean. Under it are two beds of similar rocks, 20" thick, divided by a thin bed of shale. All the ore drifts are abandoned here, and the thickness of the beds cannot be substantiated.

Chestnut Ridge, in this part of the field, is an anticlinal like that of Ferguson Valley, which for 6½ miles keeps the Ore sandstone above water level in a double outcrop, from a point about 4 miles southwest of Lewistown to the south side of the river at McVeytown. The ridge is from 100'-125' high and between the two outcrops of the Ore sandstone its crest is composed of the lower Clinton shales.

The *Juniata river* cuts this ridge in two about 2¼ miles east of McVeytown, where north and south dips of about 25° are exposed. *Strouds run* makes another gap through the ridge, 2½ miles further east, where the north dip is only 10° and the south dip 25°, the Ore sandstone of the latter being eroded. The dips on the crest are very flat. At the west end of the ridge the dips are about 15°.

The Salina rocks flank the ridge above the Ore sandstone geologically, composed of variegated and red shales.

The Ore sandstone is everywhere massive and about 15' thick. The siliceous shale between it and the underlying Danville beds is 25' thick. The *Danville ore bed* group is about 9" thick calcareous and fossiliferous, the Sand Vein and upper Danville beds being about 40' apart.

The *Sand Vein* has been mined at several places between the east end of the ridge and the Juniata river gap more on the south than on the north dip. On the slope of the anticlinal the bed is about 15" thick, soft fossil, of excellent quality. West of the Juniata gap the same bed is harder and about 10"-16" thick. In the north leg of the anticlinal the Sand Vein is only 6"-7" thick and the Danville beds throughout the ridge have never proved workable.

The Juniata river from the gap in Chestnut ridge nearly to Lewistown, flows mainly through the *upper Salina marls* and lime-shales, which contain a number of red bands, but yielding usually a good farming soil.

In East Juniata county.

In *Juniata county*, east of the river, a considerable portion of Fermanagh, Fayette and Walker townships is occupied by the Clinton and Salina rocks. In the two former the Slenderdale and Lost Creek axes elevate the *Ore sandstone* to daylight, the former showing a synclinal crimple, duplicating the ore outcrops at its western extremity; and the latter showing a similar feature causing four outcrops of the Ore sandstone in Fermanagh township. The Ore sandstone makes a high terrace on the south flank of the East Shade mountain from the Snyder county line to the middle of Fermanagh township, east of which point the fossil-ore beds have not been opened, and the Ore sandstone is about 25'-30' thick, dipping slightly towards the south-east.

At the *Suloff mines* of the Duncannon Iron Company, in Fermanagh township, the Ore sandstone shows thick outcrops, by reason of a small anticlinal roll, which just carries the Ore sandstone on its crest above water level at this point with a thickness of about 25'.

The dip of the mountain outcrop is very irregular, standing at about 70°–80° S. E. for the first 800 yards in the drift driven along the strike, and afterwards seemingly overturned to 85° N. W.

The south, or outer outcrop, further from the mountain, dips southeast only 10°, while the north leg of the anticlinal dips 25° or 30°.

The bed mined here varies in thickness, according to the swelling or thinning from 10''–3'' of a middle bench carrying "Jack" or a "soapstone slate" of the miners, dividing an upper and lower bench of soft fossil ore of good quality, each bench from 4'' to 6'' thick. The average bed section here is from 20'' to 22'' thick.

At the *Graham mines* of the Glamorgan Iron Company, near the Juniata, there is a large basin of Ore sandstone and fossil ore, south of which the Ore sandstone laps over the dying Blue Ridge axis, and runs west in a single outcrop to the river at Grahamville. All the developments have been confined to this basin, the two outcrops being locally known as the "north and south veins." The latter has a very gentle dip; the north leg, against the mountain, averages about 50° S. E. The average thickness of the Sand Vein here is about 20'', beneath which the Ore sandstone and argillaceous sandstone of the Danville group is about 38' thick to the upper Danville bed, here opened in two places, under the name of the "*Ginger Vein*," from its yellow color. The latter is only about 9'' thick, but carries about 45 per cent. iron, as against 40 per cent in the Sand Vein.

Between Mifflintown and the south flank of Lost Creek ridge, the upper and lower Salina rocks are well exposed about 1700' thick, largely olive and gray shales, with thin impure limestone. The Bloomsburg red shales are well exposed in this section.

The *Ore Sandstone* in Lost Creek ridge is well seen on the pike, 20' thick and dipping S. E. 20°. It is a gray sandstone weathering brown and making a handsome and attractive building stone. No ore has been developed here of quality or thickness.

On *Big Run*, at the gap through Slenderdale ridge, the Ore sandstone is exposed in the south anticlinal in a broad arch 60' above the creek, 25' thick in thin bands, with dips of 5° S. E. 20° N. W. Some abandoned ore-diggings were seen between the anticlinal and the north axis of the ridge in the shales *above the Ore sandstone*, a rather unusual horizon and one which does not seem to have yielded very satisfactory results here. It is said to have shown about 2'± thick; but carried Jack mixed with it. It has a sandstone floor and dips gently southeast; while above the opening, on the hill, the same ore is said to have been struck in a shaft on a north dip, yielding 12" of good ore. The exact horizon of this bed is obscure.

In West Juniata county.

West of the Juniata river, the Clinton rocks occupy the long and narrow valley of Licking creek, between Blue Ridge and West Shade mountain, and deepening towards the Juniata it receives a narrow strip of the upper Salina lime shale Vc', with Jack. On the south flank of the Blue Ridge the Sand Vein has been opened 18" to 2' thick, dipping S. 15° E. 40°.

The *Black Log axis* to the south elevates the Ore sandstone with its fossil ore in a double outcrop; while the succeeding basin deepens to receive all the Salina and part of the Lewistown limestone groups. Between this basin and the main Tuscarora synclinal, the Academia anticlinal, crossing the Juniata about midway between Mifflintown and Port Royal, elevates there the Ore sandstone, and increasing in strength rapidly westward pushes the two outcrops asunder, until at Academia they are a mile apart. From this point they gradually converge toward a common meeting point near Reed's gap.

Between these two ridges, there is a wide elevated plain of the lower Clinton rocks exposed, in which the Iron sandstone outcrops in two parallel hills, within those of the Ore sandstone, while the western part of the county, west of Reed's gap, is largely occupied by the middle and upper lime shales and olive shales of the Clinton group.

Between the Tuscarora synclinal (Nos. VIII, VII and VI) and the Tuscarora mountain, the entire Salina and Clinton series are exposed. The Ore sandstone and Iron sandstone outcropping with steep dips, hug the base of the mountain pretty closely, making merely terraces as far west as Liberty Valley. But in Tuscarora and Lack townships the dips are not over 30° – 40° , so that these rocks, especially the Ore sandstone, here about 20' thick and massive, make distinct ridges out in the valley, with the Clinton upper olive and red shales and the Salina rocks creating a broad flat between the outer (Ore sandstone) ridge and the Lewistown ridge No. VI.

The upper Salina marls and lime shales fill a narrow but well defined synclinal basin, characterized by a series of *sink-holes*, from the Juniata in Turbett township, west to the Spruce Hill township line.

More detailed references to the character of the individual members of the Salina and Clinton series will be given in the chapter on Township Geology.

Medina and Oneida sandstone. Formation No. IV.

This formation can be conveniently divided into three members, IVc, upper or white Medina sandstone; IVb, lower or red Medina sandstone, and, IVa, Oneida gray conglomerate and sandstone. Economically considered, these rocks are of comparatively small importance in the district. They contain no ores or minerals of value, and while portions of the formation should make good building stone and in some few instances possibly a fair sand-rock for glass-making, they have nowhere been so used as yet.

It has been already explained how all the mountains of the district are composed of one or the other of these divisions of No. IV, and with comparatively slight variation as to thickness and coarseness of constitution, they usually present similar characteristics, whether in the Buffalo mountain, the Seven mountains, Jack's mountain

or Tuscarora mountain. Consecutive exposures of these three divisions of No. IV are scarce.

In Logan Gap of Jack's mountain the following measured section was made, Report F, p. 54 :

IVc.	{	<i>Medina white sandstone</i> , light gray, rather fine grained, very hard and massive, surface of lower strata dotted with ferruginous specks,	820'
IVb.	{	<i>Medina red sandstone</i> and shale, fragile, argillaceous and marly, of a thinly laminated structure,	1280'
IVc.	{	<i>Oneida red conglomerate</i> , sandstone, red, massive, containing large pebbles, 309	} 622'
	{	<i>Oneida gray sandstone</i> , greenish-gray, very hard, fine grained, portions of strata contain oxide of iron, 313	

In the *Seven mountain area*, between Mifflin and Clinton counties the entire series is about 2440' thick; and 2400' may be assumed for the Union and Snyder districts.

The *Medina white sandstone IVc* is perhaps the most persistent, as it is the best exposed member of the group throughout the district, and along the Juniata has been extensively quarried in places for railroad ballast. It is finer grained and more compact than the Oneida sandstone IVa and always forms the outside crest of the numerous anticlinal mountains of the district, and therefore makes up the knobs at the ends of those ridges.

When freshly broken it is white; but when weathered it becomes yellow-stained and brown, and is usually thin bedded.

The *Red Medina and the Oneida sandstone* together form all the terrace ridges, which in places are as high as the white Medina crests. The relative position and extent of the three members of the group are shown by different tints of brown on the map. Complete exposures are comparatively rare on account of the few gaps in the district cutting through these mountain rocks and the great amount of débris which everywhere accompanies while concealing the outcrops.

Hudson River, Utica and Trenton. Nos. III and II.

These formations may be described together on account of their limited exposure in the district.

The *Kishacoquillas valley* is naturally the best place to study them, for their rocks occupy there all the space between the south bounding wall of Jack's mountain and the spurs and ridges of the Seven mountain range on the north. In the Logan Section of Report F the exposed section of these two groups is described as follows :

1. Hudson River slate, III b,	.....	937
2. Utica upper gray slate,	} III a. {	..... 210
3. Utica middle black slate,		..... 302
4. Utica lower gray slate,		..... 855
5. Trenton limestone, III c (<i>upper part</i>),		..... 320+

The *Hudson River slate division* of this section shows a considerable thickness (425') of alternate layers of hard flaggy bluish-black slate and gray sandstone, followed downward by yellowish shales (100'); bluish-gray fine grained sandstone (140') and dark ferruginous shales (182') at bottom.

The *Utica gray and black slates* combined show a thickness, partly concealed, of 1367'.

The *Trenton limestone* or top portion of the great limestone formation No. II, shows for only 320', so that over 6000' of this formation lies buried beneath the Kishacoquillas which appear in Canoe valley, Blair county.

Near Reedsville, on the Kishacoquillas creek, the top Trenton layers show a succession of dark blue and dark gray limestone, much of it when burned yielding an excellent quality of lime, while containing certain argillaceous and siliceous beds which must be rejected.

The western end of the valley along the Huntingdon county line shows a belt of limestone (colored light blue on the map) about $2\frac{1}{2}$ miles wide, flanked by Utica and Hudson slates and shales on either side. The east end of the valley is split into three long parallel anticlinal valleys, as already explained, which carry the Hudson slate crops towards and into Union county.

The most northern of these anticlinal valleys is very

largely occupied by the slates and shales of No. III, a narrow strip of the upper limestone of No. II showing east of Milroy. A considerable amount of limestone (pipe) ore was once mined south of Belleville, at the old *Greenwood bank*, which is located near the crest of the main anticlinal of the valley; but it has been long abandoned, and nowhere else has mining been carried on of late throughout the valley.

In places the limestone is cavernous, one *cave* located near Honey Creek station on the Milroy branch, being of considerable size.

Several large quarries are worked at times in the vicinity of this cave, which will be mentioned later. At times a considerable amount of money has been wasted in an attempt to find *coal* in the Utica black slates in different parts of the valley; but all such attempts are ill-advised and purely speculative, and should not be encouraged.

The *Black Log valley*, which extends some 12 miles into the western end of Juniata county between Black Log and Shade mountains, is precisely similar in its geological aspect and structure to the large Kishacoquillas valley of Mifflin county. The whole length of this narrow valley is about 36 miles; and of the 12 miles in Juniata county only about $2\frac{1}{4}$ miles along the center line is occupied by the Trenton limestone of No. II, the balance of the area being filled with the Hudson River and Utica slates.

The dip of the anticlinal sides of the valley near the Huntingdon county line is about 70° N. W. and 60° S. E. The limestone shows about the same characteristics as in Mifflin county, a series of dark gray and blue beds, some argillaceous (especially near the top of the formation), others smooth fine-grained pure limestone, and some few siliceous beds. The lowest beds are apparently more magnesian, the entire thickness of the group not being over 300'.

The *Hudson river slates*, owing to the high dip of the rocks, ride well up the flanks of the bounding mountains, forming terraces there, covered with the débris of the mountain rocks. They arch over the limestone at the north-eastern end of the valley, where they do not rise up so high on the mountain, but occupy a belt along the central part of

the valley, generally very well cleared, but not too arable or highly cultivated. The population of the valley is small and the agricultural development meager.

No. III shales appear on the crest of the elevated anticlinal which splits East Shade mountain lengthwise. This is in the Spieglemeyer valley 13 miles long. Exposures of rock here are rare and cultivation confined to the Spieglemeyer farm near the mountain road crossing from Mifflin to Wagner station.

Several other small patches of thin slate rocks occupy wedge-shaped areas between folds of the Buffalo mountains, entering the district from Centre county. But they are insignificant and generally concealed by loose boulders of sandstone from the surrounding mountains.

CHAPTER IV.

*Detailed Geology of Union County.**1. Gregg Township.*

This is the most northern township of Union county, lying on the west bank of the Susquehanna river, north of White Deer mountain and embracing about 15 square miles.

All the drainage is eastward into the Susquehanna River. Black run on the north and White Deer Hole creek, with its branches, Spring creek and South creek, in the center, are the two principal streams.

Alvira P. O. is a small village located upon the Lewis-town or Lower Helderberg limestone in the northwestern part of the township near the Lycoming county line. *Uniontown*, or *Allenwood P. O.*, the chief village of the township, is situated upon White Deer Hole creek, not far above its entrance into the river, and close to the Philadelphia and Reading R. R.

The *geological rock series* extend upwards from the Medina white sandstone, making the crest of the White Deer mountain anticlinal along the south border line of the township, to the Marcellus and Hamilton measures No. VIII, in the valley of Black run along the northern border.

All the measures dip N. N. W. except in a small synclinal roll of Lower Helderberg limestone and Oriskany sandstone extending for about a mile west of the Uniontown-Alvira road from the Presbyterian church.

The *Medina sandstone* of White Deer mountain is nowhere exposed in place; but the rocks of this formation extend along the southern township line for about 3 miles before sinking under the Clinton measures which continue the ridge and axis for 2 miles further to the Susquehanna river.

The new road which has been constructed over the eastern end of this ridge displays only outcrops of the Clinton measures, with dips on the north side of the anticlinal of from 10° – 30° . The same rocks are well exposed in the railroad cuts facing the river, where the Iron sandstone forms the arch of the anticlinal with north and south dips of 10° – 15° . This rock has been largely quarried at this point for culverts and bridge construction, and appears to make a handsome and durable stone for such purposes. It seems to be from 10'–20' thick, and is underlaid by about 40' of the lower Clinton shales.

North and up the river from the disappearance of the Iron sandstone on its northern dip, 300' of olive and brown shale appears on a north dip of 15° – 20° , overlaid by a thickness of 350' of reddish-brown shale upon somewhat increased dips. The *Ore Sandstone* immediately overlies the latter. It is fossiliferous; about 30' thick, and with a greyish-brown color, dipping N. 25° . There was no appearance of the Sand Vein fossil ore at this point, the Ore sandstone being immediately succeeded by the top limy members of the Clinton formation, showing a waved structure, but with an average northwest dip of from 30° – 40° .

These same rocks are excellently exposed along the road leading west from the saw-mill at the river up White Deer Hole creek and at the first bend of the road going over the mountain on a N. 28° W. 30° dip. The Ore sandstone, rather shaly, also shows on this road upon a similar dip and about 25' thick.

The *Danville fossil ore bed*, beneath this rock, was once opened here by Mr. Lawson of Milton; but no information could be obtained concerning its condition.

Mr. M. C. Tate has opened the same bed, $\frac{1}{2}$ mile further west on property of Lawson & Farley, who shipped about 2000 tons from one opening to Danville in Montour county from a bed which is reported to show the following section, dipping 35° – 40° N. W.:

Roof slate.	
Top ore,	6''
Jack,	2' to 6''
Soft ore,	16''

The drift was in about 75 yards and the ore was stoped out to the outcrop in breasts 60 yards long. It is claimed that the ore bed is still in good condition at the face of the present entry; but of late there has been no demand for the ore. When actively worked, from 12 to 15 tons a day were mined here at a cost of about \$2 per ton delivered at Allenwood.

A few hundred yards west, in the next ravine, the same bed is opened at water level in a drift about 25 yards long. The dip is about the same, but as the ore-ridge has increased slightly in height, the breasts obtained here were 90 yards in length. Only a hard limestone ore was said to exist here, yielding an average of about 38 per cent. of metallic iron; whereas in the next knob east the bed is entirely soft fossil, and east of the ridge road it has become almost too siliceous to work at all.

At the hard-ore opening the bed is in places 30'' thick, the bottom bench showing about 18'' of ore with the parting and upper bench slightly increased.

All the loose outcrop soft fossil ore at this place was, during the summer of 1888, carted away to Mr. Tate's Paint Mill on the river below the mouth of White Deer Hole creek, where it was burned in a fire-brick kiln to the extent of about 1½ tons per day; ground and packed in barrels and sold as brown paint in various markets, bringing high prices.

There are no additional openings of fossil ore further west towards the Lycoming county line; but the dip becomes apparently very gentle, inasmuch as the Ore sandstone makes a series of detached knobs well north of the base of White Deer mountain, a narrow valley of the lower Clinton measures intervening between the two hills.

The *lower Salina*, Bloomsburg red shales No. Vc, make a narrow strip north of the Ore sandstone ridge with dips of about 30°-40° and exhibits its peculiar cleavage and physical characteristics in the several bends of South creek.

The *upper Salina No. Vc'* lime shales and marls succeed northward in a belt about a mile wide along the river

and nearly 2 miles wide on the Lycoming county line, owing to their duplication there in the small synclinal basin already mentioned.

They give rise everywhere to a most fertile farming territory and in places contain some fair beds of limestone. This is especially true of the upper portion of the formation bordering upon the Lower Helderberg limestone No. VI.

Leonard G. Meek's limestone quarry is opened in the Lower Helderberg formation along the center of the little synclinal basin and just north of Spring creek; and H. Scott has opened the same rock series at the east end of the same ridge on a small branch of the main creek.

The limestone quarried at both places is not over 40' thick and occurs in rather thin beds, somewhat stained with red clay seams. The entire 40' of limestone is burned for building and plastering lime, as well as for farm fertilizing; and in each quarry there is a bottom gray limestone and some blue beds on top which would further amplify the section by about 20'.

During the active season Mr. Meek stated that he burns 20,000 bushels in two kilns, 20' high and 6' wide at top, using a ton of anthracite pea coal to each 100 bushels of stone burned. The limestone beds seem to lie perfectly flat at his quarry, showing a slight tendency to turn up at the north and south sides.

The Lower Helderberg limestone folds over a small anticlinal axis near the Presbyterian church, and passes thence along the public road westward to Alvira, on north dips of about 12°, and eastward passes through the forks of the road near the Baptist church and thence to the Susquehanna river,

Bowers' quarry is a small opening in the limestone a short distance west of the railroad, where the beds seem to be considerably twisted, some of them showing dips of about 50° towards the southeast. The quarry was idle and the stone exposed rather inferior.

The *Oriskany sandstone No. VII* is very poorly exposed in this township and its outcrop can only be traced by

means of numerous small blocks of cherty sandstone containing the well known *Spirifera arenosa* fossils. The outcrop of the formation lies just north of and coincides with the Lower Helderberg limestone, and it is largely shaly in character.

The *Marcellus and Hamilton* divisions of No. VIII occupy the northern portion of the township along Black run; but their exposures are so largely concealed by drift and boulders of Catskill and Pocono rocks that comparatively little can be said concerning the character of No. VIII in this township. This drift material rises to elevations of 400' above the river in several distinct terraces.

The *Tate Paint Mine* has been opened apparently in the Marcellus division of these rocks, just west of the P. & R. R. R. and about $1\frac{1}{2}$ miles north of Allenwood. It is presumably the Marcellus ore bed which had been developed here, although unfortunately the opening was so badly fallen in as to prevent any personal examination. Mr. Tate reports that the main drift had been driven 75 yards west into the hill, with gangways north and south in a flat bed of carbonate ore. The bed is capped with black slate, with thin but regular layers, under which there is 2' of a black carbonate ore furnishing only 10 per cent. of metallic iron. A stratum of 6'' of hematite ore underlies the carbonate, and a $\frac{1}{2}$ inch of yellow ochre on the bottom. Several carloads of the black carbonate ore have been shipped to the Allenwood Paint Mill, where it is dried and ground and is said to make an excellent black paint or polish for iron and wood structures.

The mining of this material is necessarily very cheap as it is said to yield to the pick, although the gangways require a large amount of timbering to preserve the roof of the mine.

The 6'' band of hematite ore, after being roasted, has been treated in the same manner and makes a brown paint somewhat siliceous, which does not command so high a price.

No work has been done at this opening for nearly 3 years, so that the facts are recorded simply as Mr. Tate has kindly

offered them. No limestone is reported to occur at or near the opening and the raw material, as mined, is intensely black, without grit and sooty. It stains the fingers as lamp-soot would do, and when used as a pigment it is said to be very durable and will not fade. It has been shipped to Williamsport, Reading, Harrisburg and elsewhere through central Pennsylvania.

2. *White Deer Township, Union county.*

This township lies next south of Gregg, with the Susquehanna river for its eastern border and White Deer mountain on the north for a distance of 10 miles. The western line runs roughly at right angles to White Deer mountain for about 4 miles, crossing the valley of White Deer creek and the Nittany mountain to a branch of Spruce run. This stream forms its southern line for about 4 miles and extends some 6 miles further to the river north of Catawissa junction and West Milton. In shape it is rudely rectangular and contains an area of about 40 square miles.

Its *drainage* is entirely eastward into the Susquehanna, although two branches of Little Buffalo creek flow southward before passing to the Susquehanna. White Deer creek drains all the synclinal valley of that name lying in the northern portion of the township between the White Deer and the Nittany mountains. It flows for 10 miles through the township.

White Deer Mills is a small village situated near the mouth of the creek and on the Philadelphia and Reading railroad, while *New Columbia* lies some 3 miles further south along the railroad and river bank.

The *rock series* exposed extends from the Oneida gray sandstone which is on the crest of the Nittany mountain anticlinal at the western border line of the township up to the lower portion of the upper Salina lime-shales occupying narrow strips in the White Deer and Spruce Run synclinals.

Structure.—The map coloring plainly shows the structural features of the township, which are extremely simple, consisting of the two mountain anticlinals which have elevated the No. IV rocks to the surface and the Buffalo mount-

ain axis on the south along the Kelly township line, which here only carries the lower Clinton rocks on its crest.

Between each pair of anticlinals there is a synclinal basin carrying the upper Salina rocks for some distance west of the river until their westward rise brings to daylight successively the lower Salina Bloomsburg red shale, the ore sandstone, which makes a low ridge throughout this township, and finally the lower Clinton rocks in the upper portion of White Deer creek and Spruce run.

In entering the township from the south along the river road the upper Salina lime shales are first seen dipping southeast in obedience to the Buffalo mountain anticlinal.

The Bloomsburg red shales or lower Salina rocks are next exposed on a dip of 40° S. E., succeeded northwards by poor exposures of the Clinton rocks which occupy a belt more than a mile wide between opposing outcrops of the Bloomsburg red shale. At the first road below New Columbia, olive and brown Clinton slates dip only 10° N. W., and it is this low dip as well as the presence of the Buffalo anticlinal which has served to keep these measures above water level through so wide a belt of country.

From New Columbia to White Deer Mills exposures are unsatisfactory, there being another broad anticlinal belt of the Clinton rocks between these two places, flanked on either side by synclinal valleys of the lower and upper Salina rocks.

The Bloomsburg shale is well exposed just north of White Deer Mills on a dip of S. 25° E. 50°, succeeded north by brown lime shales on a 40° dip, and this by a long exposure along the road in the face of a ridge of Clinton red and brown shales dipping S. 22° E. 20°-25°. There is very little sandstone and a great deal of reddish-brown shale in this exposure, and the rather gentle dip at this point keeps these rocks in view for several hundred yards along the road. The Ore sandstone must certainly lie within or near the top of these shales, but it was not noticed at this exposure. The Iron sandstone outcrops along the flank of White Deer mountain just after crossing a small stream, where it is quarried in large blocks, 2'-3' in thickness on a dip of S. 28° E. 10°-15°.

On the road leading west about a mile below White Deer Mills, a narrow compressed synclinal of Salina lime shales crosses the road near Ranck's house, and thence west keeps north of the road leading to White Deer church, marked by a series of low hills. Each individual farm has a small limestone quarry opened in these upper Salina rocks, and while the beds are only a few feet in thickness, interbedded with shales, they furnish a fair quality of crystalline blue limestone, rather quartzose, burned for farm fertilizing.

At *Monpeck's quarry* the rocks dip nearly due north and south 25° and 40° , but are much curled and twisted and interleaved with thin bands of shale. All these quarries make rather poor exhibits, but in the absence of the thicker and purer Lewistown limestone beds in this township they are naturally largely utilized.

These limestone and lime-shale rocks occupy the center of this narrow valley for 6 miles west of the Susquehanna river, flanked on each side by the underlying Bloomsburg red shales, the latter rocks forming low but distinct ridges, and giving rise to an intensely deep red soil in strong contrast with the gray soil of the lime-shale valley.

On the first road leading west below New Columbia there is a good exposure of dull gray lime shales about one-half a mile from the river and near the top of the Clinton formation. As the road rises up the hill it passes into a series of calcareous shales, weathering brown and making a fertile soil and extending south about to the school house. Along the road south from the school towards White Deer church the Ore sandstone is exposed with a double outcrop on the crest of the Buffalo mountain axis, and between here and the Kelly township line the Clinton and Bloomsburg rocks are repeated on southeast dips of about 35° .

The Bloomsburg shale is quite massive here, showing beds of red sandstone between the shale which makes the largest portion of the formation, well exposed in a quarry near the Kelly township line, 60' thick dipping S. 20° E. 35° . The exposure is marked by the same strong cleavage planes, unfitting it for building use and bringing about its rapid disintegration down to water level at least, whenever the

crevices are sufficiently great to give access to rain water and the action of frosts. The rock is largely quarried for road purposes, and while no doubt a poor substitute for broken limestone during the winter and spring months, it nevertheless makes an excellent summer road.

The *Ore sandstone* and the *Sand vein fossil-ore bed* make a zigzag outcrop through the township nearly 25 miles long from the river above White Deer Mills to where it enters Kelly township, a short distance east of Spruce run. It extends up the White Deer creek valley for about 5 miles, crossing the old turnpike road just west of the old Forestville iron works. Comparatively little ore was ever mined near this locality for use in the old furnace, which has been out of blast for 10 or 12 years, and when active was run largely upon brown hematites from Centre county.

The *Hafer mine*, situated in the north leg of the Nittany mountain anticlinal about 2 miles from the river, has furnished both hard and soft fossil ore recently to the Dry Valley furnace below Lewisburg, but when visited no mining was being done and very little ore was to be seen at the drift mouth. A pile of hard ore near the opening seemed to be very calcareous, holding large chunks of a bluish-gray limestone spread through the ore-mass which must have necessarily produced a rather low percentage of iron.

The dip is only about 5° N. N. E., and the ore was mined by sloping southeast under a nearly flat field across the measures to meet the gently dipping ore-bed on the north flank of the Nittany axis. The mine could not be entered, but is said to furnish about 8" of soft ore and is probably the Sand Vein fossil bed. It is no doubt the same bed as the *Beck ore*, formerly mined on the old *Bohr farm* directly southwest of this opening on the south side of the ridge and anticlinal, where the bed dips about 10° S. E. This place has been long abandoned, though an excellent quality of ore is said to have occurred there.

There are two more openings of a similar character further east, both of which were abandoned and fallen in.

The *Ore sandstone* is again exposed on the Buffalo mountain anticlinal, where it is cut through by the branches of

Little Buffalo creek. On the east branch of this stream the opposing outcrops are seen above and below the saw-mill, showing a hard gray sandstone, dipping 40° towards the north and about 10° toward the south, underlaid with brownish-red shales and carrying a slight showing of lean ore on each flank of the axis. North of B. K. Yoder's some little of this lean ore has been dug along the outcrop, and about the same amount of digging has been done on the west side of the creek on the northern outcrop, where the ore is of slightly better quality, but of doubtful commercial value.

Indeed it is extremely doubtful whether in any portion of this township, with the possible exception of the extreme eastern end of the Nittany mountain anticlinal, the *Sand Vein* fossil ore-bed exists sufficiently thick and of good quality to warrant its mining; and even at Hafer's mine it owes its development largely to the presence of the soft ore found there upon very flat dips. Elsewhere the ridge containing it is low, and therefore there would be but little opportunity of obtaining any considerable extent of stoping ground. The Danville series is entirely undeveloped.

The valleys of Spruce run and White Deer creek both contain the lower *Clinton shales*, but show very little evidence of the presence of the Iron sandstone upon either flank of the Nittany or White Deer mountain. However, the hillsides of all these No. IV mountains are so covered with boulder and débris as to almost preclude the possibility of finding any good exposures of rock in place, except where a considerable water course has exposed the rocks in ravines. On the old wood road passing through and over Nittany mountain from Spruce run to White Deer creek the Medina sandstone is poorly exposed on the west side of a branch of Spruce run on a dip of S. 30° E. 40° .

The Medina red sandstone No. IVb makes a valley behind the white Medina crest, which is divided centrally in this township by an elevated spur of Oneida gray sandstone No. IVa, which marks the crest of the Nittany mountain axis. No exposures of these rocks were seen on the waters of White Deer creek at all, and their relative position can

only be inferred from the topographical features existing in the gap.

3. *Kelly Township in Union county.*

This township lies immediately south of White Deer, with the Susquehanna river for its eastern boundary, Buffalo creek for its southern border line, and Spruce run on the west. The nearly straight southern line of White Deer township, 6 miles long, between Spruce run and the river, is a mutual north line of Kelly township. The area embraced between these lines approximates 15 square miles.

The *drainage* is all eastward through Buffalo creek to the river, the main creek receiving the waters of Little Buffalo creek about 3 miles from the river and Spruce run at a distance of 6 miles, both of which streams rise in the mountain area of White Deer township and flow southwards into Buffalo creek.

West Milton, in the extreme northeast corner, on the river and Philadelphia and Reading R. R., is the only village of importance, and is practically a suburb of the larger town of Milton, on the east side of the river, in Northumberland county.

The *Milton anticlinal axis* of that county reaches the Susquehanna river just below Catawissa Junction, and carries a narrow strip of the *upper Clinton* brownish lime shales on its crest for about 5 miles west of the river, where the Bloomsburg red shale or *lower Salina* rocks fold over the expiring western end of the axis, which cannot be traced beyond Spruce run.

The *Jones mountain anticlinal*, or the northern sub-axis of the Penns Valley anticlinal of Centre county, expires coming eastward just beyond Spruce run in this township, where its crest is dimpled with a double fold of the upper Clinton rocks, with a little of the Bloomsburg red shale caught in the narrow synclinal crimple between them.

The *Lewisburg synclinal*, corresponding to the *Lackawanna basin* of Northumberland county, just touches the southern border of this township along Buffalo creek, where it holds an elliptical area of the Marcellus black slate nearly

2 miles wide (on the river on very flat dips) and narrowing westward as the basin rises into Buffalo township in about $2\frac{1}{2}$ miles.

The *geological column* of rocks exposed in this township is confined between the upper Clinton rocks on the Milton axis and the Marcellus and Hamilton rocks in the trough of the Lewisburg synclinal.

Along the river road leading north from Lewisburg towards New Columbia, the *Marcellus* black slates are well exposed about $\frac{1}{4}$ mile north of the saw-mill at E. Slifer's place, where they dip very gently 8° to 10° towards the southeast. In the first railroad cut on the Philadelphia and Reading R. R. this dip is increased to about 15° , and ascending the ridge still farther north the *Oriskany* sandstone and shale, mixed with a large amount of chert, shows at Hollenbach's, on a 20° S. E. dip, largely a gray sandy shale weathering brown at the outcrop, and containing much less sandstone than in Mifflin and Juniata counties.

The *Lower Helderberg limestone* underlies No. VII still further north, and really creates the crest and northern flank of a high hill, known as the "Limestone Ridge," in Northumberland county. The rock exposures show largely a blue and gray limestone in beds from 1' to 4' thick, the whole massive series showing perhaps 60' or 70' in thickness, and with the shaly portions of the formation approximating 100' thick. The overlying *Oriskany* beds are not over 40' in thickness.

The *upper Salina No. Vc'* rocks outcrop in a belt of valley land nearly a mile wide, north of the "Limestone Ridge," creating a fertile soil highly cultivated and containing some few thin beds of limestone, which are best exposed near G. F. Miller's house, where they have been slightly burned for lime.

Just beyond the first road leading west to the Dunkard church the *lower Salina* Bloomsburg red shales show about 150' thick on a dip of 40° - 45° towards the southeast, making a broad band of deep red soil, succeeded by the brownish lime shales of the *upper Clinton* on the Milton axis. North of the latter rocks there occurs another belt of the Blooms-

burg rocks on the north side of the anticlinal, dipping northwards at angles of 40° into the succeeding synclinal basin along the White Deer township line, which contains a strip of the *upper Salina* lime shales, narrowing westward for about 6 miles, where these rocks are eroded at Spruce run and the basin filled with the Bloomsburg red shales.

These Bloomsburg shales create low but distinct ridges on each side of the basin, and are excellently exposed in the north leg of the synclinal, between the forks of Little Buffalo creek at Parvin's and Rothermel's store, on a dip of S. 20° E. 45° . The gray lime shale valley to the south of this point is only about 250 yards wide, the Bloomsburg red shales forming its southern boundary also, dipping N. 25° W. 35° .

The gentle *Milton anticlinal* still further south along Little Buffalo creek, shows merely a narrow band of upper Clinton rocks, with dips of 10° , and almost immediately succeeded by a third band of the Bloomsburg red shale somewhat wider at this point than on the river, owing to the effect of the Jones mountain axis.

Exposures of the succeeding *upper Salina* marls and lime shales south towards Buffalo creek are exceedingly rare, but invariably show gentle southeast dips of from 10° - 15° .

Buffalo creek marks the northern limit of the Lower Helderberg limestone from the mouth of Little Buffalo creek up stream to Hafer's grist and saw-mill, so that all the limestone exposures here are in Buffalo township. From Little Buffalo, however, the limestone outcrops in a prominent ridge running a little north of east, and reaching the river about $1\frac{3}{4}$ miles above Lewisburg.

Sections further east along the two north and south roads crossing this ridge to Buffalo creek show the Marcellus and Hamilton rocks occupying the broad inside sloping terrace of the ridge on southeast dips of about 10° .

Both the Oriskany and Lower Helderberg rocks are poorly exposed, owing to the absence of ravines cutting the ridge and the low dip of the rocks. The limestone rocks are nowhere quarried in this township.

4, *Buffalo Township in Union county.*5, *East Buffalo Township.*

These two townships can be best described together, inasmuch as the exceedingly irregular outlines of the former extending along Spruce run and Buffalo creek on the north and east to the river, and south to the crest of the Shamokin mountain, largely surround East Buffalo township. The river forms the eastern border of the latter township for about 3 miles below Lewisburg, while a southern line, 5 miles long, follows the crest of the Shamokin mountain.

The *drainage* of both of these townships is eastward into the Susquehanna river; Buffalo creek and its tributaries, Spruce run, Black run, Armstrong run and Rapid run largely drain Buffalo township, while Turtle creek performs a like office for East Buffalo township.

Lewisburg, while actually an incorporated borough, occupies portions of each township just below the mouth of Buffalo creek, on the Susquehanna river. It is the county seat of Union county and a town of great natural beauty.

Mazeppa, *Buffalo Cross Roads* and *Vicksburg* are thriving villages in Buffalo township, and *Linntown* and *Turtleville* in East Buffalo township.

The *chief structural features* of these two townships are first the Lewisburg or *Lackawanna synclinal* on the north, which cannot be traced far west of Hafer's mill, on Buffalo creek, through the wide plain of upper Salina lime shales which occupy fully one-half of the area of Buffalo township, everywhere giving rise to an ideal farming soil and justifying the fame and wealth of the Buffalo Valley.

Along the western line of Buffalo township, which is practically straight and nearly north and south for seven miles between Spruce run and the Mifflinburg ridge, there are several anticlinal and synclinal rolls of greater or less importance, which serve to modify the topography and geology there.

Buffalo mountain on the north is the first of these, creating a high anticlinal spur of Medina white sandstone, just south of Spruce run, extending for about a mile in length

in this township before subsiding beneath the lower Clinton shales and sandstones, which extend the ridge to and beyond Spruce run into White Deer township.

A compressed synclinal extends along the south base of the Buffalo mountain, carrying for a mile west of Spruce run a narrow tongue of the Bloomsburg red shales, separated from the mountain by a low ridge of the Ore sandstone.

In the valley of Black run, the *Jones mountain axis* carries on its dimpled crest the Clinton rocks in a belt a mile wide, with dips of only about 10° along the axial line, stiffening to 40° or 45° to the north and south.

Armstrong run waters a synclinal valley of upper Salina rocks flanked north and south by low ridges of Bloomsburg red shale. The latter rocks between Armstrong and Rapid runs lap over the dying end of the *Little Buffalo mountain anticlinal*, which become much more prominent to the west in Center county, where it forms the southern sub-division of the Penns Valley axis, running through the Penns Valley Narrows. This axis expires about a mile and a half east of the Buffalo-West Buffalo township line, carrying the upper Clinton and lower Salina rocks on its crest and if continued passing through Mazeppa.

Rapid run, on the south side of this ridge and axis, waters a synclinal valley of upper Salina rocks, similar to, but not quite so wide as that of Armstrong run; and these two synclinals, separated by the Little Buffalo mountain anticlinal, form together when continued eastward, the great *Lewisburg* or *Lackawanna synclinal*.

The *Paddy Mountain anticlinal*, lying south of the Rapid run basin, likewise expires in Buffalo township along the south base of the Limestone Ridge. Its crest as it sinks beneath the wide plain of upper Salina rocks is dimpled along the West Buffalo township line, showing two anticlinal prongs of the Bloomsburg red shales, separated by a narrow tongue of the upper Salina rocks. These latter shales and limestones are considerably twisted and curved further east by the effect of this axis, and in all the territory, both north and south, of the Lewistown and Ty-

rone railroad, show but comparatively few dips to indicate the structure minutely.

The *Montour anticlinal axis* of Northumberland county, passing through the high and prominent Montour ridge, reaches the Susquehanna river in East Buffalo township about $1\frac{1}{2}$ miles below Lewisburg; but its strength has become so reduced that its presence is only detected by the zigzag outcrop of the Bloomsburg red shales, whose low dips at that point make a broad double belt of red soil between Lewisburg and Turtle creek.

The *Jack's mountain anticlinal*, which marks the crest of Shamokin mountain in East Buffalo township, likewise expires along the river about 2 miles south of the Montour anticlinal, these two axes strengthening and rising in elevation and importance in opposite directions. The Medina white sandstone occupies the crest of the Shamokin mountain for about $1\frac{3}{4}$ miles in East Buffalo township, sinking eastward beneath the Clinton rocks, while the axis in approaching the river becomes dimpled and carries a narrow synclinal roll of the Ore sandstone and fossil ore for perhaps a mile west of Turtleville.

The *Mifflinburg synclinal* occupies the valley of Turtle creek between the Montour and Jack's mountain axes. It deepens going westward from the river, so that from first holding only the upper Clinton and lower Salina rocks in its trough, it sinks along Turtle creek to receive the upper Salina in a broad basin, 5 miles in length, and along the Limestone township line the next higher (Lower Helderberg) limestone rocks.

The *geological section* of rocks exposed in these two townships extends from the Medina sandstone of Shamokin and Buffalo mountains upwards to the No. VIII Marcellus black slates occupying a narrow strip in the Lewisburg synclinal along the south bank of Buffalo creek.

Ore mines.

The *Ore sandstone* and *Sand Vein fossil ore bed* show but a single outcrop in the north end of Buffalo township, creating a low ridge about three miles in length, between

White Deer and West Buffalo township lines. The sandstone was exposed in the gap of Spruce run; but its dip was rather obscure, and no good ore has been developed along this portion of its outcrop.

On the south side of the Buffalo valley there is another outcrop of the Ore sandstone, extending through East Buffalo and Buffalo townships on the north flank of the Shamokin mountain, nearly 7 miles long, and everywhere dipping at gentle angles of from 10°-35° to the northwest.

A considerable amount of ore has been mined in this portion of the range in former years for the *Dry Valley* or *Union Furnace Co.*, whose furnace, situated at Winfield on the Susquehanna river in Snyder county, has been so long and successfully managed by Dr. Levi Rook.

The almost entire cessation of the iron business in this portion of the state during the last few years has practically led to the abandonment of work, except in one or two localities, all through the Jack's mountain section in Union and Snyder counties. Formerly both the *Danville ore beds* and the *Sand Vein* fossil were mined in large quantities from both the north and south outcrops of this anticlinal, and a hundred different openings attest the former activity of mining operations hereabouts, as well as the general good character of the ore obtained.

Dr. Rook has already furnished a large amount of information bearing upon the old operations in this district, and all his facts have been already incorporated in Report F. His long acquaintance with the mining and use of these ores would make it seem superfluous to add anything additional, even had it been possible to enter and examine these old openings.

The *Danville ore beds* have probably been more largely developed along the eastern end of Jack's mountain anticlinal, one of the beds yielding in places from 2' to 3' of ore. The Ore sandstone is neither compact nor massive here, occurring in two divisions separated by slate, and from 20'-30' thick; and the Clinton shales, immediately overlying the Ore sandstone, have been so largely eroded along the eastern end of the ridge that a very large quan-

Quantity of soft fossil ore has been obtained from the ore beds underlying it. These beds have been pretty well robbed of their ore on both sides of the mountain for some distance west of the river.

A short distance below *Turtleville*, the Ore sandstone is exposed with a south dip in the northern sub-axes of the mountain anticlinal, here known as the "Longstown ridge." A small ravine, known as Miner's Hollow, flows in the compressed synclinal between the two sub-axis and carries the Ore sandstone and accompanying fossil ore bed for about a mile west of the river. The lowest of the *Danville ore beds* has been largely worked here, the thickness varying from 20" to over 3', largely soft fossil ore. This ravine has been the means of developing also the northern dip of the south anticlinal, which is so flat at this point that every small branch of the stream seems to cut into the ore outcrop. This accounts for the large quantity of soft ore found; and as the ridge rises to a considerable elevation, the stoping ground was everywhere ample. Only one mine was actively worked during 1888, owing to the Union furnace being out of blast. It is situated about $\frac{1}{2}$ a mile from the river and was worked upon a miner's contract, upon the *Danville bed*, which exists in good condition there.

This bed has furnished by far the largest percentage of ore mined further west on the north flank of the mountain, and occurs behind or south of the Ore sandstone, which, owing to the prevailing low dips, creates a distinct ridge away from the foot of the mountain.

A number of abandoned openings were noticed further west, especially between the two roads crossing the mountain into Snyder county.

Wolf's opening, south of the school and church, and *Mertz's opening*, on the west side of the main mountain road, both furnished large quantities of ore to the Union furnace, and both are probably opened in the *Danville beds* on a dip of 30°-35° northwest.

Krause's mine. The road from Buffalo township keeps behind the Ore sandstone ridge for about a mile in the

lower Clinton shales, finally turning north and descending the flank of the ore ridge which has one old opening here, known as the *Krause mine*. The ridge is about 150' above the valley and is said to have furnished mostly soft ore.

Further east, about a mile from the Buffalo line, the ore ridge is completely gapped by a small branch of Turtle creek, and on the *Zook* and *Walter* farms the Danville (?) bed was formerly mined to a considerable extent by water level drifts. The waste dump at these openings shows mostly a mass of yellow roof shales with but little ore, and the Ore sandstone, which is both thin and shaly here, apparently outcrops to the north of the openings.

In Buffalo the contraction of the east and west lines of the township permit of only about two miles of the Ore sandstone ridge to occur. The Medina red sandstone makes the crest of the Shamokin mountain here, and the top layers of the overlying white Medina are seen along the road crossing the mountain, dipping northwest 15°, a short distance south of the red frame church on the north flank of the mountain. The church itself stands on the lower Clinton brown shales, which dip about 30° northwest.

The Ore sandstone ridge stands out distinctly, away from the base of the mountain, and at the forks of the road, near Gauberman's, it outcrops upon a 30° N. W. dip.

Joseph Spangler's mine was being actively worked in 1888 on the west side of the road, under a lease of Messrs Heinback & Zubler, who sent all their ore to the Union furnace, 9½ miles distant. The lower bed averages from 14''-18'' thick, and is probably the Danville bed. The drift is about 300 yards long, with possibly 20 yards of breast, all in soft ore, except about 4 or 5 yards just above the level of the gangway. The bed seems to have a blue slaty limestone foot-wall and a sandstone roof. Occasionally a small seam of slate or Jack occurs in the bed about 2'' or 3'' from the top; but it is not persistent.

This same bed has also been worked on the east side of the ravine upon John Reed's property; but his opening has been temporarily abandoned. Roland's property lies

next west, where a considerable body of ore is still reported to exist.

Reed's property has been excavated eastward to the line of the Walker property. During the season of 1888 about 75 to 100 tons of ore a month was being produced in this vicinity and shipped to Union furnace at a contract price of \$1.10 a ton, delivered at the mouth of the drift, and as a dollar a ton was paid to haul it for $9\frac{1}{2}$ miles to the furnace this ore could not have been laid down in the stock pile at that point for less than \$2.25.

In traveling southwest across East Buffalo township from Lewisburg the Lower Helderberg limestones are first passed over, although these rocks are so largely eroded as to create no hill at this point. The upper Salina lime shales succeed, showing dips of 20° - 25° N. W. in the vicinity of school house No. 5, and then a broad belt of the Bloomsburg shales lapping over the Montour axis with dips of from 10° - 15° N. and S.

These latter rocks are exposed also along the river road in an old road quarry, dipping N. W. 20° and are succeeded further south at Penny's house by a flat anticlinal of upper Clinton shales, perhaps 200' thick, and excellently exposed in the cuts of the Philadelphia and Reading railroad. Further south the dips flatten greatly in the succeeding Mifflinburg synclinal, and after a dip of 20° to the north west are again repeated by a gentle local anticlinal, north of Turtle creek on dips of 10° and 15° .

Limestone quarries.

The structure all through here is rather wavy, due to the overlapping of the Montour and Jack's mountain axes.

In Buffalo township are several openings in the *Lower Helderberg limestone*, occurring in the south flank of the limestone ridge west of Lewisburg.

These in order westward are the quarries of Messrs. Gephart (erroneously printed Gephew on map); Cameron, or Duck; Wolfe; Wolfe No. 2; and on the western point of the ridge along Buffalo creek, Beaver's or Miller's quarry. None of these openings were very actively worked in the

summer of 1888, and it was with difficulty that any information could be obtained concerning the markets or the general commercial characteristics of the stone; but they are evidently mainly worked for local farm use and plaster lime.

J. Wolfe's No. 1 quarry, on the south side of the hill, is about 250 yards north of the pike and near the crest of the ridge. It has been mainly worked to produce farm lime, which is burned in two kilns. The dip is gentle, not over 20° N. 5° W., and upon this dip the quarry exposure, which is about 50' square, shows about 60' of rock, capped with shaly fossiliferous beds, not worked. There is one good massive blue bed in the north face of the quarry, from 12'-15' thick, separated by about 15' of small one foot beds from a lower deep blue bed of excellent quality, about 6' thick, smooth grained and very free from siliceous matter. These two beds are chiefly worked here: the underlying beds exposed are all shaly and are not burned.

Martin Wolfe's quarry is about $\frac{1}{4}$ of a mile east and differs in no essential points from the one just described, except for a slightly steeper dip.

The *Cameron quarry* (now *Packer*) is about $\frac{1}{4}$ of a mile east and was being actively worked during the summer of 1888. All kinds of lime are made here upon demand, and the average output is from 6 to 7 thousand bushels of burned lime per month.

The quarry is opened geologically and topographically like the others in this hill, and exposes a rock section, 50'± thick, dipping 25° N. W. The upper 25' is shaly and white, and is rarely used. Beneath this there is a good 10' blue bed separated by about 6' of shaly beds from a lower 6' blue bed, corresponding to the two main beds of the other quarries and apparently associated with the *Bossardville horizon* described in G7, embracing the counties on the east side of the Susquehanna river.

The quarry is about 150' long, but narrow, and most of the information regarding markets and use of lime was withheld.

Gepheart's quarry is next east, separated by a small

quarry formerly worked by Cameron. But these latter openings were idle and both small.

The *Beaver, or Miller, quarry* is situated high in the ridge about $\frac{1}{4}$ of a mile down Buffalo creek from Hafer's grist mill in the north leg of the synclinal on a low E. S. E. dip. Probably 60' of good blue stone is exposed here 200' above creek level, and in the interval there are several additional ledges of limestone rather more white and gray, so that the entire series cannot be less than 200' in thickness, estimating the top layers of the upper Salina beds to be above creek level here.

The quarry was being operated by Mr. Stall, but was not active at the time of inspection.

The limestone can be quarried here with great advantage and cheapness, as the opening is practically in the center of the synclinal, and can be worked in both directions with equal advantage.

In the *Mifflinburg ridge*, which is also sometimes called the "Limestone Ridge" by the local inhabitants, there are one or two small quarries close to the Limestone township line, opened near the crest, with dips of from 15°-20° N. W. This ridge is of synclinal structure, and in its length of 7 miles, contains three narrow compressed strips of the Oriskany sandstone, separated from one another by erosion along the crest of the ridge. The eastern extremity contains limestone throughout, and its southern crest has been cut down in a desultory manner for several hundred yards along properties of Messrs. Frock & Bucher.

Henry Frock's quarry, which is the more eastern, is only worked for private farm use; but the stone is in fair condition to develop well and enable an excellent quarry to be opened at this point.

The *Rev. Mr. Bucher's quarry* is really a series of small openings for several hundred yards along the hill, beginning at $\frac{1}{4}$ of a mile west from Frock's opening and extending to, if not entirely in, Limestone township. A very small section of the limestone measures is exposed in any of these openings, although the stone worked is apparently of excellent quality.

A section from the pike in the neighborhood of Vicksburg south to Shamokin mountain displays the erosion of the limestone rocks in the *Mifflinburg synclinal*.

The upper Salina lime shales crop on the pike with a 20° S. E. dip and continue to the Luthern church, where some very fat limestone beds occur on a 35° S. E. dip, sufficiently massive to make a distinct *terrace* ride further west on the north flank of the Mifflinburg hill. South of the church, still higher shale beds dip 45° S. E., the synclinal passing near the school house on Turtle creek, and reversing the dip to 45° N. W. in similar rock measures, north of S. L. Glick's house.

Further south, beyond his house, a road cut makes an excellent exposure of the Bloomsburg red shales or lower Salina rocks, dipping 25° N. W., and separated from the Ore sandstone ridge by an open valley of upper Clinton brown shales.

6. *West Buffalo Township in Union county.*

This is a long and narrow township, lying immediately west of White Deer and Buffalo, with Lewis township on its west and extending along the White Deer mountain on the Lycoming county line. Its southern line is the turn-pike road for three miles west of Mifflinburg, running thence east up the flank of Limestone ridge to corner of Buffalo and Limestone townships. The east and west lines, running north and south, are practically parallel, and but for an offset of about 1½ miles along Spruce run, the township would be almost a perfect parallelogram, 4 miles wide and 10 miles long. As it is, the offset along Spruce run takes out between 7 and 8 square miles, so that its area will hardly reach 35 square miles.

As its border lines cross so many structural features in the county its topography and soils are necessarily very much diversified.

Its *drainage* is generally eastward, and although no one stream has a very extensive flow on account of the narrow width of the township, it is watered by a great number of branches of Buffalo creek.

Both branches of *White Deer creek* flow through its northern portion; the south branch, after rising in the No. III Hudson river slate valley, created by the Nittany mountain anticlinal, creates a *fine gap* in the north leg of the mountain, although presenting no good exposure of rock in place.

Spruce run waters the valley of that name, between Nittany and Buffalo mountain, and flows through the township for 4 miles; while *Rapid run*, entering on the west from the narrow valley between Seven Notch mountain and Shriner's mountain, cuts diagonally across the Jones mountain anticlinal axis, here flanked with a double Ore sandstone ridge, and after passing over the western extremity of the upper Salina synclinal valley north of Forest hill, it passes out of the county through the upper Clinton shales, on the back of the Penns Valley or Little Buffalo mountain anticlinal.

The North branch of *Buffalo creek* enters the township in the synclinal between Jones and Little Buffalo mountain, and gradually works its way southeastward across the latter anticlinal, passes over the *Cowan synclinal* of upper Salina rocks, and cuts directly across the dimpled anticlinal crest of the Paddy's mountain axis, here occupied by upper Clinton and lower Salina rocks.

The South branch of Buffalo creek waters the fertile Buffalo valley of upper Salina rocks, north of the railroad at Mifflinburg, and with the North branch passes into Buffalo township along the southern leg of the Paddy's mountain axis, in Bloomsburg red shale.

Mifflinburg, situated on the Lewisburg and Tyrone railroad about 10 miles west of the river, and in the southern portion of the township, is a thriving, industrious village, with a considerable population, and is the only place of size or significance in the entire township.

The *geological series* of rock exposures in the township extends from the top of the Hudson river slates No. III, elevated by the Nittany mountain axis, up to the Lower Helderberg or Lewistown limestone No. VI.

The *Oneida and Medina sandstone rocks*, although occurring in four separate anticlinal mountain ridges in this township, are nowhere very well exposed in place, although their eroded outcrops furnish the usual plentiful piles of angular bowlders on the flanks of each hill. So profuse are these bowlders in a larger portion of this district that they have not only concealed the lower Clinton rocks, but very largely the Ore sandstone as well.

The *Ore sandstone* can be fairly well traced however in a very crooked outcrop in the synclinal basins and over the anticlinal axes in the central portion of the township; but this rock does not occur either in the Spruce run or White Deer creek valleys this far west. In its outcrop from the Buffalo line along the south base of Buffalo or Seven Notch mountain to the valley of Rapid run, the Ore sandstone and its fossil ores above and below can only be traced by a limited outcrop of loose bowlders.

A few yards north of the hotel at the entrance to the Brush Valley Narrows, it is exposed however on both sides of Rapid run, thin bedded and about 15' thick, dipping to the northwest about 15°. On the north side of Rapid run, nearly due east from Royer's saw-mill and hotel, the Ore sandstone is excellently exposed dipping N- 10° E. 30° and about 30' thick. At this exposure the rock seems more massive and thicker than any where else in the northern portion of Union county; but neither the Sand Vein nor the Danville beds are exposed. Further west, up Rapid run, the Ore sandstone is eroded, at least on the south side of the synclinal; but eastward the north leg can be well traced by its terrace ridge into Buffalo township.

The double south ridge, marking the extension of the Jones mountain axis, dies out about a mile east of the run, near J. Shamp's, where the Ore sandstone folds over the dying axis, and returns again into the North branch synclinal.

At *J. Deal's*, near the end of this ridge, ore has been struck on both dips of the axis which is very flat; but all the openings were closed and no information could be obtained of any definite value regarding the thickness or

character of the ore bed mined. It was probably one of the Danville series.

From Mifflinburg north to Forest Hill, a good structural section is exposed.

The wide belt of *Bloomsburg red shale* north of Buffalo creek, covering the eastern extremity of the Paddy's mountain axis, shows dips of only 10° S. E., where first struck; but with nearly vertical (80°) northwest cleavage planes. These intense red beds spread on this flat dip northwards for nearly $\frac{1}{2}$ a mile, aided by the synclinal crimple in this axis, until they are quarried for road purposes on a 50° N. W. dip in the narrow ridge east of the Red Bank school house.

Overlying *upper Salina* olive lime shales north of the Bloomsburg beds, on a 60° N. W. dip, indicate at once the character of the closely folded synclinal basin, extending east and west through this township from Cowan.

At *J. Swarm's house*, on the north side of this valley, the Bloomsburg red shale again appears on a 60° S. E. dip, but only in a thin band, north of which there is another narrow strip of upper Salina measures.

Penns Valley Narrows, or Little Buffalo mountain anticlinal, succeeds further north, and carries on its crest in this township a belt of *Clinton rocks*, a mile wide, with dips each way of 30° - 40° , and is strong enough upon the Lewis township line to elevate a double outcrop of the Ore sandstone as well.

Forest Hill is situated upon a synclinal belt of Bloomsburg red shales, which are excellently exposed in the cuts made by Rapid run east of the village.

Limestone quarries.

At Mifflinburg, the pike is close to the northern edge of the *Lewisburg limestone* in the Mifflinburg ridge; but there is a comparatively small area of those rocks exposed in this township, the greater part of the ridge lying in Limestone township, to the south. All the openings immediately south of Mifflinburg were idle in 1888, although

only temporarily so, and the extensive quarries south and east of the town all showed good sections of the limestone measures upon 30° S. E. dips. The limestone industry, however, has evidently deteriorated for some reason at this point, for many of the kilns have been entirely dismantled as if the owners did not contemplate an early resumption. With railroad facilities so near at this point it seems strange that an extensive operation for quarrying and shipping both stone and burned lime is not inaugurated, for there would seem to be no good reason either in the character of the stone or in its location to prevent such an operation being successful.

The *Benchof* or *Tees quarry* is the most eastern opening and is worked periodically. It shows some excellent stone, the lower portion 10' to 20' thick, consisting of a good blue and gray rock, fine and smooth-grained; 15' of darker rougher stone, but of good quality and from 10' to 20' of thin beds on top, the dip is S. 100° E. 30°.

A section of this quarry from top to bottom amounts to 66 feet, thus:—

1. Shaly limestone, in very thin beds, 10'
2. Blue limestone, irregular fracture, and weathering rough, 20'
3. Bluish-gray massive bed, somewhat jointed, 12'
4. Blue limestone, smooth grained and of good quality, . . . 8'
5. Dark blue limestone in beds 2' thick, 6'
6. Gray shaly limestone in bottom of quarry, 10'

The opening is about 100' long east and west, and has been a large producer in the past, though idle during the summer of 1888. An excellent quality of lime should be made here.

Some little development has been made in a smaller quarry immediately east, equipped with two kilns and developing largely the upper strata.

Mifflinburg borough owns the next *quarry* further west, where the same rock section practically is exposed on a dip of only 6° to 10° S. E. This is sometimes known as the *Wolf quarry*.

The *Mench quarry* shows a similar dip and is located just west of the road crossing the ridge to Centerville and the *Faust* or *Hearn quarry* lies a short distance still further

west on the south side of the next road crossing the ridge and is close to the Limestone township road.

7. *Limestone Township in Union county.*

This is a small township lying south of West Buffalo and Buffalo townships, and extending south to the Snyder county line, having Penns creek for its southern border line from a point about $1\frac{1}{2}$ miles east of New Berlin to the end of Jack's mountain beyond Centreville, with an additional 2 miles along that mountain crest.

Its western line is a straight north and south one in common with Lewis township, about 3 miles in length, and its eastern township line, dividing it from Buffalo township, and Union township, has a double irregular L-shaped offset for 2 miles along Limestone Ridge and about the same distance along Shamokin mountain. It may be roughly computed at about 7 miles east and west and 3 miles north and south, its total area approximating 24 square miles.

Penns creek, following the northern base of Jack's mountain for about 2 miles and thence eastward for over 5 miles along the Snyder county line, comprises, with its numerous small branches, the chief of which is *Sweitzer run*, the entire drainage outlet for the township, and as it cuts entirely through the Jack's mountain spur, double outcrops of the Clinton, Salina and Lower Helderberg measures are exposed along the southern portion of the township on both sides of the Jack's mountain anticlinal.

New Berlin, formerly the county seat, situated upon the north bank of Penns creek, is the principal village of the township, while *Battletown* and *White Springs* are the names of two smaller villages located respectively on Sweitzer run, about 2 miles northwest of Penns creek, and upon a small tributary stream in the southwestern corner of the township.

The *geological rock section* extends from the red Medina rocks No. IVb of Jack's and Shamokin mountains, up to the Oriskany sandstone, occurring on the summits of the Mifflinburg ridge and in a narrow outcrop along the north

- bank of Penns creek, where it forms a low ridge in the north leg of the Northumberland synclinal of Snyder county. A limited area of the Marcellus black slates No. VIII is exposed in the loop of Penns creek a short distance west of the mouth of Sweitzer run.

The *Jack's Mountain anticlinal* and the *Mifflinburg synclinal* are the two most important and striking structural features of the township.

The former, after rising on the east from the Susquehanna river, succeeds in elevating a strip of Medina rocks on its crest for nearly 5 miles in length in Shamokin mountain, which is a virtual eastern extension of the main Jack's mountain. The axis continues to rise for a distance of about 8 miles west of the river to a point opposite New Berlin, where, partly in this township and partly in Buffalo township, it has exposed the red Medina rocks on its crest for about $1\frac{1}{4}$ miles, the ridge being about 600' at this point above the level of Penns creek.

Westward from this point the anticlinal descends rapidly, until in about 2 miles, along Sweitzer run, the flexure is spanned at water level by the lower Clinton shales south of Battletown, with dips of 10° and 15° north and south.

From this point the axis again increases in strength westward and at the same time increases the north and south dips along Penns creek to 35° and 60° respectively; and just before reaching the Penns Creek Narrows it elevates the white Medina sandstone No. IVc, 200' above creek level, and to even greater elevations on the west side of the creek, where the mountain is fully 600' high.

The Medina rocks are well exposed on the north dip of the anticlinal along Penns creek, 80'-100' thick, on a north-west dip of 35° .

The *Iron sandstone* of the lower Clinton measures, occurring about 500' geologically above the Medina sandstone, is also well exposed further west towards the Lewis township line on the Hartleton road, near David Baertges' saw-mill, where it shows 20' or 30' of a hard bluish-gray rock, weathering red at the outcrop, dipping N. 22° W. 30° .

The *Ore sandstone* makes a distinct ridge further north,

first seen on the western side of the township just where Penns creek crosses the line; and along the public road, a short distance further east, it outcrops on a northwest dip of 10° , near J. Miller's, the ridge rising and becoming more prominent as it extends eastward.

North from the bridge over Penns creek at Centerville, still farther east, the Medina white sandstone of Jack's mountain has sunk beneath a plain of the lower Clinton shales, the latter rocks dipping about 25° N. W. before reaching the school house, where this dip has increased to about 30° in the upper Clinton brown shales underlying the Ore sandstone. The latter rock is not well exposed at this point, although the ridge that it creates is quite persistent and prominent by reason of the prevailing low dips, which throw it nearly three-quarters of a mile north of the base of the mountain.

North of Battletown, along Sweitzer run, the Ore sandstone shows on a 35° N. W. dip, shaly and without ore, and soon succeeded northward by a wide band of the Bloomsburg or lower Salina red shale on an 80° dip, which outcrops all through this township in a belt generally parallel to the trend of the mountain, from White Springs on the west to West Buffalo township line.

Neither the Sand Vein or the Danville fossil ore beds ever seem to have been worked along this northern outcrop of the Ore sandstone, west of Sweitzer run, although if either bed was found its low dip would insure a large quantity of soft fossil ore.

East of this creek, the Ore sandstone is not well exposed; but an ore bed, 15'' thick, yielding both soft and hard fossil, was reported open on the Kunkle farm, which has developed the same ore formerly worked by Mr. Rohbach and Dr. Rook, between the New Berlin-Mifflinburg road and the Buffalo township line.

Dr. Rook's mine is a slope, about 100 yards on the vein, and driven east from the foot about 50 yards, probably in the Danville beds, where as much as 3' of ore has been found for short distances, although the bed will not average more than half that throughout any length of its outcrop. Roh-

bach developed the same bed to a small extent, and both are no doubt the same as mined by Messrs. Heinbach & Zubler on the Spangler property in Buffalo township, where an excellent quality of hard fossil ore has been obtained.

Both the Ore sandstone ridge and the band of red Bloomsburg shale create similar parallel outcrops along the south side of Shamokin and Jack's mountain, entering on the east from Union township, and extend west to the Centerville gap on Penns creek. The terrace ridge formed by the Ore sandstone here lies much nearer the base of the mountain, and though the Ore sandstone is not well exposed, owing to the covering of drift from the mountain, its dips are evidently steeper than along the north side, while the rock itself is generally more shaly.

The Old *Maize ore bank*, in a small ravine near the Union township line and about one and three-quarter miles east of New Berlin, operated the two lower Danville beds, having a combined thickness of only 10'', in the two parallel gangways, one above the other, during an interval of about ten years, during which time about 5,000 tons of ore were mined for the Union Furnace Company. This operation has been long abandoned, the lower gangway having been in hard fossil ore, and the upper one in soft fossil of good quality.

The *C. Moyer ore bank*, situated one mile northeast of New Berlin, is also mentioned in Report F, p. 10, as having been worked for some years before its abandonment in 1869, owing to the beds containing too small a quantity of ore. The ore dipped about S. 45° E. here, and contained about 12'' of ore, largely soft fossil.

Michael Cleckner's opening was about three-quarters of a mile east of New Berlin, where the Danville beds were worked at various times between 1868 and 1875, and just north of New Berlin the same ore beds were opened for the Union Furnace Company in 1853, but abandoned after five years' operation. The ore bed was rolling here and from 3''-6'' in thickness, which was about the section found at Christopher Seabold's mine, one mile west of New Berlin,

where the beds were formerly worked on a 45° S. dip. All of these operations here have been abandoned for a long time, and to a large extent the drifts have become almost obliterated.

Between New Berlin and Centerville no openings have ever been made, the ore ridge being largely eroded and broken down. Throughout this southern outcrop the Sand Vein fossil ore bed has never been developed in workable condition, and the Danville beds are entirely too thin ever to warrant their re-opening considering the present requirements of the iron trade.

The *Bloomsburg red shale* can be readily traced all through the lower end of the township by its red soil and peculiar physical structure, outcropping north of New Berlin and along Sweitzer run on a south dip of about 45°, and crossing Penns creek on steeper dips just east of Centerville.

The public road entering along Penns creek from Union township on the east, keeps for some distance along the low limestone ridge of *Lower Helderberg* rocks No. VI, showing dips of S. 15°–20° E. 50°–60°; but the limestone nowhere seems to be very massive or very thick. Between this low ridge and the Bloomsburg red shales, there is a narrow fertile valley of the upper Clinton lime shales No. Vc', which are well seen west of New Berlin, in the gap of Sweitzer run.

Limestone quarries.

Seabold's quarry has developed some thin layers of the Lewistown limestone on the east bank of this creek in a low ridge facing Penns creek. In the western and smaller quarry the stone is very shaly and of a white color, sparingly developed on a dip of S. 18° E. 50°. In the larger quarry adjoining it on the east, some good massive layers of a deep blue stone have been uncovered; but the quarry has been very badly opened for the purpose of extracting lime for local farm use, and is only worked from time to time as

needed. The better stone occurs further south in the top of the quarry, but none of it seems particularly attractive.

The *Oriskany sandstone No. VII*, lying south of the limestone belt, is composed of shale and chert, which has been so largely eroded by the action of Penns creek as to make its location uncertain.

The *Mifflinburg ridge* in the northern portion of the township, has already been referred to as containing a good series of limestone beds. About a mile west of Mifflinburg there are three small quarries opened about 250 yards south of the pike, all in the same portion of the Lower Helderberg formation, as exposed in the large town quarries on the West Buffalo line. The dip is about S. 15° E. 10°–20°.

Royers quarry, with two kilns, is the first operation; *Kleckner's*, with one kiln, the second; and *Youtz's*, with one kiln, the third. The first two are practically continuous, and expose about about 30' of rock, including the soft blue-gray stone, for a distance of about 100' along the outcrop. The Youtz quarry is about 100 yards west, and while it was not thoroughly developed, presented a face of excellent stone. None of these quarries were being operated when visited and are probably only developed for private farm purposes.

J. Strickler had just started a small quarry along the north flank of the ridge, about one mile west of the Youtz quarry; but comparatively little stone had been quarried here.

Immediately south of Mifflinburg and somewhat higher in the ridge than the town quarries:—

Anspach & Cotelius' quarry is opened close to the synclinal in limestone, dipping about 5° S. E., the reverse dip showing a little higher on the ridge. The stone exposed here is not burned at all and occurs geologically above the good fat-lime beds of the Lewistown formation, and is largely developed for building and paving purposes in Mifflinburg. It has a blue color and is exceedingly hard, breaking out in small or large blocks as required, and apparently an excellent stone for the purpose for which it is required. There is about 20' of rock exposed in the quarry.

the thickest layer so far developed being about 14". One bed of good limestone, about 2' thick makes the bottom rock of the opening.

The *King quarry* is located just west of the road leading to White Springs, opened in the massive limestone series of No. VI., and furnishing an excellent quality of lime. It is a small opening however, and has not as yet developed any thickness of rock.

R. & D. Long's quarry is situated a couple of hundred yards west on the east side of the next road crossing the ridge, where the limestone developed and burned is of first-class quality. The general trade is supplied from this opening, field and plaster lime selling at 7½ cents per bushel for "run of quarry," and 10 cents for picked lime.

The rock section exposed is about 40' thick, the lower 25' consisting of good blue beds, less silicious, and are said to make the best plaster lime, but no better for fertilizing purposes than the upper beds.

The quarry is about 70' long and is equipped with two kilns, one of which is kept going constantly. Work has been carried on for about 2 years, averaging about 9 or 10 thousand bushels per year. The dip is S. E. about 10° and the Oriskany sandstone and chert caps the ridge above the opening where it has been somewhat quarried for road purposes; but it only makes a small knob at this point, being eroded to the east and west. It is about 15' thick.

From Long's quarry to White Springs the synclinal of the limestone ridge is crossed further west, where it again holds a strip of the Oriskany sandstone measures.

Barber's quarry, just north of White Springs, has developed the bottom members of No. VI on the south flank of the ridge, largely exposing a gray and white stone, not particularly good. There should be better layers opened higher in the ridge. The dip is about 15° N. W., increasing to about 35° southwards in the upper Salina lime shale valley, which spreads out between the limestone ridge and the Bloomsburg red shale, east of White Springs.

Along the eastern end of the Mifflinburg ridge the No. VII Oriskany rocks again cover the crest with a thin

mantel of broken sandstone and shale, the ridge being slightly divided here by a narrow valley, but keeping a nearly dead level eastward, where the two prongs come together again.

Hassenplug's quarry is a large opening on the south flank of the ridge and west of the road to New Berlin, where the dip is about 10° N. W. The quarry was idle during 1888 and shows a somewhat similar rock section to the Mifflinburg opening.

8. *Lewis Township.* 9, *Hartley Township.* *Union county.*

Lewis township forms a long narrow strip extending completely across the country from north to south, making almost a perfect parallelogram a little over $2\frac{1}{2}$ miles wide, east and west, and 14 miles long north and south, with an area of 30 square miles.

West Buffalo and Limestone townships lie to the east of it, and Hartley on the west. Lycoming and Clinton county form its northern border lines, which is 2 miles long on the White Deer mountain crest, where it makes a right angle bend to the south for a mile to the Tea Spring, on the White Deer turnpike and nearly an equal distance along the White Medina sandstone plateau at the head of the north branch of White Deer creek. The crest of Jack's mountain forms its southern border line, which, by the recently reviewed line between Union and Snyder county, is nearly 3 miles long.

Hartley township, as the map will show, is somewhat irregular in its outlines, and of a roughly right-angle triangular shape. Its eastern border line, in common with Lewis township, is 12 miles in length; its southern line, dividing it from Snyder county, a little over 10 miles long, along the crest of Jack's mountain, while its north and west lines bordering Centre and Mifflin county, is as follows: Beginning one mile from the Tea Spring on the Lewis county line; S. $44\frac{1}{4}^{\circ}$ W. 4 miles to the Brush Valley Narrows; thence S. $38\frac{3}{4}^{\circ}$ W. 7 miles to the Penns Valley turnpike; thence S. $49\frac{1}{2}^{\circ}$ W. 6 miles to a mutual corner of

Union, Centre and Mifflin counties on the Lewisburg and Tyrone railroad in the valley of Penns creek; thence along the Mifflin county line S. $53\frac{1}{2}^{\circ}$ E. 119 poles to a stone on the north side of Penns creek, and with that county S. $21\frac{1}{2}^{\circ}$ W. a little over 2 miles to the summit of Jack's mountain and a corner of Snyder county. Thus this north and west line has a total length approximating 20 miles, and the total area of the township is from 60-70 square miles.

Nearly all the various water courses already mentioned rise in this portion of the county, and eventually find their way eastward into the Susquehanna river; but of these Penns creek, the most southern, is likewise the most important, flowing through the upper Buffalo valley along the north base of Jack's mountain for something over 12 miles and with its main tributary, Laurel run, in Hartley township, drains nearly one-half of that township. Buffalo creek, through its branches and White Deer creek complete the drainage of the northern portion of both townships.

Lewis township is without any prominent village, although *Hartleton* and *Laurelton*, just beyond its western line in Hartley township, are thriving villages within easy access. In addition to these considerable settlements are being made in the vicinity of the several stations along the line of the Lewisburg and Tyrone railroad.

Each one of the six sub-divisions of the Buffalo mountain range lying between the White Deer mountain on the north and Jack's mountain on the south, is represented *en échelon* in these two townships, and all of them being anticlinal ridges they show pairs of double hills, five of them eroded along their center lines to expose areas of the Hudson river No. III slates, and each pair separated by valleys of the lower Clinton measures along the principal water courses of the district.

The *rock series* of these two townships extends from the top of the Hudson river slates upwards to the Lower Hellderberg or Lewistown limestone, the latter rocks only existing in a small triangular area at the western end of the Mifflinburg synclinal ridge, in Lewis township south of the railroad.

None of the slate valleys marking the positions of the anticlinal axes in the mountain area of the district contain any very great thickness of the No. III measures, and are all much more important in Centre county, where they spread out considerably through the eastern end of Penns Valley. In Union county these slate rocks present no good outcrops, being largely covered with bowlders of the Medina rocks and drift from their decomposition.

The same thing is true of the mountain members as well; for though their presence and extent can be very nearly located by their influence upon the topography of the country, as well as by the immense number of bowlders which their eroded outcrops have given rise to, yet exposures of these rocks in place are extremely rare and are largely confined to a limited area in the southwestern corner of the township, where the erosion of Penns creek and its branches have exposed the white Medina sandstone in the White mountain sub-division of Jack's mountain.

Nearly half the area of both townships is occupied by these mountain-making rocks, which have formerly and in a measure still furnish a large quantity of timber, the bulk of that left being of smaller size and largely marketed for props for the coal mines of the anthracite region. Some timber is still being cut from the flanks of the White and Paddy's mountains, tributary to the railroad; but the operations are largely in Centre and Mifflin counties.

In the area further north most activity was displayed along the waters of Rapid run, a branch of Buffalo creek, rising in the Brush Valley Narrows, and in the high Medina sandstone flat formed by the junction of Seven Notch and Shreiner's mountains between which ridges the main stream flows in a narrow and deep valley of lower Clinton rocks.

From the entrance of the narrows in West Buffalo township to the Centre county line beyond the Half-Way Hotel, this valley, for about 8 miles, is exceedingly rough and wholly given up to lumbering. Four steam mills and one water mill were in active operation during the summer of 1888, all of them practically "cleaning up" the large timber tracts, from which most of the large trees had been

cut. Indeed but one tract, owned by the Beck estate, in Hartley township, above S. M. Luker's house, had not been cut over.

Hemlock and white pine have furnished by far the largest percentage of material cut, and both varieties have existed here in great quantity and of excellent quality.

In the gap near the Half-Way House, made by the north branch of Rapid run, the *Oneida sandstone* shows a partial outcrop, dipping S. 10° E. 40°, showing a marked north-west cleavage which cuts its beds into large square blocks. The mountain to the east of this point forming the southern leg of the Buffalo mountain anticlinal, is gapped by a number of small tributaries of Rapid run, most of which take their rise in the *red Medina sandstone*, which makes an elevated valley between the *Medina white sandstone* and the outer Oneida terrace; and their effect upon the topography of the terrace ridge is so marked as to have given it the name of the Seven Notch mountain.

The Little Buffalo mountain, lying further south, is similarly notched by branches of Buffalo creek and Laurel run, the latter stream cutting so deeply in the mountain members as to afford a natural avenue for the location of the turnpike leading from Lewisburg, via Mifflinsburg and Hartleton into the Penns Valley Narrows of Centre county.

The *Ore sandstone measures* create through the greater part of the southern part of these two townships a distinct outlying ridge, nowhere rising to any very great height, except along the north flank of Jack's mountain, where the steeper dip of the measures carries the Ore sandstone well up the flank, making an indistinct terrace ridge upon the side of the main mountain.

A glance at the map will show the somewhat irregular zigzag outcrop which the Ore sandstone makes through the several synclinal and anticlinal flexures of these two townships. It shows a small triangular area in the synclinal along the north branch of Buffalo creek close to the West Buffalo line, and after reëntering the latter township, it

folds over the Penns Valley Narrows anticlinal at the end of the Little Buffalo mountain and returns to make a double outcrop in the narrow synclinal basin extending west from Cowan.

In this basin, in Lewis township, the two opposing outcrops of the Ore sandstone, dipping towards one another at angles of from 40° - 60° are never more than three quarters of a mile apart, and contracting rapidly westward, they come together in Hartley township a little over a mile from the Lewis line, and from that point westward occupy the whole of the synclinal basin as one ridge and outcrop a mile and a half long.

Witmer's mine, on property of David Yohn, is located upon the northern outcrop of this synclinal in Lewis township about a mile east of the Hartley line, near a small branch of Buffalo creek. The bed mined here on a 55° S. E. dip is probably the Sand Vein; but the Ore sandstone, as well as the roof slates are so thoroughly decomposed in and around the mine as to be scarcely recognized. The ore has been largely changed to hematite, and occurs in soapstone clays in a double bed with 15"-20" of ore on top; 8"-14" of clay slate in the center and 4"-9" of bottom ore, all overlying a decomposed sandstone.

This mine was worked 40 years ago, and had only been recently reopened by Mr. Witmer and 40 tons of ore sent upon trial to Bloomsburg. The ore seen did not appear very rich, and the clays adhere closely to it requiring a great amount of timbering in the mine. The drift is in 75 yards and stoped for 30'. Several thin beds of ore, 2"-6" thick, overlie the two main benches, and give it the character of the Danville series, which indeed it may be. Should the ore be found of suitable character it could be well developed from this point, and loaded upon the broad gauge tramway of the Ryan & Thompson lumber operation, about $1\frac{1}{2}$ miles east, whose track extends from the railroad below Mifflinburg into the valley of the North branch of Buffalo creek, where an extensive lumber operation is carried on.

The *Mull property*, $\frac{1}{2}$ a mile east of Witmer's mine, has

furnished some little hard ore from the same bed, but has not been recently worked.

The *Bloomsburg red shale* occupies the center line of this basin all through Lewis township, but is eroded soon after entering Hartley by the coalescing of the two Ore sandstone outcrops, as already mentioned.

The *Ore sandstone* south of this basin folds over the Paddy's mountain anticlinal, the axis line passing a little north of the Pleasant Grove Evangelical church, with dips of about 10° in the Clinton shales underlying the ore group. On the road from S. Yohn's saw mill to Mifflinburg and on the crest of this axis east of Pleasant Grove, E. Orwig has opened a *lime quarry* in the *lower Clinton lime shales*, which are said to have furnished some thin but good lime beds. The dip is flat towards the northwest and the quarry and kiln have been abandoned for some time.

The *Ore sandstone* shows slightly on a south dip of 20° , just before reaching the triangular forks in the road near Hoofnagle's place, south of which the Bloomsburg red shale makes a distinct band passing into West Buffalo township above the forks of the road at J. Boyer's and about $\frac{1}{4}$ of a mile north of the Buffalo creek ridge.

Along the public road south of Pleasant Grove, the Ore sandstone is not exposed; but the underlying brownish shales show near the old burned grist mill on a 30° S. E. dip. Further west and near the school-house, a brownish-gray sandstone crops upon a 25° dip, possibly a representative of the Ore sandstone, which nowhere seems to carry ore on this outcrop.

Entering Hartley township, west of Pleasant Grove, the outcrop is in places somewhat obscure; but seems to be displayed in a long gently curving ridge extending for about 9 miles west in the main Buffalo valley synclinal to within about 3 miles of the Mifflin county line. Here it basins and returns about 2 miles, apparently crossing the railroad east of Weiker station, and after lapping over the White mountain anticlinal makes a synclinal loop between

that axis and Jack's mountain and then returns on a north dip along the flank of the latter for 10 miles to the Penns creek crossing on the Limestone township line.

The *Bloomsburg red shale* in a measure follows this outcrop from Hartleton to within 3 miles of the Mifflin county line; but when its outcrop returns on the south side of the Buffalo valley synclinal, the local Laurelton anticlinal axis extends its double outcrop for almost 2 miles east of Laurelton without apparently effecting the Ore sandstone outcrop in the least. Indeed this Laurelton axis seems to be a local roll entirely, extending for about 2 miles east of Laurelton and 4 miles west, everywhere crowned with the upper Clinton lime shales just under the lower Salina or Bloomsburg division.

North from Hartleton about half a mile this red shale belt crosses the road near Hower's on a 50° S. E. dip, and again upon the Centre county turnpike about a mile west of Hartleton and near the blacksmith-shop, where it shows a dip of 15° S. 30° E. and carries some brownish-gray sandstone. The road turning south to Laurelton soon passes into a synclinal of upper Salina gray calcareous shale; but at Laurelton the red beds come in again on a 30° N. W. dip on the south side of the basin, behind which on the Laurelton axis, the *Clinton shales* have been considerably dug in a clayey condition for *brickmaking*, and from it some excellent bricks have been made and considerably used in that village.

North of the Smith shop along the pike and up Laurel run Paddy's mountain anticlinal is present in fissile yellow shales close to the forks of the road west of the Evangelical church, with dips of 20° S. E. and 10° N. W.

Further west at Kleckler's the same rocks dip 20° to the northwest and outcrop for some distance along the pike, decomposing readily to a reddish-brown soil. The Clinton measures extend well up the valley of Laurel run, though nowhere well exposed beyond the toll house, where the dip is 45° S. E.

In the gap through Little Buffalo mountain the *Medina* rocks are nowhere exposed in place, although a profusion of bowlders occur on both sides of the creek, while the Oneida sandstone No. IVa, slightly conglomeritic, shows two fairly good exposures close to one another; one dipping 80° (overturned) towards the northwest, and the other 65° towards the southeast.

A narrow point of Hudson river slates fills the valley within the Oneida sandstone mountain, which westward in Centre county develops into the Confer valley.

The *Oneida* crest was originally heavily timbered here with white, yellow and pitch pine, and a good deal of chestnut occurred on the bottom slopes; but the valley of Laurel creek and Paddy's mountain on the south have both been pretty thoroughly stripped of their pine trees, some little hemlock, and the chestnut oak, by Pardee & Co.'s operation, whose tramway, 6 miles long, extended 2 or 3 miles into Centre county. Odd trees have been left and a good deal of yellow pine still stands.

The Paddy's mountain axis was again passed over on the road leading south from the hotel on Laurel run and meeting the valley a mile west of Laurelton. It carried here on its crest the lower Clinton brown and yellow shales, and the ore sandstone occurs with such a flat dip on the south side of the axis that it scarcely makes a ridge and was but slightly distinguished on a dip of 10° S.

No ore operations were active in this part of the field; but it is reported that quite a large quantity of ore has been taken from the *Rutherford farm*, half a mile north of Laurelton, and a little east of this road, as also on the *Hoffman farm*, a short mile west of the road, where it occurs on a 40° S. E. dip.

Ore mines.

The *Bower ore mine* is situated about $\frac{1}{2}$ a mile N. N. E. of Laurelton on the right bank of a small branch of Laurel creek, and but a short distance below the breast of an old

mill dam. Some 400 or 500 tons of ore are said to have been taken from a 10' bed here between yellow slates, all of which was shipped to the old dismantled Berlin Iron Works furnace, situated on Penn's creek, 1½ miles south of Laurelton.

The drift was not carried in far and is about 40' above water level, the hill rising probably from 75' to 100' higher. The dip was quite steep, 60° to the southeast, which is about the inclination of a series of red and gray slates underlying the bed along the creek bank further north; but south and north of this point the dip is not over 15.°

The ore sandstone, if existing at all here, is both thin and shaly and split into two bands, separated by slate; and the fact that this rock is sparingly exposed at the bend of the road near Bower's store makes it probable that the ore-bed developed belongs to the Danville series, and is *not* the Sand Vein bed.

Rutherford's farm to the west of Laurel creek worked this bed under lease to Schure & Co.

About a mile west, the ore ridge begins to assume shape and height along the south flank of Paddy's mountain, and the sandstone is exposed at Hoffman's house, 300 yards north of the main road, in a gap made by a small branch stream. Its dip and that of the series of gray sandy slate and shale, in places calcareous, overlying it, is from 30° to 35° and up to 40° towards the southeast.

Hoffman's mine is opened to the north and beneath the ore sandstone, and is unquestionably developed on one of the Danville beds, which gives more probability to the horizon of the Bower and Rutherford openings. The drift is rather badly located on the west side of the ravine, where the hill is low and therefore presents but a limited opportunity for obtaining long stipes of ore. On the east side of the ravine the hill is much higher and the ore bed could have been much more advantageously opened. No information could be obtained as to the extent of the development here, or the character and thickness of the bed. The ore ridge is well out from the mountain, separated by a ridge of variegated, but generally brownish-red fissile shales.

The Bloomsburg red shales outcrop to the south, but are not very well exposed, while the main valley west of Laurelton is largely composed of the upper Salina rocks.

Beyond the Dunkard church and cemetery the road rises to the north flank of the Bloomsburg red shale ridge, where the rocks of the lower Salina member dips 35° to the northwest with marked cleavage planes dipping about 55° to the southeast.

James Pursley has opened several *ore-pits* south of the Heranimus church in the field east of his house and just north of Penns creek. The rock measures all through this farm crop out with steep angles, and show largely a section of the lower Clinton yellow shales, but without much sandstone.

The horizon of the ore developed is rather uncertain, although unquestionably beneath the Ore sandstone, and, therefore, either some one of the Danville beds or possibly the lower Block or Bird's Eye fossil ore beds, occurring in Snyder county near the base of the Clinton group.

None of the old openings could be inspected, having been long since abandoned; but the superficial examination which was all that it was possible to make seemed to indicate the presence here of two distinct beds of ore, probably 250' geologically apart and separated by brownish-yellow shales holding a bed of sandstone several feet thick, and a possible representative in this field of the Iron Sandstone.

From Mr. Pursley's information on the ground, one pit sunk on the top of the ridge, about 6' deep, struck a 12'' ore bed dipping steeply (60°) southeast. The ore was fair. North and south of this about 30 and 40 yards the ore outcrops again, making a double synclinal and anticlinal.

A short distance east where the ridge is cut off in a bluff facing Penns creek at Weikert station, the first or most northern outcrop is opened 12'' thick on a dip of 50° N. W. This drift has been carried in 25 yards and stoped up 60 yards, with several additional adits near the hill top, 200' above creek level.

The same ore-bed has evidently been opened in two drifts a little further south, one in the synclinal basin and the

other on a second north dip of 50°. The former of these two had been developed for 20 yards and considerably stoped in both directions from the basin.

The sandstone bed before mentioned lies to the south of this opening, thin, but making a distinct ridge north of White mountain. About 10 yards south and back of this sandstone bed the lower ore-bed (*Black Fossil?*) is opened about 20' above water level carrying 12" to 18" of ore between the slate roof and floor, driven in for 30 yards and stoped to daylight. It was impossible to secure any samples of this ore which would have shown the characteristic marks, and its horizon is, therefore, only a suggested one.

The railroad cut, just south of this opening, shows a *splendid exposure* of sandstone and shale 60 thick on a northward dip of 20°, red at the bottom and gray on top, evidently a portion of the white Medina sandstone No. IVc. The proximity of this rock to the ore-bed seems to confirm the correctness of its being placed near the bottom of the Clinton series.

Zimmerman's old mine (now owned by D. C. Johnson), is situated about 1½ miles below Cherry run, and is opened on the south side of the railroad on a steep northwest pitch and a short distance from Kaylor station. This bed is called the Bird's Eye fossil, and probably correctly so, as it is quite fossiliferous and is evidently low down in the Clinton series. It is from 12" to 14" thick, with a yellow shale roof and floor. About 100 tons have been mined, yielding about a 45 per cent. ore. The tunnel across the measures to the bed is about 100' long, and the breast about 30' high.

A tramway has recently been run west from the original opening towards the point of the hill, where a new cross-cut, 30' long, through the same measures, strikes the ore bed, 10"-12" thick, at a somewhat lower level and on a dip of N. 25° W. 45° between gray slate walls. The ore is here largely hard fossil; but softer towards the outcrop, and has perhaps 60 yards of breast. There is a thin sandstone underlying the ore bed at a vertical distance of about 150', locally called the "blue rock" but probably a representa-

tive of the Iron sandstone. This sandstone makes the crest of the ridge and covers the south flank with numerous boulders. It weathers decidedly red, and at the nose of the hill shows about 6' thick in a prominent ledge, dipping N. 10° W. 45°.

Some difficulty was experienced in suitably preparing this ore from the fact that both the roof and the floor slate sticks to the ore mass, which itself shows in places thin bands of a hard red slate.

The *Zimmerman ore* is about at the western end of this central valley Clinton ridge; westward this ridge is entirely eroded, and any profitable ore in this vicinity must be sought for along the flank of Paddy's mountain, where the *débris* of the Medina sandstone makes its outcrop difficult to locate.

This *lower ore bed series* is also said to show an outcrop for some distance up Weikert run, south of White mountain, but not opened there.

The Clinton ore measures extend west a short distance into Mifflin county, making a low ridge as far as Aumiller's place; but only containing the lowest ore bed.

Just west of Cherry Run Station the railroad cuts through red and brown shale, dipping 70° N. W., and at the west end of this cut, test pits, which had only partial success, had been put down for ore.

Just below the bridge on Cherry run, these Clinton shales had a southwest dip of 50° and are well exposed, so that there must be a small local anticlinal roll running along the middle of the basin as suggested by the structure further east towards Laurelton.

Going up Cherry run the dip is steeply northwest at first, but soon reversed in a tight synclinal, marking the extension of the Hartleton basin.

The first ore drift is about 100 yards north of the railroad, driven northwards 50' to the ore, and then east and west on the bed. Nearly a thousand tons are said to have been mined at this point and shipped to the Berlin Iron Works, Bloomsburg and Danville. The bed when first struck, as reported by Mr. Johnson, was 2' thick; but pinched eastward

to from 10''-12''. It is a soft fossil ore and should correspond to one of the Pursley ore beds. The bed is said to have contained in places a band of slate or "Jack" which however did not split the bed, which is said to have furnished a 45 per cent. ore.

The *Bird's Eye fossil ore* was once opened well up the south flank of Paddy's mountain on the west side of Cherry run, where it was found only 8''-10'' thick. Mr. Johnson claims that it showed an entirely different character of ore from that mined in the valley.

The *Old Johnson bank*, situated about $\frac{1}{2}$ a mile east along the flank of the mountain, is no doubt on the same ore bed although as far as mining was carried on here the entire yield of the bed was an altered brown hematite. The ore was dug from a long open cut some 20' deep, being found 6'-10' thick in clays and furnished most of the stock for the old Berlin furnace for many years. Nothing can be seen at the pit now, which is all filled in with clay and sandstone; but from the description given the bed was evidently contained in a local basin, duplicating its thickness for some distance east and west, beyond which it was found much thinner and leaner.

Mr. Johnson reports having opened the same hematite ore further east and immediately north of Kaylor Station. A drift 100' long has been driven across the measures to the ore which was found 4' thick, but interleaved with a soapstone slate. It occurs between beds of decomposed slate, without distinct foot or hanging walls, but a fairly regular bed structure.

The old *Berlin Iron Works*, which was the principal consumer of all the ores mined in this section of the county, have long been dismantled. The furnace stood on the south bank of Penns creek, about $1\frac{1}{2}$ miles south of Laurelton, and was a charcoal plant erected in 1818, since which time it has been operated by several different parties. Their first failure was due to their lack of sufficient power, and their failure to realize the fact that the ores which they proposed to use were cold-short, and were consequently

unfitted for forge-irons. An attempt was made to mix them with Centre county brown hematites, but with no greater success for a like reason, as many of the ores of that county contain a high percentage of phosphorus too. Foundry iron was next tried, especially for stove castings; but commercial success was not even then attained. Consequently for the past ten years one of the best equipped small furnaces in the state has remained idle, largely from a lack of suitable local ores, which alone could have justified its location.

Bloomsburg red shale.

Going east from Weikert Station by the Penns creek road, the south belt of Bloomsburg red shale basins in the ridge [at] A. Rote's with 50° dips, forking into two belts about a mile east of Simpson's, running respectively to Laurelton and Laurelton Station. Clinton lime shales underlying the red slate on the south, but above the Ore sandstone group, shows at D. Horner's and on the road at Simpson's dipping N. W. 50° and quite calcareous, while reddish shale shows between these outcrops on a 60° dip.

Near the junction of Laurel creek with Penns creek the Bloomsburg red shales dip 60° N. W.; and 150 yards north, along the road to Laurelton, the upper Salina lime shales are apparently overturned dipping 80° S. E., although this dip may be due to excessive cleavage.

East of Laurelton there is a fine exposure of the Bloomsburg red shales in the north limb of the Vicksburg and Laurelton anticlinal on the bank of Laurel creek below the church. It is here again so cut up with cleavage as to make its real dip uncertain, though it is probably 30° towards the northwest. This shale and red sandstone extends along the road without interruption for about a mile to Miller's, forming a well defined ridge with many outcrops. Beyond this point its crop is obscure, though passing south of the road and evidently merging with the south leg of the anticlinal which shows a dip near Lepley's of about 60° S. E. Southwards to the railroad the valley is occupied by calcareous shale, with a thin streak of impure

limestone, showing at the forks of the road above the school house, dipping 50° S. E.

Crossing Penns creek the red shales are again seen on the south side of the synclinal, and along the road down the creek ; but all this territory soon becomes a wide flat from the creek to Jack's mountain, where the Ore Ridge terrace becomes well nigh obliterated and the geology effectually concealed.

Limestone quarries.

In Lewis township at the western extremity of the Mifflinburg ridge there are a series of small quarries opened on the north side of the hill in the Lower Helderberg limestone, extending for about 1000' along the outcrop to the end of the ridge, and one opening, Halfpenny's, on the south side.

They are all small local quarries, generally run from time to time as their product is required for farm use, each farmer owning a strip about 2 rods wide, east and west, and 50 rods long, north and south.

J. Ruhl's quarry is the first and most eastern, having one kiln ; quarry about 30' wide and exposing 15' of rock, only slightly developed on a southeastern dip of 10°.

S. F. & H. W. Ruhl's quarry is about 100' further west and shows about the same amount of development. It is 50' long, and shows 18' of blue limestone in thin beds ; one kiln.

William Fees' is the next small opening, with one kiln. It is worked partly for farm and partly for general trade use, opened on the same section of beds as the last.

I. Reiss and *D. Knauss* have a quarry and a pair of kilns next west ; and *D. Knauss* a single kiln, all furnished from one large quarry, showing a section of about 30' of stone, the bottom 20' of which show good massive blue beds from 6" to 2' in thickness, pure and making an excellent lime. These beds have not apparently yet been reached in quarries further east and are not far below the summit of the hill.

William Fees' come next with two kilns, supplied from

one quarry about 30' wide and 25' north and south, where a small portion of the lower and upper beds have been developed sparingly.

George Ruhl has a small quarry immediately adjoining, but no kiln. It shows about the same features as the last.

William Fees again joins him on the west with one kiln, practically making a continuous quarry.

J. Speese has the last quarry on the western extremity of the ridge, with one kiln and about 20' of rock, dipping very gently 10-15 towards the south

In other words all these quarries are practically upon one series of beds, aggregating about 60' in thickness, all the openings making nearly a continuous quarry. All the coal used here is hauled from Swengle Station, one mile, at a cost of about \$2.40 at the railroad, and very little attempt is therefore made to manufacture any lime except for local use.

J. R. Halfpenny's quarry, on the south side of the ridge, develops the same stone on a north dip.

The Ore sandstone ridge in this township is largely eroded by Penns creek and when it gets to the south side of that stream the rocks dip so steeply as to form only an indistinct terrace on the north flank of Jack's mountain.

The Bloomsburg red shales however show distinctly at the base of the ridge, just south of the valley road, and are crossed going to Rearick's saw-mill on Penn creek on a low 15° N. W. dip, which spreads them over quite a wide area.

10, Union township in Union-county.

This township occupies the extreme southeastern corner of Union county along the Susquehanna river, with East Buffalo and the crest of Shamokin mountain for its northern line and the township road running from New Berlin to Northumberland, over a high ridge of Devonian measures, for its southern border. The township is about 6 miles long, east and west, and will not average 2 miles in width, its north and south lines being drawn together towards the

west, where they are scarcely a mile apart. Its area will fall short of ten square miles.

Winfield on the river and the Shamokin and Sunbury division of the Philadelphia and Reading R. R. is the only village in the township ; but it is noted as being the seat of one of the most successful and best managed iron plants in this part of the state, which has been largely responsible for the development of the ore beds of Union and Snyder counties for many years.

The *geological section of rocks* exposed in this township extends from the Medina sandstone No. IVc on the crest of Shamokin mountain up to the Chemung division of No. VIII in the high ridge along the Snyder county line.

The *structure* of the township is very simple, as it lies entirely on the south side of the great Jack's mountain anticlinal, all its rocks dipping comfortably towards the southeast into the Northumberland synclinal.

It has already been stated how the eastern end of the Jack's mountain axis is dimpled along the river, carrying a close synclinal fold and an *ore basin* for about a mile west of Turtleville.

On the south side of the main anticlinal, the *ore beds* are comparatively thin, except at the eastern extremity ; still a large quantity of ore has been mined at various times from different openings in the Danville ore beds and used at the Union furnace at Winfield. The *Sand Vein* ore bed does not seem to exist in this portion of the range at all until after passing west of Centerville on Penns creek ; and the *Ore sandstone* itself is generally shaly and porous, breaking up readily and therefore largely eroded.

The underlying Clinton shales show with flat dips along the flank of Shamokin mountain ; but the *Iron sandstone* and *Bird's Eye fossil* ore germane to this portion of the formation seem to be as conspicuously absent or as hard to recognize as the higher Ore sandstone group.

The lowest *Danville ore* bed developed a thickness varying from 20'' to over 3', where first opened at the eastern end of the ridge, and according to Dr. Rook, manager of the Union furnace, it maintained that thickness for about

a mile west with a general dip of about 35° southward, giving long breasts of over 80 yards above water level. The bed shows soft fossil ore near the outcrop, where the overlying Ore sandstone has been eroded, but hard fossil ore near water level.

Numerous openings upon this bed are described in Report F, p. 5 *et seq.*, and as nearly all of them were closed during 1888 the reader is referred to that report for information upon this region.

Dr. Rook, in conversation about the first of August when the furnace was idle, stated that his company were paying about \$1.60 a ton for ore delivered at the mine mouth, and an average of 30 cents per ton for hauling it to the furnace from points all through the valley, so that the least total cost at the tunnel head could not be less than \$2 per ton. He estimated the cost of ore per ton of pig iron produced at about \$6, which should require three tons of ore of about 35 per cent. His mixture of one-quarter hard fossil and three-quarters soft fossil gave him a greater and more satisfactory yield of No. 1 iron than any he could get.

The use of the Sand Vein ore bed, which was being mined near Adamsburg in Snyder county, he found most beneficial in improving the character of his iron. The average royalties paid are about 25 cents per ton. One curious feature in the immediate vicinity of Winfield is the occurrence of soft fossil ore in the Danville bed to some distance beneath water level, which is not usually found to be the case elsewhere, and can only be accounted for by the shaly condition of the Ore sandstone overlying it about 36', and the low dip of the rocks.

The old *Dunlap farm opening*, about $\frac{1}{4}$ of a mile west of the river, was being worked in a desultory fashion during the summer of 1888, and a short distance further west a gang of four men were operating in different levels of a second opening. The Danville bed is worked at both places, never over 20'' and averaging about 15'' in thickness. It has a slate roof and floor and dips about 30° S. E.

Going down the railroad from Winfield, the outcrops of

Nos. VI and VII are pretty generally concealed. The No. VIII, the Marcellus black slate, shows just north of the school house on a 60° S. E. dip, indicating the rather stiff inclination of the north leg of the Northumberland synclinal, and permitting successively higher members of this formation to come in rather rapidly towards the Snyder county line. The upper divisions, Portage and Chemung, are however not well exposed.

Limestone quarries.

The *Winfield limestone quarries* of the Union Furnace Company are situated at the east end of the limestone ridge, a short distance south of the furnace with which it is connected by a short railroad siding. They are the most extensively worked quarries in the county and the only ones having direct railroad connection. There are 12 set-kilns, with a capacity of 800 bushels of burnt lime, and which require about 3 weeks on an average to burn out. There are in addition 4 draw-kilns, which yield 75 bushels each 24 hours, so that the daily output of burnt lime here, when all the kilns are active, is about 750 bushels. All the plaster lime is drawn from the set-kilns, which appear to make a more even and thoroughly burnt product. The draw-kilns are used for farm lime. The lime burned at these kilns has justly gained a high reputation.

A compiled section showing in all about 115' of No. VI shows the following sub-divisions at this quarry :

Section at the Winfield Quarries, Union Township.

Shaly limestone,	6'	}	62'
Thin limestone beds from 10'' to 3',	27'		
Massive bed ; seamy,	8'		
Massive blue limestone ; solid,	5'		
Greyish limestone in small beds,	8'		
White and blue limestone in beds 1' thick,	6'		
Shelly limestone rock,	6'	}	6
Small beds from 3''-10'' thick,	5'		
Good blue bed,	2' 6''	}	48
Small beds,	7'		
Smooth blue limestone ; a thin slate in center,	8'		
Small beds,	7'		
Good blue limestone,	3'		
Small beds from 6'' to 1'' thick,	16'		
Slate.			

The section really shows two sets of stone 60' and 50' each, divided in the center by rather a prominent impure band, which, as far as possible, is left untouched in working the quarries.

The good beds immediately underneath this shelly rock are largely burned for the finest grades of paper lime, while the bottom 26' in [the quarry is more largely utilized for furnace stone.

The dip is about 45° S. E., and probably the best stone in the quarry is taken from the 8' smooth limestone bed, which is divided into two four foot divisions by a thin slate.

The product of these quarries goes to all sections in the eastern portion of the state, as well as into the markets of New York state. About 1½ miles from the river this same limestone ridge has been opened in a number of places, the quarries adjoining one another so closely as to prevent their names being put upon the map. Only one of these quarries was active in the latter part of July, 1888; but as they are all worked only for local fertilizing and plastering purposes, as lime is required from time to time, any one quarry is apt to be developed periodically. The names of the openings in order from east to west are :

1. Harrison Bailey, one kiln ;
2. Jacob Heiser ;
3. David Gross, two kilns ;
4. Hummel & Slear, 1 kiln ;
5. David Gross, one kiln ;
6. S. & W. Ritter, one kiln ;
7. Aaron Van Buskeart, four kilns.

These quarries are not over 35' wide and practically make one long opening 250' long, opened from the north flank towards the crest of the ridge, beyond which to the south, the Union Furnace Co.'s land extends undeveloped.

Of these small quarries only those which have more than one kiln burn lime for the trade. The low price of lime during this summer (6 cents for "run of quarry," and 10 cents for picked lime) and the high price of coal (\$2.70 a ton) made last season an inactive one in this locality ; and it is upon the price of coal largely that these quarries become active or remain permanently idle. A description of one of these quarries will describe them all. The dip is about S. 25° E. 50° and an average section shows :

Soil and loose rock on crest of ridge.

Good blue beds ; one 5' thick, but generally under a foot in thickness, weathering smooth,	25'	} 66'
Bastard shelly limestone, as in Winfield quarry, . . .	6'	
Good plaster lime beds, all worked out to level of kilns and not well seen, reported,	35'	

After the location of these kilns the lower division beds were taken out first as low down as they could be conveniently worked and wheeled to the top of the kiln, so that the lower beds exposed at the Winfield quarry have not apparently been reached here. Several of the quarries are pretty well worked out up to the line ; but Mr. Buskeart has a good strip of the lower blue limestone left yet, carrying two handsome beds at the bottom of his quarry, 5' and 6' thick.

The whole section, however, contains beds of good quality, and the lime burned even in a desultory and sometimes careless manner maintains the high reputation acquired by the distribution of the Winfield stone throughout the country.

About $1\frac{1}{2}$ miles further west from this string of quarries, the ridge again takes prominence and the following openings have been made in order westward :

1. Widow C. Seabold, abandoned. 2. J. Bucher, two kilns. 3. M. R. Gearhart, three kilns.

These together make one large quarry, about 150' long, from which about 15,000 bushels are burned on an average each year.

The total thickness of the beds exposed here is about 40', carrying two massive beds 11' thick near the bottom ; but made up of rather thin beds above. The dip is about 45° S. E.

The kilns have a capacity of about 225 bushels each.

The stone is about of the same character and quality as the openings further east ; but the beds are evidently above the shelly impure stratum, the two blue beds corresponding to similar strata found above the central slaty layer in the Winfield quarry.

These quarries are about $4\frac{1}{2}$ miles east of New Berlin, the public road to that place being largely upon the limestone

outcrop. The formation as a whole seems to become rather more shaly westward in Snyder county, and there have been no important quarries opened in it with the possible exception of one or two in the vicinity of Troxelville in Adams township of Snyder county. Westward to that point the limestone ridge barely holds its own, in some places being scarcely noticeable.

CHAPTER V.

*Snyder County.**11. Monroe Township.*

This is an irregular-shaped township, occupying the extreme northeastern corner of Snyder county between the Susquehanna river and Penns creek. Its southern border line along the public road dividing it from Union county is about 6 miles long; but it narrows southward to a point at the junction of the creek and the river above Selinsgrove. Its area is about 20 square miles.

The *drainage* is all southward, either by small tributary streams without names, directly into the Susquehanna river, or by Penns creek and its branches.

The *rock section* exposed within its borders is extremely limited, owing to the structural features of the township, which comprises the deep Northumberland synclinal basin crossing the river at that town and reaching Penns creek about 4 miles above its mouth, opposite Kratzerville.

The *Catskill sandstone and slate* fills the trough of this basin from east to west. Its red rocks, which here have been taken to limit the formation, occupy a belt nearly 2 miles wide through the center of the township, flanked on either side by the No. VIII slates and sandstones. The entire series of this latter formation is exposed in the south leg of the synclinal on dips of from 10° northward along the belt of Oriskany sandstone in the southern corner of the township to 60° at the margin of the Catskill No. IX rocks.

The *Lower Helderberg limestone No. VI* occupy the extreme southern corner of the township south of the Oriskany sandstone belt on very low dips in obedience to the broad flat arch of the Selinsgrove or Shade mountain anticlinal axis. No exposures of these latter rocks are seen within the limits of this township, partly owing to the flat dips

which have created a very even and general erosion, but more largely due to the rocks themselves having been almost entirely swept away in Snyder county by the junction of the waters of Penns creek and the river. On the east side of the Susquehanna river however, in Northumberland county, these rocks, as well as the Oriskany and part of the Hamilton series, have been well exposed in cuts along the Northern Central railroad where a summary of their respective thicknesses along the north side of the Selinsgrove axis is about as follows (Report G7, p. 346):

1. Hamilton and Marcellus rocks,	805'
2. Selinsgrove limestone,	50'
3. Selinsgrove shales,	170'
4. Oriskany sandstone series,	57'
5. Stormville shale,	110'
6. Lower Helderberg limestone,	413'
7. Salina,	115'
	1,720'
Interval from top of Oriskany to base of L. Held., . . .	580'

A detailed section of these formations is also given on page 345 of the same report. The Hamilton and Marcellus division of No. VIII consists largely of olive and brown sandy shales on top and black slates and shales beneath. The latter represent the Marcellus division about 250' thick, although the Selinsgrove limestone and shale, 230' thick, must be considered as belonging geologically at the base of the Marcellus sub-division. This limestone member is especially well developed in this part of the field, though much better on the Northumberland side of the river where an upper layer, 20' thick, has been quarried underlaid by gray impure limestones and shales, 30', which is separated from the Oriskany cherty fossiliferous sandstone beds by about 150' of (Selinsgrove) shale. The Stormville shale, 110' thick, is also well seen in the railroad cuts, and many of the individual beds are quite limy.

The *Lower Helderberg rocks*, to which so great a thickness has been assigned, carry on top a series of impure limestone and shale, grading imperceptibly into the Stormville shales, with a total thickness of about 180' down to the *Stromatopora bed* which is here as elsewhere a very

fossiliferous layer, 10' in thickness. From this bed to the top of the Salina there is a section of gray and dark blue limestone beds, about 220' in thickness, of which only the bottom 125' contain the massive good beds of the Lower Helderberg formation; but even thus reduced, the entire series seems to be thicker here than almost anywhere else in the vicinity and certainly much increased over the same series of rocks exposed further west in Snyder county.

Higher *Hamilton beds* are seen to the north in the vicinity of Shamokin dam above which place they begin to make cliffs and high land composed of dark brown and olive shale and thin sandstone beds on dips of from 30°-55° N. W.

Shamokin Falls in the river are created by a ledge of this Hamilton sandstone, 4' or 5' thick, which was used to construct the canal dam upon.

The *Genessee, Portage and Chemung rocks* at the top of No. VIII which occur between Shamokin dam and the bottom red layers of the Catskill formation are fairly well exposed on 60° N. W. dips. The Genessee shales do not show any outcrops in place, being largely soft yellow slates yielding readily to erosion. The Portage rocks were not independently distinguished, unless they occur in the high bluff at Clement Station, opposite the west end of the Philadelphia and Reading railroad bridge.

Good long section exposure of Chemung.

From this point northward to the Catskill rocks there is one of the finest exposures of the Chemung No. VIII rocks in the district. There is scarcely a break in it down to within a mile of the Shamokin dam, the rocks everywhere creating high bluffs and showing a constant succession of shales, slates and gray and brown sandstone beds on an average dip of about 60° towards the northwest. A computed estimate of the No. VIII series hereabouts would assign at least 3500' of thickness to the entire series.

Quarries in IX.

The *Catskill rocks No. IX* appear first along the small ravine and road leading west a short distance below the Northumberland bridge on dips of first 50° and further north 40° toward the northwest, until at the next road leading west, marking the Union county line, several quarries have been opened in massive red sandstone beds close to the Philadelphia and Reading railroad on 25° N. W. dips. The same rocks are repeated upon a reverse dip in ascending the ridge road between the two counties; but even better along the river and railroad in the narrow strip belonging to Union county.

Exposures along Penns creek.

Penns creek shows a very similar section. Above the Selinsgrove red bridge, lime shales and thin limestones make a low bluff on the south side of the creek above the residence of J. P. Kantz dipping very gently northwest.

The Selinsgrove shales and the Lower Helderberg limestone, and the Stormville and Oriskany beds are scarcely seen at all on the Monroe side of the creek, owing to erosion; but they make a very prominent ridge on the west side, in Penn township, which extends eastward to a little below the Shoch's mills bridge. North from here the Marcellus measures are not well seen; but dipping flatly they must occupy a wide strip of country.

The Hamilton shales and thin sandstones show on a 45° N. W. dip above Capt. J. Hehn's, making a sharp and well-defined ridge as usual, the more conspicuous by reason of the valley land of Marcellus slates to the south of them. With an average dip of 40° they outcrop almost 'without interruption for a $\frac{1}{4}$ of a mile along the road and must be nearly 1000' thick. They are largely shales and slates, but carrying between the layers ribs of brown sandstone which occur so frequently that they are enabled to resist erosion well and therefore create ridge land.

The Genessee yellow shales are not well exposed to the north and finally a short distance below the road leading

up a ravine to Miller's saw mill the Chemung (?) sandstone shows in a series of thin layers, a reddish-brown series about 60' thick ; not exactly massive but hard and unyielding. It dips N. 5° W. 35°-40° and creates ripples in the creek. Several outcrops of similar sandstone, 10-15' thick; occur going north, and above the next ravine the rocks become more shaly on steeper dips of 50°-60°, marking the transition to the red rocks at the bottom of the Catskill formation No. IX.

At Ritter's grist and saw mill, at the red bridge, the No. IX red sandstone dips only 10° N. W., *splendidly exposed* on the east bank of the creek below the mill dam, indicating the rapid shoaling of the Northumberland synclinal. The basin line is very distinctly marked by converging dips in red shale of about 15°, 50 yards north of this bridge, in an excellent bluff exposure on both sides of the creek.

Still following the creek road towards the Fisher farm, the south dip increases to 20° and even 30° in the north leg of the synclinal, and the same series of rocks are again exposed going north up the ridge to the Union county line.

12. Jackson Township in Snyder.

This township, having largely natural boundaries like Monroe, lies next west along the the Union county line, having Penns creek for a portion of its north and east boundaries, with a small area between that creek and the county road in the northeast corner of the township. Its western line, 1½ miles long, runs straight from Penns creek to the summit of the high Catskill ridge marking the line of the Northumberland synclinal; and the southern border has several irregular offsets along the spurs of this ridge to the head waters of Mill creek, which it follows to its junction with Penns creek, about 3 miles from the river. The total area of the township will not fall far short of 18 square miles.

Kratzerville is a small village located about 4 miles north of Selinsgrove on the summit of the Catskill ridge, a short distance west of Penns creek.

The *drainage* of the township is all carried off through

Penns creek and several small tributaries, the chief of which is Tuscarora creek, which, rising in the northwestern corner of Middle Creek township, flows northward through the western end of Jackson and enters Penns creek one mile above New Berlin.

The *rock section* exposed is extremely limited, consisting entirely of the Devonian and Catskill rocks Nos. VIII and IX, everywhere dipping southwards into the Northumberland synclinal basin whose axial line runs a little south of west from Kratzerville, and crosses the road from Kremer to New Berlin between the Lutheran church and the school-house.

A section from New Berlin south to the Middle Creek township line at the Lutheran church shows absolutely no good exposures, and only the junction of Nos. VIII and IX by the change of soil from gray to red in the little ravine at D. Himmels. Moreover it would seem as if the sandstone beds in No. VIII, which characterized that formation along the railroad and the river in Monroe township, were largely wanting here or are changed to shales, so that the group as a whole is much less massive and the hills in consequence less rugged.

Penns Creek at New Berlin is largely in the Lower Helderberg limestone, bending occasionally into the Marcellus shales, the No. VII Oriskany rocks being scarcely visible at all.

Entering the township further east and going south from the blacksmith shop in Union county, the ridge and county line road is evidently Hamilton. On both sides of the small ravine north of S. Ulrich's there are good exposures of the Genessee slates and Chemung sandstone in thin beds, dipping 60° S. E.

At the Penns creek crossing, here $\frac{1}{4}$ of a mile west of the Monroe line, the *transition measures* VIII-IX are well seen, and immediately south of the creek the lower red bands of the Catskill rocks are first seen with dips of 50° S. E. and 30° in the ravine further south at N. Fetter's. Crossing the ridge road to Kratzerville, a reverse northwest dip of 60° is

seen beyond Cline's, the No. IX rocks extending from there south to the creek and Penns township line.

On Tuscarora creek the Catskill red shales show a dip of 35° S. E. just beyond the forks of the road, the axis of the basin here lying further south in Middle Creek township. The approximate junction of Nos. IX and VIII is passed over just before reaching D. Breon's house, where the transition measures dip 40° S. E. Further north there is a good exposure of these rocks on the same dip, largely tinged with thin red beds, but producing a gray soil.

In other portions of this township there are additional exposures of the individual members of No. VIII as well as the Catskill rocks; but they are all extremely limited and none of them furnish either good or continuous sections of these formations. On Penns creek, a short distance below the northern township line, the Hamilton rocks are fairly massive and are slightly quarried upon dips of from 50° to 65° S. E., some of them being flaggy in structure and furnishing a good stone for building purposes. The same series are exposed in a small branch stream $\frac{1}{2}$ a mile further west upon similar dips and presenting similar characteristics.

13. Centre Township in Snyder county.

This township lies next west of Jackson, along the Union county line. It has the Jack's mountain crest for its northern border line, 4 miles long to Penns creek and extends nearly 2 miles further along that stream to the northwestern corner of Jackson. Its eastern line is about 2 miles long bordering on Jackson and Middle Creek townships. Its southern line is 6 miles in length, running east and west, a little south of the Northumberland synclinal basin, and generally keeping along the high land between the waters of Penns creek and Middle creek. Its western line, 3 miles in length, makes a right angle with the last and extends north to the crest of Jack's mountain, giving a total area of about 18 square miles.

Centerville, located close to Penns creek in the north-

eastern portion of the township, is the only village and is not far distant from the Union county line.

The *drainage* is largely carried off through Penns creek and its small tributaries, some few small branches of Middle creek rising in the high plateau along the southern portion of the township and flowing southward through Franklin township to Middle creek, but hardly affecting the topography of Centre.

The *structure* is that of a simple synclinal, the general dip of the rocks being southward away from the Jack's mountain anticlinal into the Northumberland basin, whose axis extends east and west through the Methodist and Zion churches, generally parallel to the southern border line of the township.

The *rock series* exposed extends from the red Medina sandstone along the summit of Jack's mountain up to the Catskill red sandstone No. IX, which occupies the basin of the Northumberland synclinal for about 4 miles west of the Jackson-Middle Creek line before expiring by erosion at a point midway between the two churches just mentioned.

The *Medina rocks* No. IVb and No. IVc are first lifted to daylight along Penns creek, and rise rapidly westward in a long regular slope to form the crest and flanks of Jack's mountain. Neither of these formations is well exposed in this township, although they affect the topography distinctly.

The *lower Clinton shales* create a strip of valley land along the south flank of the mountain, back and to the north of the Ore sandstone ridge with few exposures and dipping steeply to the southeast. At Centreville this dip is fully 60° , so that the overlying *Ore sandstone* and ore-measures outcrop high upon the mountain, practically on a level with the terrace of that ridge, so that the ore beds become difficult of access and would necessitate the driving of long cross-cuts to afford any length of stopes.

The *Ore sandstone* continues to remain comparatively shaly as it shows eastward along this side of the anticlinal in Union county, and west of Centreville the ore ridge merges to a great extent into the Jack's mountain terrace.

About $1\frac{1}{2}$ miles west of the village the ore measures outcrop through lower ground away from the mountain, owing to the dip decreasing to about 40° , and they continue to form distinct low terraces westward into Adams township. Nowhere in this part of the outcrop have the *ore-beds* been developed whatever, and there is no evidence at hand to show that they are any larger or more desirable than they have been found to be east of Centreville.

The *lower Salina* or *Bloomsburg red shale* creates a parallel band of red soil running east and west through the township and best seen in the village of Centreville.

The *upper Salina No. Vc*, overlying these red rocks, make a somewhat wider belt to the south of them and contain several thin but rather impure beds of limestone; but their high dip makes the belt of valley land occupied by them quite narrow and thereby reduces the width of farming land.

The *Lower Helderburg limestones No. VI* make no well defined ridge until about 1 mile east of Centreville in Union county and crossing into Centre township, a short distance west of Kerr's saw mill, there are two small *quarries* or side cuts on Mr. Kerr's land which have been sparingly worked for local supply of lime. The dip here is about S. 15° E. 35° – 40° and about 20' of the upper part of the formation has been exposed. The quarries were in bad shape and the lime burned seemed rather dull and gray. West of the kiln some good stone had been developed along the creek; but the better beds cannot be properly quarried here by reason of the danger of undermining the public road which runs along their outcrop. The limestone measures create a low but rising hill westward, generally south or along the public road leading to Troxelville; but as there are no ravines cutting the ridge until within a short distance of the Adams township line there are but few natural advantages for quarrying in this part of the field, and the beds consequently are nowhere well exposed.

There is a small *quarry* just south of the small stream at Centreville on the east side of the road leading to Middle-

burg; but it seems only to have furnished a little building stone for village use and shows generally hard siliceous beds 15' or 20' thick on a southern dip of 40°.

A thin mantle of Oriskany shale and chert is seen along the crest and south flank of this ridge; but the formation nowhere shows any massive beds and scarcely any sandstone at all.

The southern two-thirds of the township is entirely occupied by the Devonian and Catskill ridges, which show to about the same extent as they do in Jackson township, except in the western portion, where the basin has so flattened out while rising westward as to present flatter dips as well as a more even erosion and regular topography.

The *upper Marcellus black slates* show at the bend of the Middleburg road, a mile south of Centerville, where they have been slightly quarried, presumably for road purposes. They are very much twisted and the dip is therefore obscure, but not less than 50° towards the southeast. In the next $\frac{1}{4}$ of a mile south from George Young's there are several more or less satisfactory exposures of Hamilton shales and thin sandstone on dips of 45° and 40°, decreasing as the axis of the synclinal is approached:

At *S. Bruner's*, approaching the forks of the road, the Chemung rocks show an exposure of sandstone and shale, dipping only 30°, and to the south of it the transition members between No. VIII and No. IX inclined but 20° to the southeast.

The Methodist Episcopal frame church and cemetery on the crest of the ridge, an eighth of a mile north of Franklin township line, closely marks the position of a *synclinal* axis with the Catskill No. IX rocks occupying a belt in its trough, about $\frac{1}{2}$ a mile wide, showing converging dips of 15°-20°. The precise limits of this formation are hard to determine, for the red bands are largely mixed with olive ones, weathering yellow and with layers of greenish-gray sandstone, hard to distinguish in the absence of fossils from the Chemung type of rocks.

The Centre-Franklin township line at the head of the ravine near J. Shambach's place closely limits the southern outcrop of the Catskill rocks.

From Centerville to Beavertown, through the "Ridges," there are but few exposures of value, the Devonian rocks being very shaly and their low dips create a very uniform erosion.

14. Adams Township in Snyder county.

This township lies immediately west of Centre and like it has the Jack's mountain crest for its northern line nearly 6 miles in length, now a perfectly straight line extending for nearly 4 miles along the central Oneida mountain and the balance eastward in the Medina red sandstone No. IVb. Its east and west border lines are of nearly equal length, the former, 3 miles long, being straight and the latter, about $3\frac{1}{2}$ miles long, with three or four angles. The southern line, with one obtuse angle, fairly continues the Centre township line westward, and is about 4 miles long, so that the area will approximate 12 square miles. This is a new township, created entirely out of Beaver township.

Troxelville and *Port Ann* are two small villages situated on either side of Kline ridge, which is a low limestone hill running east and west through the center of the township.

All *the drainage* is southward into Middle creek, the right hand fork of which heads up in Centre township and receives three or four small mountain branches in Adams township before it turns south to cut across the Northumberland synclinal to join the main Middle creek in Beaver township.

The *structure* here is quite similar to that of Centre township although it receives one important modification in the presence of the Swift Run synclinal, which, further west, cuts off a portion of Jack's mountain and continues westward into Mifflin county as the Beatty's Knob synclinal between the Triester and New Lancaster anticlinals of the Kishacoquillas valley. In Adams township its effect is very slight, merely causing a slight offset in the Bloomsburg red shales along the Spring township line.

The *Northumberland synclinal axis* closely follows the southern line of the township and its trough is completely filled here with Devonian rocks.

The *rock series* of the township extends from the Oneida sandstone No. IVa, making the central crest of Jack's mountain up to No. VIII. None of the three members of No. IV are any better exposed than they were further east, although Moyer's Mill run, Shrader's Mill run and Breinger run all have their source in the red Medina plateau and cut southward through the outer white Medina crest, facing the "Musser valley," a name given to the fertile belt of Clinton and Salina rocks which occupies the northern central part of Adams township.

The *Ore sandstone measures* make but a single belt in this township and create a high terrace between Moyer's run and Centre township, which should afford opportunity for working the ore beds with higher breasts than was possible further east. The dip of the measures is only 25° southward here, which, taken in connection with the ravines through the ridge, should afford a larger quantity of soft fossil ore.

Ore mines.

Between Moyer's and Shrader's gaps, about 2 miles along the outcrop, the ridge is nowhere broken by ravines, and shows only a copious outcrop of brown hematite or altered fossil ore along its summit. The *Ore sandstone* is more massive here and forms a more decided hill, so that the underlying Danville beds will generally furnish hard ore.

J. Fetterolf's mine is situated directly north of Troxelville in a small ravine and probably on the Danville ore bed.

The Bloomsburg red shales are first seen along the mountain road $\frac{1}{4}$ of a mile beyond its first bend on a 50° S. E. dip, and where this road crosses the stream the Clinton upper slates and shales have been quarried opposite N. M. Middleworth's place on a 60° S. E. dip, underneath which some little ore has been reported to exist, not now open.

Fetterolf's mine is probably $\frac{1}{2}$ mile west from here, and

was opened some 10 years ago under lease to Messrs Simpson, Specht & Gift. The bed is scarcely 15'' thick, and adheres strongly to a fine-grained gray sandstone roof, slightly calcareous which is removed partially in the gangways and breasts. The ore bed has a sandstone floor dipping conformably 25° S. E. The drift is about 40 yards long going westward from Breininger's run with three levels. The ore is soft fossil of fair quality, but too far from market to justify its operation at the present time. It is evidently in the Danville bed group, underlying the Ore sandstone which is here 25-30' thick.

The ore ridge, locally known as *Gold Hill* here, is not high and the ore-breasts cannot be over 30 or 40 yards in length.

On *Henry Hartman's property*, one mile west from Troxelville, a shaft on the Sand Vein developed a bed from 16''-18'' thick, which however contains a considerable amount of siliceous matter which seems to characterize this bed all along the Jack's mountain side of the valley.

The *upper Salina No. Vc'*, owing to their low dip in this township, creates a fertile strip between the Bloomsburg red shale and Kline's ridge.

Limestone quarries.

The *Lower Helderberg limestone* in this latter hill shows a small synclinal loop along Moyer's Mill run, which makes its outcrop somewhat irregular.

Just west of Troxelville a good exposure of the limestone shows on the west side of the Beavertown road dipping 35° S. E.; but the limestone itself is not of very good quality. On the east side of the creek in this gap a quarry is opened, exposing about 40' of medium quality stone, which is worked from time to time as required for local fertilizing use. This *quarry* is owned jointly by Messrs. W. Baum, N. Fetterolf, Jacob Nerhood and James E. Kline, who purchase $\frac{1}{4}$ acre lots here and burn jointly for private use. The stone is not well developed, but is said to furnish a very satisfactory lime and is open for a couple of hundred yards east.

John Moyer's quarry is the first opening, merely a small hole south of the new Grace Reform church.

J. D. Schrader's quarry is the next, about a mile east on the west side of the gap through the ridge and about 300 yards from the Musser valley road. It is a small opening, showing about 20' of ribbed and roughly weathered stone at the bottom, and a 10' massive bed on top, rather siliceous and not quarried, dipping S. 18° E. 35°.

The quarry has long been idle and the kiln dismantled, and the opening is largely in the bottom portion of the formation. A somewhat larger opening, probably belonging to the same party, is located 100 yards east; but no larger or better section of limestone is exposed there, and it is also abandoned.

Henry Moyer's quarry is 50 yards still further east, and faces the gap road nearly, still on the western side of the ravine. It is 80' long, east and west, and 25' wide, and in the center has been worked down on a belt of good blue stone, 20' thick, to a depth of about 40'. The southeast dip is about 40° and the cleavage or joints in the quarry incline north-west 50°. Some excellent stone near the bottom of No. VI has been recently quarried and burned here. A section shows about as follows:

Top soil and slaty limestone,	6'-10'
Bluish gray bed; massive and fair quality,	10'-12'
Soft blue beds, thin seams,	20'
Hard blue beds at base,	10'

East of the gap road the ridge is largely eroded for about 300 yards, but soon forms a broad flat hill in the local synclinal already mentioned, which doubles the width of the outcrop.

Jacob Bingamen's quarry is the first opened on this ridge, quarrying and burning lime for farm use in the neighborhood, and furnishing between 5 and 8000 bushels per year from one draw-kiln of a capacity of 180 bushels. Coal is hauled from Adamsbury on the railroad 6 miles distant, and costs delivered from \$3.50 to \$4.00 per ton, so that no very wide market for the products of this ridge could be expected.

The quarry is about 60' long, opened on the crest of the ridge, and shows about 25' of stone, dipping 15° S. E. The beds are very thin and somewhat irregular; but the stone is of excellent quality and is highly prized by tanneries and for plastering purposes.

The stone is very much exposed here on the summit, which may account for its weathered appearance and mud seams; but the quarry could be easily developed for a large and active output in lower and thicker beds on account of its position.

Isaac Krebs works the next small *quarry* at the eastern end of the loop ridge alongside the road, sparingly developed on a gentle southeast dip, but showing some good stone. The main ridge lies further south across the creek and is reached by a private lane leading south from the Musser valley road, near the crossing of Moyers' mill run.

Another *Kreb's quarry* is located near the top of this ridge, 60' long and 20' deep, showing a weathered white stone, largely shaly but with good small blue beds, all dipping 40° S. E. This opening was idle and in rather bad condition, only worked for farm use.

Near Port Ann there are one or two additional small openings.

John Moyer's quarry is the first west of the road to Middle Creek. It is a small opening and in very bad condition, but was active in 1888, and had been opened for 7 or 8 years. It shows 50' long, 15' wide, and 8' or 10' deep, and the burnt lime seems to give entire satisfaction. The dip is 10° S. E.

S. G. Bingeman has a small opening in the next field west, hardly large enough to be called a *quarry*, developing a few feet of stone near the bottom of No. VI on a dip of only 5° or 6° to the southeast. This opening was once more largely worked and is said to have furnished about forty thousand bushels of burnt lime.

The hillside to the north of it is strewn with a thin coating of brown hematite ore, which must have resulted from the erosion of the Oriskany measures now thinly capping the hill. It is very siliceous.

The *Devonian rocks* occupying the valley of the right fork of Middle creek ; are everywhere shales and create very few hills. It is doubtful whether any of the Chemung measures are exposed in this township, except, perhaps, along its eastern side south of Port Ann, where a considerable ridge marks the center of the basin showing a somewhat massive sandstone accompanied with shales with converging dips of 25° S. and 30° N.

The right fork of Middle creek flows largely through a valley of Marcellus slates from Port Ann to below Troxelville, and where it turns southward these measures are exposed on south dips of about 40°. Some Hamilton measures show further south towards Beavertown, but without prominent sandstone beds except on either side of the main valley. The central area is largely occupied by the brown and yellow Genessee slates.

15. *Penns Township in Snyder county.*

This is rather an irregularly shaped township, lying along the Susquehanna river and to the south of Jackson and Monroe.

Penns creek for 3 miles forms a portion of its eastern border line and the river continues that line for 2 miles further south above and below Selinsgrove. The Mill branch of Penns creek forms its north border dividing it from Jackson township, while Middle creek creates an irregular southern border from Kantz's mill near the Middle Creek township line to the Susquehanna river, nearly 2 miles below Selinsgrove. Its western line is a straight one 3 miles long, between Kantz's mill and the Mill branch, and its entire area will approximate 15 square miles.

Selinsgrove, the most important town in Snyder county, is likewise the chief place in Penns township, situated on the west bank of the Susquehanna river, just below the mouth of Penns creek and on the Sunbury and Lewistown railroad.

Salem, 2 miles north-west, and *Kantz*, about 2½ miles southwest on Middle creek, are two smaller villages situated in the fertile Middle Creek valley of upper Salina Ve

lime shales, which are spread over a wide area in this township on both sides of the Shade mountain or Selinsgrove anticlinal.

The *drainage* is all southward and eastward into the river through Penns creek and Middle creek, each of which drains an equal portion of the township through smaller tributaries.

The *Shade mountain* (or *Selinsgrove*) *anticlinal axis* is the most important structural feature in the township, crossing Middle creek a short distance below Kantz's mill, with the top of the lower Clinton shales on its crest; and passing eastward through Selinsgrove and sinking rapidly in that direction to carry down the ore sandstone, the lower Salina red shales and the upper Salina marls in approaching the river. From this central line all the rocks dip north and south towards the Northumberland and Shamokin synclinal basins respectively.

The *rock series* therefore extends from a little below the Ore sandstone measures of No. V upwards to a thin band of the Catskill No. IX, exposed in one or two places along the south flank of Middle branch near the Jackson township line.

At Middle creek the *Selinsgrove anticlinal* is slightly furrowed by the presence of a *synclinal dimple* along its crest, well seen in the outcrop of the Ore sandstone and the Bloomsburg red shales. The arch of the axis is very flat, showing dips of from 10°–15° each way.

The *Bloomsburg red shales* or lower Salina rocks enter from Middle Creek township on the north side of the anticlinal a short distance above Kantz's mill, and create a broad band outcropping eastward to the brick school-house, where they are exposed well on a 15°–20° dip, conforming to that of the dying anticlinal, and making a low ridge in front or north of that made by the Ore sandstone. Just south of the school-house the dip is N. N. E. and about 80' of the Bloomsburg red shale is exposed there, gradually blending southward into the Clinton olive lime shales, which weather brown and are quite massive and laminated. The dip decreases in these shales to about 10°, immediately overlying

the Ore sandstone, the latter rock being well exposed, 20' thick, and making a distinct ridge from the ravine to Mr. Koster's barn, which is built upon its outcrop. The ridge is very low, however, and there cannot be much ore above water level, though some little exploration has been made with a view to locating the Sand Vein and the Danville fossil-ore beds. The underlying Clinton fossil shales are also well exposed between Koster's and Middle creek on a 10° N. N. E. dip.

Middle creek at Kantz's mill has eroded a wide basin in these lower Clinton shales, leaving the ore sandstone ridge isolated and prominent to the east in Penn's township and skirting the north flank of a sharp but low ridge in Washington township, formed by the iron sandstone. Both the ore sandstone and the Bloomsburg red shale fold around the anticlinal axis and recross Middle creek between the village of Kantz and Kantz's mill the two opposing outcrops of the Bloomsburg shale being about 1½ miles apart.

The *upper Salina lime shales* are very largely eroded through the fertile valley they create in this township, about 2½ miles wide, flanked on either side of the axis by ridges of the Lower Helderberg limestone. These rocks everywhere outcrop at angles not exceeding 15°, so that their erosion has been very even everywhere. These are the same rocks composing the Buffalo valley of Union county, where, owing to the presence of a number of anticlinal and synclinal rolls, they have been spread through a much wider area than they occupy in Snyder county, on both sides of the Selinsgrove arch. A small tongue of these rocks crosses the river into Northumberland county, where, too, there is an excellent section of the overlying Helderberg limestone and Oriskany shales and sandstone exposed in the cuts of the Northern Central railroad.

In Report G7, p. 344, Prof. White gives a detailed section of these rocks upon both sides of the anticlinal, which may be summarized as follows:

Summary of section along Northern Central railroad, beginning 1 mile above Selinsgrove Junction; South side of anticlinal.

No. VII.	{ Oriskany, visible,	20
	{ Stormville shale,	125'
No. VI.	Lower Helderberg limestone,	343'
No. Vc'.	Salina, upper,	115'
	Total,	603'

*Summary of section along Northern Central railroad;
North side of anticlinal.*

No. VIII.	{ Hamilton and Marcellus,	805'
	{ Selinsgrove limestone,	50'
	{ Selinsgrove shales,	170'
No. VII.	{ Oriskany sandstone,	57'
	{ Stormville shale,	110'
No. VI.	Lower Helderberg limestone,	413'
No. Vc'.	Salina upper,	115'
	Total,	1720'

It will be seen from these two sections that the rocks assigned to No. VI, the Lower Helderberg limestone, vary in thickness from 343' to 413'; but only the bottom portion, from 100'–125' thick, immediately overlying the Salina, and known east of the Susquehanna river as the "Bossardville limestone," contain the massive good beds of the formation.

Limestone quarries.

S. Harmon's quarry is the first opening in these lower limestone beds west of the river, about $\frac{1}{2}$ a mile from the bridge at Shoch's mill, opened on a northwest dip of from 10°–15°.

The quarry is about 100' long, east and west and 30' wide, and shows an excellent section of the Bossardville beds from 85' to 100' thick. The exposure contains some little shaly limestone and some bands of lime shale, but shows several excellent blue beds. Nearly the same beds developed at Winfield in Union county, are developed here, and in many respects the exposures are identical, although the lowest Union county beds have evidently not been opened here as yet.

A bed of lime shale or "soapstone" as the quarrymen term it, 6' thick, divides the quarry near the center. The good beds above this band show the same rough surfaces

and irregular erosion noticed in the Winfield quarries, whilst the lower division blue beds show hard smooth faces and furnish the very best quality of commercial lime. Farm lime is mostly burned in this quarry, where there are three draw-kilns with a capacity of about 225 bushels each. The quarry is a good one, though not very well opened or very regularly worked.

A small stream creates a gap and break in the ridge west of Harman's quarry; but following around the contour of the hill west and southwest there are five additional small *quarries* within a distance of 300 yards, all of which were idle during 1888.

E. Klinger is the first of these, opened on the east side of the branch in the very top beds of the formation, about 25', shaly and impure. No work has evidently been done here for a long time, and it is probably operated solely for private use.

S. Knause has the next quarry west, opposite the last but on the west side of the stream. It is a somewhat larger opening and shows a section of about 20' of limestone, the bottom 12' of which contains some good blue beds, sparingly developed.

B. Harmon's quarry lies next southwest, opened in slightly lower beds and displays a slightly greater thickness of rocks but still above the soapstone parting. The best beds are at the bottom; but the quarry has been badly opened and does not present a very favorable appearance.

B. Klein operates the fourth quarry, which presents a badly weathered face of stone about 40' thick, all above the soapstone. The quarry is of good size, but was in a very bad condition.

C. Benfer has apparently two *quarries* further west, the eastern one of which seems to have been permanently abandoned, exposing about the same section as Klein's and in about the same condition. The more western and lower of the two quarries is in better condition than any of the neighboring openings, except S. Harman's but only 35' of a face has been uncovered in the upper rough beds from a few inches to 2' in thickness. When burned however they

make a fine fertilizing lime and can be quarried here to advantage. The dip is exceedingly gentle in all these quarries, which accounts for the breadth of outcrop on the hill, and the fact that only the upper beds, most naturally exposed, have been developed.

The Lower Helderberg rocks spread southwards on this flat dip nearly to the red bridge crossing Penns creek north of Selinsgrove. Westward as the Shade mountain axis increases in strength the outcrop of these rocks become more contracted, making a distinct ridge and a prominent feature in the topography of the township all the way to the Middle creek line, passing a little north of Salem. On the private road leading south from the group of quarries last described there are two additional small openings :

1. *Apps' quarry*, opened in the middle of the limestone formation, and, 2. *Millhoff's quarry*, opened higher on the ridge in the top of No. VI and exposing about 30' of rock on a 5° north dip.

Miller's quarry is a small opening lying just inside of Middle Creek township line, not active and having no kiln. It shows about 25' of good stone, evidently quarried for building, on a 30° north dip. Two more quarries, said to be upon Mr. Miller's property, show a short distance further east; one opposite the road leading south to the railroad, an old opening of good size; and the other a new and smaller opening, opened slightly in the steep hillside, where it will be very difficult and expensive to quarry, but where some good soft blue limestone has been removed and burnt in open ricks. The dip at both quarries amounts to about 20° and the southern limit of the limestone here will extend but little, if any, south of the Selinsgrove road.

The entire north flank of this ridge carries the remains of the Oriskany sandstone formation No. VII, mainly shale and chert, crossing Penns creek just above Shoch's mill, but nowhere well exposed in place. To the north towards Jackson township, the No. VIII rocks occupy a series of ridge and valley land about 2 miles wide on dips varying from 10° along the limestone ridge to 60° at the junction of the Catskill No. IX. A section of these rocks

along Penns creek has already been given in the description of Monroe township, and westward to the Middle creek line they are but poorly exposed for any additional description.

Going south along Penns creek from Selinsgrove the erosion of the creek and river has made a wide flat and concealed all exposures. The upper Salina rocks are first passed over and then the Lower Helderberg in Limestone ridge, a short distance below the Freeburg road, but its rocks eroded as well.

Neither the Oriskany shale or sandstone is well exposed; but the Marcellus slates are shown in a quarry opened for road purposes just south of the school house on the road leading west before reaching Middle creek. About 65' of slate with a few very thin sandstone beds are displayed here, dipping S. E. 45°.

West along this road the Marcellus rocks are sparingly exposed, and the Hamilton measures make a well defined ridge to the south in the great loop of Middle creek.

The first limestone quarry on the south dip of the anticlinal west from Penns creek in the Limestone ridge is—

Witmer, Flanders and Stael, located about 300 yards west of the creek, and close to the base of the hill, south from John Romig's house. It was idle, only being actively worked during the winter, when lime for farm use is burned there. The dip is 30° S. E., and the stone is covered with a good deal of top soil, which in a measure conceals the outcrop and prevents an examination of the character of the stone along this ridge. This is the only quarry between the river and Middle creek below Kantz.

16. *Middle Creek township in Snyder county.*

This township, lying west of Penns and south of Jackson on the north side of the Shade mountain anticlinal, is nearly square in shape, its sides being a little less than 4 miles in length, giving an area of about 15 square miles.

Kremer and *Meiser* are two flourishing villages situated on the Sunbury and Lewistown railroad in the fertile upper Salina valley which extends east and west through the

southern portion of the township, and everywhere largely cultivated.

Middle creek follows the course of this valley between the railroad and the limestone hill from the Franklin line on the west to a point north of Kremer, where it turns towards the southeast to cut across the valley and through the Ore sandstone ridge to the south. All the drainage of the township enters this stream on both sides and through it to the Susquehanna river.

The *structure* is quite similar to that of Penns township. The Shade mountain or Selinsgrove anticlinal lies a little south of the southern township line in Washington township, but its effect is to create north and northwest dips all through the township to the Jackson line, a short distance beyond which is the Northumberland synclinal axis.

The *rock section* exposed extends from the Clinton on the south to the Catskill on the north. From a point west of Middle creek, where the axis of Shade mountain crosses, there are two parallel ranges of hills which follow along the north base of the mountain all the way to and beyond Adamsburg. The outer ridge overlooking the valley of Middle creek is formed by the Ore sandstone and the inner ridge by the Iron sandstone and the lower Clinton shales, and both of them quite distinct and at some distance from the Medina crest of the main mountain.

The inner crest of these two subordinate ridges forms the southern township line to a large extent ; and as the dip on each side of the axis is still very gentle, the ore associated with it has been largely mined along the Middle Creek-Washington township line. These openings will be described together with the geology of the latter township, where the greatest development has been made.

The *lower Clinton* shales between the Iron sandstone and the Ore sandstone crop in the belt three-fourths of a mile wide along the southern township line. They weather brown and yellow and upon a low dip of about 20° they have resisted erosion fairly well and make therefore high ground.

The *Sand Vein ore-bed* has never been opened in this township, and it is doubtful whether it exists with mining thickness or of good quality. The Danville beds, underlying the Ore sandstone, have been found, but usually as a ferruginous fossiliferous limestone.

In the southeast corner of the township along Middle creek, there are a few small exposures of the Clinton rocks in ascending the stream on a dip of 20° northward. The outcrops of both the Ore sandstone and the overlying Bloomsburg red shales are concealed where they cross the creek; but the latter shows prominently in the field south of Kremer, and the latter in the gap still further south on a dip of 25° nearly due north, and from 12'-15' thick.

The *Upper Salina rocks* show several outcrops east and west of Meiser along the pike, with dips of 30° and 50° northward, and containing some thin limestone beds.

The *Lower Helderberg No. VI* makes a very distinct ridge, capped with Oriskany sandstone No. VII, through the center of this township, a short distance north of the railroad. In places its south flank is cut into by Middle creek, and for a short distance between Kremer and Yoder's store it has largely eroded the hill.

Limestone quarries.

Henry Wetzel's quarries are located in this ridge just north of Kremer on both sides of a small branch. The one back of his house shows the best exposure, consisting of about 35' of rather thinly bedded blue limestone on a dip of N. 5° W. 35°-45°. The quarry has been long idle however, and its stone is greatly weathered. Mr. Wetzel accounts for the inactivity by the greater popularity of phosphates for fertilizing purposes, which have been largely introduced into this valley to the exclusion of lime, and the detriment of that industry.

H. Aurand's quarry is opened about 100 yards further east and about 60' above the Selinsgrove road. An excellent opening has been made here, equipped with a good kiln and ready for work at any time. There is a handsome exposure of stone in all about 80' thick and containing 20'

of solid blue stone in two beds about 20' from the bottom. The bottom stone is thin bedded, as well as that above the massive beds, but produces good lime. The stone weathers curiously to rough uneven surfaces, if indeed this may not be the natural bedding; for when freshly broken in the quarry the flat surfaces between the beds are quite rough. This is characteristic of the stone in many of the quarries here as well as in Union county.

The *Fisher Estate quarry* is opposite Aurand's but a little further east on the south side of the road towards Middlecreek. It has sparingly developed some lower beds, lighter in color and more slaty, and taken in connection with the beds exposed in the Aurand quarry, there should be a series of good limestone here at least 150' thick.

The road east from his quarry towards Penns township is largely composed of chert rolled down from the crest of the ridge and largely concealing the limestone rocks which would otherwise outcrop on the south flank.

Miller's quarry is opened close to the township line on the north side of the road, and like all others hereabouts was inactive. It shows about 75' of stone, dipping 35° northward. The bottom portion consists of thin gray beds, aggregating 6'-10' in thickness, and not quarried. Above them is 15'-18' of smooth-grained blue limestone of excellent quality, and above that a 10' bed of stone, generally blue in color but not so pure as the lower bed. The top of the quarry shows thin-bedded gray and white limestone, containing many shaly beds. The quarry is not large, but is sufficiently developed to indicate what an excellent quality of stone might be obtained here and good facilities for working the same.

Going west from Wetzels on the north side of the creek, the road soon passes over the outcrop of No. VI and for a time runs along No. VII, gradually working north into the Marcellus limestone and slate on a 40° dip. The Oriskany ridge is well developed from here to the Franklin line, and while it shows no outcrop of rock in place, the whole road is laid upon boulders and pebbles of chert derived from the erosion of the crest, which is here high and well wooded.

Between Meiser station and Kremer, along the north bank of Middle creek, and nearly opposite the Keller or Stuck blacksmith shop, there is another series of *small quarries* just at creek level, which are worked from time to time for local farm use. All of them were inactive during the summer of 1888 and display a fair section of the lower part of No. VI, 25'-30' thick, containing some first-class stone. They are owned in order from west eastward as follows: 1. E. Keeler; 2. A. D. & J. Kremer; 3. M. Ginney; 4. M. Dauberman; 5. W. Fryman; 6. C. Keck.

All these quarries are very narrow and develop in the aggregate about 200' of the outcrop. A most excellent face of stone could be opened in conjunction with the beds there exposed by developing the steep hillside above them.

On the road leading north from Yoder's store toward New Berlin, starting in the *Marcellus* slate, the *Hamilton* shales and sandstone are well exposed at the first cross-road on 40° N. W. dips succeeded northward at the next private lane to the right with Portage-Chemung rocks on a 50° dip; but neither exposure shows any very great thickness of these measures. Taking the right hand road at J. Bolig's, Chemung rocks, largely shale, prevail to the summit of the ridge made by the Chemung-Catskill transition series with the red rocks of No. IX first showing on the north side of the summit on a dip of N. 10° W. 40°. The dip slackens to 30° at Neiman's lane, where some olive and green bands occur with the red; and down Tuscarora creek the Catskill red shales can be seen to and beyond the Jackson township line.

A section along the eastern portion of the township shows similar characteristics. The Catskill red shale and sandstone extend about $\frac{1}{2}$ a mile south of the Lutheran brick church into this township, without exposures; and there are no outcrops of the No. VIII rocks until in descending the ravine below H. Benfer's house, there is a good exposure of the Genessee shales and slates, gray in color and weathering yellow on dips of 55°-60° north, the outcrop extending south to the forks of the road. The Hamilton

shales and sandstone show further south in a good exposure below Mrs. Aurand's, still dipping 60° northwards; and still further south there is another good exposure of brown slate and sandstone on a 45° dip. The Marcellus slates come in between this and the Oriskany sandstone ridge, but are not exposed.

17. Franklin township in Snyder county.

This township is nearly a parallelogram with an average length east and west of 6 miles and a width north and south of 4 miles, approximating 24 square miles in area. Its north line, in common with Centre township, is straight, keeping along the south edge of the high ridge marking the Northumberland synclinal basin, while its south line extends for 5 miles along the red and white Medina crest of Shade mountain, where it is offset to the northeast for about 2 miles to the crest of the Iron sandstone ridge, forming a mutual line of Middle creek and Washington townships.

Middleburg, the county seat of Snyder county, is beautifully situated on the north bank of Middle creek, along the base of the Lower Helderberg limestone ridge; and *Paxtonville*, formerly the scene of much activity during the life of Beaver Furnace, is about 2 miles west and on the south side of the railroad and valley.

Middle creek flows eastward through the center of the township and drains its entire area by means of small tributary streams rising in Shade mountain on the south and in the high Catskill ridge to the north.

The *structure* of the township is monoclinical, all the rocks dipping northward away from the Shade mountain anticlinal and towards the Northumberland synclinal, whose axial line lies just north of and parallel with the northern township line.

The *rock series* extends from the red Medina plateau of Shade mountain up to the top of No. VIII, a small strip of the Catskill rocks occupying the northeastern corner of the township.

The *Medina rocks* Nos. *IVb* and *IVc* are nowhere well

exposed, for no streams cut through the high mountain wall so as to expose them; and the lower Clinton rocks, embracing the Iron sandstone series, occupy an area along the southern side of the township a mile wide and extending east and west for 6 miles.

The *Iron sandstone* ridge, capped with *block ore*, forms a prominent hill, broken by some few ravines south of Middleburg. This rock occurs geologically about 150' beneath the Ore sandstone, which forms a similar ridge lying further north. Portions of the Iron sandstone in some localities are quite rich in iron, the whole series varying between 10' and 15' in thickness. About a mile southeast of Paxtonville, on property of the Bloomsburg Iron Company, there is an old open cut on the crest of the ridge, where the block ore, some 8' or 10' thick, was formerly mined for the Beaver furnace. About 4' or 5' at the bottom of the bed is fairly rich in iron, though siliceous; but when worked, nearly 10' of material was blasted out here and sent to the furnace, which could not have proved but disappointing and highly siliceous. The open cut is about 250' long and the bed shows a dip of 45°-50° N. W. The floor is sandstone, rather bulgy and irregular. The best ore was a hard dense reddish material, yielding about 35 per cent. of iron and capped with seams of slate and ferruginous sandstone, carrying blocks of ore from 2" to 6" thick, much of which was mined and shipped with the better 4' at the bottom and smelted both at the Beaver furnace and at Bloomsburg.

The *Danville fossil ore bed* was opened on the north flank of this ridge, at its eastern end; but it was lean also and only 6" thick. Further north the Sand Vein is reported to have been opened in a monkey drift and found 2' thick, carrying two layers of slate and furnishing a lean ore.

Between the *Block ore* ridge and the Ore sandstone there is a small synclinal, showing at Paxtonville a north dip of 45° and occupied by Clinton shales, whose dip flattens going westward and permits the ore measures to remain in the synclinal.

At *Bobb's run* the block ore shows at water level in a

double bed, 3' below and 8" above, separated by 15" of shale and very lean in iron.

The *Sand Vein ore bed* has not been worked east of Middleburg, though its outcrop shows along the ridge as a thin and lean bed. West of Middleburg, towards Paxtonville, the ridge becomes more prominent, but the several openings made upon the ore bed were all immediately abandoned on account of the small thickness of the bed.

The *Danville beds* have proved of slight importance here as well. They increase in size somewhat west of Paxtonville, but have never yielded much ore in this township; and the *Bird's Eye fossil ore bed*, the lowest stratum of the series, which has been so largely worked in the past on the crest of the Shade mountain anticlinal further east, has never been developed on the steeper dips in this township, although there is little doubt of its presence here as well.

The *Bloomsburg red shale*, or lower Salina Vc, is well exposed at the first road west of Meiser near the eastern Franklin line. The dip is about 30° northwards and the beds show some cleavage. West to a point south of Middleburg the red shale belt is not very distinct, though hugging the valley road pretty closely until within $\frac{1}{2}$ a mile of Middleburg, when it gets to the south and is replaced by the upper Salina lime shale. These latter rocks make quite a ridge west of Middleburg and north of the railroad.

The *Lower Helderberg limestone ridge* is not very prominent west of Middleburg until after passing the first gap, about $\frac{1}{2}$ a mile west of the county seat, and there are no quarries in this part of the range. A shaly limestone outcrops in this gap on a 40° N. W. dip and not far beneath No. VII. Between this gap and the next, a distance of one mile, the limestone is pretty well concealed by the chert of No. VII, occasional outcrops on the road, showing 40° north dips.

Limestone quarries.

John Hassenger's quarry on the eastern side of this gap, shows a dip of N. 12° W. 50°, and has exposed about 60' of

limestone, in which the good beds are interleaved with inferior ones as follows:

Gray blue stone, weathering rough,	8'
Siliceous white stone; cavernous,	4'
Good blue beds, smooth grained,	8'
Thin bedded blue stone, weathering rough but pure,	12'
Hard blue limestone bed; good quality,	6'
Thin blue beds, hard and siliceous,	6'
Massive blue bed, sparingly opened,	12'
Bluish-gray bed, not well exposed,	4'

The *Lutheran church quarry* on the west side of the ravine shows the same beds, but not so largely developed. Both furnish good lime for country use and both carry a considerable thickness of sandy lime shales on top, quarried slightly for road purposes, and showing lime shales and thin limestone beds, from 50'-60' thick. There is an interval between these lime shales and the quarries with a vertical thickness of about 100' which may contain good limestone beds. Just before entering Beaver township the ridge shows a long sloping terrace to the south of a backbone of No. VII chert, exposing an outcrop of shaly limestone from 60'-80' thick on a 25° north dip. This gentle dip of course spreads the outcrop; but the No. VI formation does not seem to be very massive here.

Smith's quarry is located within the borough limits of Middleburg on the west side of the Centerville road. The rock exposure consists of the upper 30' of No. VI dipping N. 10° W. 40°-50°. The "soapstone" band is visible here; but the good beds beneath it are largely covered up with *débris* and have not been actively worked. The quarry is about 60' long; but when seen in August, 1888, was in a frightful condition, the stone having been quarried here and there, without rhyme or reason, and producing a very rough and unattractive appearance in the exposed faces.

East from Middleburg along the road, the limestone outcrops frequently on a 40° north dip, the road gradually ascending the hill and passing over higher limestone beds.

J. Walter has opened a small quarry $\frac{1}{2}$ a mile from the county seat and close to the north side of the public road, and exposing about 30' of the upper rough beds of the massive portion of the Lower Helderberg formation.

Phillip Spade has the next quarry, 100 yards east, working the same beds close to the roadside. The quarry has one kiln.

Kersteller & Bower and *N. Walter* have kilns adjoining the last party and work practically the same beds on a 40°-50° dip.

Peter Frain has the next kiln, 25 yards along the road, and *Hartman & Beachel* have a small quarry adjoining him on the east. About 10 yards further along the road *Weirich & Ocker* own an abandoned kiln. The last three quarries are practically one opening, each party owning about 50' along the outcrop.

J. Arnold lies next east, and there are six additional openings of the same character in the next 200 yards, all exposing about the same beds and worked from time to time for local farm use. These are: 1. Walter Stuck. 2. W. Bailey. 3. J. Shambach. 4. E. Hummel. 5. Musser & Brunner. 6. J. Mitchel.

Hare, Swineford & Erde own *quarries* west of Walters, but have no kilns, and their openings look more like side cuts for the passage of the road than like limestone quarries. The entire series of quarries is comprised within a thousand feet of outcrop and much better stone could be obtained by opening between the road and the creek, if facilities existed for getting the product to market. The ridge is cut off on the east by a small stream entering at the mill, and the Lower Helderberg limestone outcrop is largely concealed there by the detritus derived from the broken down Oriskany sandstone ridge.

West of Paxtonville and in the center of upper Salina valley of Middle creek, a short distance north of the railroad, there is a synclinal ridge of Lower Helderberg limestone, and about 1½ miles long, partly in Franklin and partly in Beaver township; and between it and the main limestone ridge to the north there is a flat anticlinal of the Salina rocks near Grimm's mill. Another small synclinal knob of limestone lies wholly in Beaver township to the southwest of the longer hill and south of the railroad, a little over ½ a mile in length in which there are no quarries.

In the larger hill, known locally as Benfer's ridge, there are four small quarries; two on either side of the public road crossing the ridge and two lying further east towards Middle creek.

1. *Shoch's quarry* is a small abandoned opening where no work has been done for years. It is situated on the east side of the road, on the backbone of the ridge, and exhibits a section of about 20' of limestone on a 5° N. W. dip, all of it of good quality except the upper 5', and advantageously located for development.

2. *Benfer's quarry* and kiln is immediately opposite Shoch's on the west side of the road; 60' long and 30' high, exposing about 30' of flat dipping limestone right in the trough of the synclinal which is well developed in the west end of the quarry. There are two principal beds, 8' and 4' thick, separated by one foot of shale; but the larger 8' bed on top shows a somewhat vertical cleavage and breaks out in irregular blocks. Above it are 10'–15' of smaller beds and some shale. A great deal of excellent farm lime is burned here to the extent of about 800 bushels a year, all of which is used locally on Mr. Benfer's property.

3. *Gill's quarry* is a side hill cut on the east side of the road near the south base of the ridge and about 150' in length. The dip here is fully 40° to the northwest, although but a short distance from the two before mentioned quarries, and is developed in lower beds. About 40' of gray and somewhat discolored limestone is exposed here, generally in thin and somewhat shaly beds.

4. *Smith's quarry* is the last opening near the eastern end of the ridge, developing only a few feet of stone in the center of the synclinal on the summit of the hill.

The Devonian rocks No. VIII, which occupy a strip along the north side of the township, 6 miles long and one mile wide, are nowhere well exposed. Perhaps the best section of them can be seen along the ravine descending from the Catskill ridge at the M. E. church to Middle creek at Middleburg. The top layers of the Chemung formation are exposed on a 20° north dip just at the

Centre township line, extend for about 300 yards down the ravine largely sandstone, with some beds of shale holding pebbles and boulder-shaped rocks; in places as large as cocoanuts. At the southern end of the exposure the dip has increased to 30°, to the south of which the Genesee slates show on a 50° dip and finally the Hamilton slates and sandstone at Buffington's and Shambach's where the dip has increased to 60°. These same rocks show in detached exposures along roads ascending the ridge further west, where they preserve about the same characteristics.

18. *Beaver township in Snyder county.*

This township comprises an area of about 15 square miles, lying immediately west of Franklin and north of Shade mountain. Formerly its area was much larger, Adams and a part of Spring townships having been erected a few years ago. These two townships adjoin it on the north and west respectively.

Beavertown is the only village within its borders, situated in the upper Salina valley on the Sunbury and Lewistown railroad about 2 miles east of Adamsburg.

Middle creek is still the only stream draining this part of the county, entering this township from Spring in the Marcellus slate valley in the northwestern corner and cutting its way southeastward through the limestone ridge and into the upper Salina valley along the Franklin township line. It drains the north flank of Shade mountain through several important tributaries, the chief of which are *Shipton* and *Mill* runs, the latter passing through Beavertown and making a second gap in the limestone ridge.

The *structure* of the township, while normally monoclinal and showing northwest dips away from the Shade mountain anticlinal, is modified by several local synclinal rolls, which duplicate the outcrops of the rocks in which they occur. The first of these is a long narrow *basin* in the Clinton measures between the main ore ridge and the Medina white sandstone, which has preserved in a high ridge south of Beavertown a small circular knob of the Ore sandstone and accompanying fossil ore beds.

Another *double synclinal* roll separated by a small anticlinal occurs along the Franklin township line, deep enough to contain small areas of the Lower Helderberg limestone as already mentioned in the description of Franklin township; while a third synclinal, possibly coincident with that of Benfer ridge, creates a loop and a high knob in the limestone ridge northeast of Beavertown, high enough to preserve on its summit a strip of the Oriskany sandstone nearly $\frac{1}{2}$ a mile in length, between which and the main Oriskany ridge further north there is a narrow anticlinal which can be traced from Grimm's mill on the Franklin township line to and beyond a gap of Mill branch north of Beavertown.

The *rock series* contained in this township extends from the Oneida sandstone and conglomerate, here elevated in a high central ridge of Shade mountain, to a strip of Marcellus and Hamilton slates nearly a mile wide along the northern side of the township.

The *Oneida* and *Medina* rocks of No. IV show no good exposures, for none of the mountain streams are sufficiently long or strong enough to cut into these hard mountain rocks; but the flat dip of the rocks in this part of the range, not averaging over 30° , has created a distinctly double ridge of Oneida No. IVa, and Medina No. IVc, $\frac{1}{2}$ a mile apart and separated by an elevated valley of Medina red sandstone and shale, IVb.

The *Clinton rocks* occupy the north flank of the outer Medina ridge and spread through a belt of country nearly a mile wide, at the northern end of which the Ore sandstone ridge makes a prominent break in the topography.

At Shipton run, which cuts through this ridge a mile west of the Franklin line, the *Sand Vein* ore bed is small and the hill low, affording very little breast; but south of Beavertown, and for some distance east and west of that point this ore-bed contains from 20''–26'' of good soft fossil ore, which has been opened in fifty places by small cross cuts driven through the overlying shales which dip about 20° towards the northwest.

In the ravine however, the Sand Vein is largely a hard

fossil and throughout its range contains a smaller percentage of iron and ore lime than it does in the basin between the ridge and the mountain.

Ore mines.

J. F. Middlesworth's property has a small opening close to the Spring township line. The first drift east in Beaver township on N. Spaecht's property followed the Sand Vein 300 yards to the Middlesworth line and produced mostly soft fossil ore, the bed averaging 2' in thickness. This opening, in common with all the other drifts in Beaver township, has been abandoned for some time and the ore largely removed. The bed is reported to have been almost clean at this point without "Jack" or slate. The Ore sandstone is seen at the drift mouth perhaps 20' thick; but still rather shaly. All the soft ore has been mined here down to water level and future developments will have to be made by small shafts in the valley to the north where hard ore will probably be obtained unless the low dip of the measures and the soft nature of the overlying shale have combined to produce a fairly soft ore beneath water level. A small drift in the Danville beds underneath the Ore sandstone was not successful, the bed being very thin and lean.

On the east side of Mill run several cross cuts were driven on *Mr. Yerger's* land by Dr. Conrad and perhaps 30-40 yards of breast above water level has removed most of the ore at this point and as far east as Spaecht's second drift. The slope of the hill is very gentle here and it would seem natural to expect a considerable body of soft ore beneath water level on this property.

M. Spaecht's or *Hedrick's* farm to the east of Yerger's, has been worked out to about the same level for $\frac{1}{4}$ of a mile along the outcrop; but there should be good ore found further north and lower on the slope of the ridge. This farm is now owned by Messrs. Snyder & Bowersox.

Immediately south from here, about $\frac{1}{2}$ mile back of the Ore ridge and between branches of Mill run, *Messrs. F. Middlesworth* and *C. Hoofnagle* have mined ore on leases held by the Bloomsburg Iron Company on property of Mr. Arp, formerly the Torman farm.

A drift has been driven east here at the western end of a high spur contained within the local synclinal basin already described and evidently holding a small area of the Ore sandstone and Sand Vein fossil ore bed. It is presumably this latter bed which has been developed, although the openings were entirely closed and there were only boulders of the Ore sandstone to establish the probability of this presumption. The Bloomsburg Company only control the west end of this little basin in Beaver township, joined on the east by N. Speacht who has 60 or 70 acres and was driving a new drift on the south side of the basin, which was stopped just after touching the ore. The dip is about 30° N. W.

Other small test shafts and drifts are located further east, all developing a soft ore near the surface, but all filled with water. The ore-bed evidently lies flat through the larger part of the basin rising on steeper angles around the rim and may be contained within an area 500 yards long and from 50-75 yards wide.

The general testimony of those who have worked here assigns a thickness of from 16"-20" to the Sand Vein fossil ore bed.

Dr. Rook formerly operated an old drift, located further east and about 100' below the top of the hill, evidently in one of the Danville beds; and near by Mr. Speacht has developed the same bed in a new shaft, 20' deep, which was likewise filled with water. The ore-bed is said to show about 18", with 6" of block ore in the center.

Messrs. Middleworth & Hoofnagle have likewise opened this bed near here, and have mined a considerable quantity of ore from it; but the bed is somewhat thinner. This lower Danville bed should be found on the east side of Mill run where the ridge in this synclinal trough is high enough to contain it; but it is doubtful whether the upper Sand Vein bed exists.

Returning to the main ore ridge to the north, several additional openings were visited between Mill run and Ship-ton run.

The *Conrad drift*, on property formerly owned by Mr.

Stuck and now owned by Mr. Fees, the Sand Vein was opened and showed about the same character as it did further west. East from here there are openings on properties of J. M. Smith, J. G. Snyder, R. Aigler, A. Aigler and finally on the Shipton farm, now owned by Jonathan Haines, where the ore-bed has deteriorated so much as to become practically worthless. In all these properties the Sand Vein was found from 18''-20'' thick. In this vicinity, however, the Danville bed, or "brown fossil" becomes better and has been opened in many drifts for the old Beaver Furnace. It is found from 5''-18'' thick and was mined near the outcrop first by the Paxton Furnace Company and afterwards by Messrs. Rook, Francis & Nutting. It occurs on the north side of the Ore ridge, which in the neighborhood of Aigler's run is made up largely of the shales underlying the Ore sandstone. The dip is quite severe, amounting in places to 40°, and as the slope of the ridge is very gentle it would require very long drifts to reach this ore-bed by cross-cuts, and when reached it would be almost too thin to mine cheaply.

Mr. Boyer has a drift back of Paxtonville in this Danville bed, which developed 11'' of ore with a small parting, and near the house of Mr. Arnest, further west, the bed is from 7''-9'' thick. Both these latter places are in Franklin township and west of the latter the small synclinal basin develops, carrying the ore over a saddle beyond which it is developed as already described.

The *Block-ore bed*, overlying the Iron sandstone, is exposed on the north slope of the ridge in one or two places in the southeastern portion of Beaver township; but it is nowhere rich enough in iron to be of any value.

The *Bird-eye fossil ore bed* has not been opened in any portion of the range west of Paxtonville, although it has never been very diligently sought for in the presence of thicker and more accessible beds lying further north.

In Report F, pp. 26 *et. seq.*, there will be found a considerable amount of additional detailed information concerning the different ore beds opened in this and adjoining townships prior to 1874, and as the region was very much more

actively worked at that time the opportunity for an investigation was much superior.

The *upper Salina rocks* have a considerable breadth in this township, outcropping between a low ridge of the lower Salina or Bloomsburg red shale on the south, and the Lower Helderberg limestone ridge on the north. A small anticlinal issuing between the two limestone knobs along the Franklin township line reaches the main valley road near the school house 2 miles east of Beavertown, carrying the upper Salina lime shales on its crest, which here show several good but thin beds of limestone dipping about 20° each way. This axis extends west to a little north of Beavertown, where some thin red beds are mixed with the gray limy ones and dip southwards at angles of 60°. A short distance west, however, after crossing Mill creek, the axis dies away rapidly before reaching the Spring township line.

The *Lower Helderberg limestone* is not well exposed between Middle creek and the Franklin township line, although it makes quite a distinct ridge and the few outcrops seen dip northwards at angles of about 25°. A small quarry shows on the east side of the ravine close to the Franklin line, probably on property of I. Klose. The section exposed, however, is thin and the stone poor. Further north the Oriskany sandstone No. VII is exposed on a similar dip about 30' to 35' thick, the stream falling over it as it descends towards Middle creek.

G. Dreese, Jr., has opened a small quarry on the east side of the public road leading to Port Ann, just south of the bridge over Middle creek. About 25' or 30' of stone is exposed here on a 30° N. W. dip, sparingly developed as yet.

G. Dreese, Sr., has a larger opening higher in the ridge immediately west of the last, the opening running up to the backbone of the ridge for perhaps 40' in elevation and 125' long. The dip is N. 10° W. 50° in a rock section about 40' thick, mostly in the upper part of No. VI. The quarry was ruinously opened and all the stone developed shows want of experience and good judgment in the opening made.

The beds occur largely in thin seams from a few inches to one foot thick, and weathers into rough irregular masses. It is of good quality, however, and if properly opened at the eastern base of the ridge in the ravine a very excellent and economical quarry could be developed here.

Wagner's quarry joins Dreese immediately on the west, so closely as to make them practically one opening. It is not developed so deeply, but by nearly the same method and in the same measures. About 60' down the south slope of the hill nearly 40' of lower beds are exposed, somewhat shaly and showing the presence of the "soapstone division" mentioned in the openings further east towards the Susquehanna, so that the lower Bossardville beds of No. VI maintain their thickness of 100' to 125' in this part of the field. Few openings have been made in the high synclinal knob to the west of the Wagner quarry, where the dips must be rather severe and there are few natural advantages for opening.

D. Bauch has a small quarry about 100 yards east of the road between Beavertown and Troxelville, and about half way up the south flank of the ridge. Going north through the gap of Mill run the limestone ridge is seen to be doubled, being divided into two separate ridges opposite the bridge over the stream. Down the creek the side hill has been quarried for gravel for road purposes and shows slate, limestone and loose chert with an average dip of about 60° S. E. in the north leg of the synclinal. This dip is quickly reversed, for just before reaching the forks of the run the Oriskany flinty sandstone outcrops on a 30° N. W. dip. There are no additional openings west to the Spring township line except perhaps to make mention of a small hole on the west side of Mill run, where some few feet of limestone are exposed, dipping 30° N. W. There is not in the whole township a single good quarry and but little first-class stone has been developed in any of the small openings visited, despite the fact that the ridge is everywhere close to the railroad, and is twice completely gapped by Middle creek and Mill run, in which gaps excellent quarries could be opened.

The *Marcellus and Hamilton measures outcrop* along the Franklin township line, the first exposure showing a streak of Marcellus limestone, only a few inches of impure greenish-gray rock, immediately overlaid by black slate; dip N. 15° W. 30. The Hamilton slate and thin sandstone follow further north, creating as usual a sharp ridge and showing frequent exposures on a 30° N. W. dip.

On the next road west the Chemung rocks, largely a gray and bluish sandy slate, are exposed close to the Adams township line, above J. Moyer's house, on a dip of N. 15°-20° W. 25°. Dark gray and black slates follow southwards on the same dip to the forks of the road at M. Gerheart's, frequently exposed and probably representing the Genessee measures. The low and sharp ridges intervene between this point and Middle creek, evidently composed of the Hamilton measures although there are no good exposures.

Further west, Middle creek flows largely through a Marcellus and Hamilton slate valley, the entire width of No. VIII in this portion of the field not being over two miles and the higher Chemung beds, largely eroded, along the line of the Northumberland synclinal.

19. Spring township in Snyder county.

This is also a new township, erected out of parts of Beaver and West Beaver, and extending north and south for about 7 miles between the crests of Jack's and Shade mountains, and about 4 miles wide along the Middle Creek valley, with an area of about 24 square miles. Adams and Beaver townships lie to the east of it and West Beaver to the west, while the two mountain crests confine it north and south.

Adamsburg is the only place of prominence within the township, an active growing town, situated on the Sunbury and Lewistown railroad, about 2 miles west of Beavertown, and a place nearly as large in population as the county seat.

Middle creek forks in this township into a number of branches which together collect all the drainage from both mountains and the valley to the west and carry it eastward to the river below Selinsgrove. *Swift run* is its most im-

portant tributary on the north, while a smaller branch issues from the interior slate valley of Shade mountain on the south, gapping both the Oneida and Medina crests, and creating an avenue for the only passable road leading from this portion of Snyder county over into Juniata.

The *structural features* of this township are to a large extent a western prolongation of those described in Beaver and Adams townships. The Shade mountain anticlinal has become so strong here as to shove apart the interior Oneida mountain to carry a narrow slate valley on its crest in West Perry township, from which line the Oneida and Medina rocks dip northwards towards the Northumberland synclinal. This dip, however, is interrupted temporarily by a subordinate basin south of Adamsburg between the Ore ridge and white Medina crest; which here, as in Beaver township, is sufficiently deep to carry the Ore sandstone and Sand Vein within its borders for a distance east and west of about 2,100 yards. In this part of the ore field therefore, there are three distinct outcrops of the Sand Vein ore and the underlying Danville beds.

Jack's mountain on the north is an anticlinal like Shade mountain although its Oneida ridge has not been parted in this township to receive the Hudson river slate. Its rocks dip southward from the Union county line into the Swift run synclinal of lower Clinton rocks south of which they are again elevated in an anticlinal ridge terminating eastward at the High Top.

The *Marcellus, Hamilton and Genesee* slates occupy the floor of the Northumberland synclinal in a belt a little over 2 miles wide through the center of the township, flanked upon either side with the Oriskany and Lower Helderberg rocks, forming distinct ridges. The rock series therefore embraces everything between the bottom of No. IV and the Chemung division of No. VIII.

The *subordinate anticlinal* ridge to the south of Jack's mountain ending in High Top rises rapidly to the west, so that along the West Beaver line the central Oneida keel is brought to daylight and it in turn is thrust apart to admit the No. III slates at the head of the New Lancaster valley along the Mifflin county line.

The north dip of this axis continues into the county to the Beatty's Knob synclinal at the eastern end of the Kishacoquillas valley, while the south dip forms the long straight monoclinical mountain extending west to Reed's gap and the Juniata river at Mt. Union.

In Spring township the Ore sandstone makes a small synclinal loop just northeast of High Top, but does not extend further up the Swift run valley, curving southward around the crest of the anticlinal and thence westward, forming a low ridge along the south base of the mountain cut by several ravines. The Ore sandstone in this ridge is from 15'-18' thick, generally massive and dips southward about 25°. The Sand Vein ore bed outcrops all along the flank of this ridge; but it is much more siliceous than it is along the north side of Shade mountain, and is moreover quite inaccessible. The developments, however, are exceedingly meager.

John Moyer had the Danville ore beds formerly opened on his property about 2 miles west of Troxelville and on Stony run. On the east side of the ravine the upper Danville bed was found from 16"-18" thick, soft ore when first opened but changing within 20 yards from the outcrop to hard fossil. On the west side of the ravine, about 30 yards of gangway were driven and according to report upon the lowest of the Danville beds, found to contain 8" of soft ore on top and 4" of Jack, here a lean siliceous band, on the bottom. The Ore sandstone here is massive and about 30' thick, and where it covers the Danville ore beds they will most likely furnish only hard ore.

On the south side of Spring township the sequence and character of the Salina, Clinton and Medina rocks are very well seen along the road from Adamsburg over Shade mountain to McAlisterville. The upper Salina lime shales make the valley of Beaver creek, through which the railroad is located; and the lower Salina Bloomsburg red shale makes a distinct band and a low ridge everywhere readily discernable by its deep red color and peculiar cleavage. These rocks are very well exposed near the saw-mill on dips of from 30°-40° N. W. The upper Clinton rocks, largely

calcareous, succeed to the south and then the Ore sandstone, which makes a long sloping hill, rising to the summit 400' above Adamsburg. Loose pieces of siliceous fossil ore are scattered over the surface to about 100' below the summit.

Brown shales and the block ore and Iron sandstone make a summit still further south and perhaps 50' higher than the Ore ridge terrace; but with a deep valley between it and the main mountain watered by a small branch of Beaver creek. All this ridge is cultivated on the summit and north flank and from it looking east the dome-shaped knob of the ore synclinal back of Adamsburg can be well seen.

The gap in the Medina ridge to the south is opened by a water course in which the erosion of No. IV rocks has been enormous, vast quantities of sharp white sandstone boulders covering both flanks of the mountain facing the ravine and largely concealing all outcrops of this rock in place. The Medina red sandstone and slate IVb is likewise largely concealed by this erosion, and the summit of the interior Oneida ridge can only be well located by the break in the topography upon entering the slate valley, although many large boulders show the conglomeritic nature of its layers.

The *Adamsburg ore range* is commercially dependent upon the Sand Vein, and this bed was the only one being worked during 1888, and the only one from which any large quantity of ore could be mined at a profit at the present price of raw material. Even the commercial area of this bed is somewhat limited, for it has never been found of much account west of the mountain road and its outcrop south of Adamsburg in the main ore ridge has been largely worked out down to water level.

The ore basin is about 2100 yards long east and west, tapering at the west end to about 25 yards wide; still wider in the center and at the east end about 30 yards. The south dip on the north side of the synclinal is very steep, in fact it becomes in places vertical and even overturned; but the north dip on the south side of the synclinal is very gentle from 10°-20°. In addition to this dip towards the centre line a section along the synclinal in an east and west direction would show a slight eastern rise

from the western outcrop for about 250 yards, crossing a small knuckle there and then dipping eastward, of course at a very gentle angle, for about 1800 yards, where it rises sharply again for the last 50 yards to its eastern outcrop. The structure of the basin, therefore, is by no means symmetrical, the axial line showing two rolls and passing much closer to the north outcrop than to the south.

The *Shauberville opening* (Messrs. Bucher, Rook & Swengle) is the first drift at the west end of the basin and all the ore mined from this point has been hitherto sent to the Union Furnace at Winfield. The gangway was driven eastward and keeping everywhere on the Sand Vein ore-bed it developed the structure already described for about 550 yards from the western outcrop. The vein shows entirely soft ore here about 28'' thick, with a small band of Jack showing in portions of the mine near the middle of the bed and varying from 0'' to 8'' in thickness. All the ore mined is conveyed by a tramway 2 miles long to the ore shutes at Adamsburg. Three samples of this ore sent in car lots for trial to the Logan Furnace in Mifflin county, yielded from 32½ to 40 per cent. of metallic iron and from 24 to 35 per cent. of silica; but with proper care in mining there is no reason why this ore should not furnish at least 45 per cent., though this is not possible if the Jack is included in the shipments.

The north rim of the basin from this opening to Dr. Smith's mine shows everywhere a vertical dip, in places overturned at the outcrop and folded back so as to show a north dip parallel, or nearly so, with that of the same vein outcropping in the main ore ridge. A small fault may have developed between the two opposing outcrops on either side of the Ore ridge, which is made further probable by the fact that all along the north side of the basin, there is an overlap of the ore-bed, which, as far as developed, thins out on its outcrop to about 18''. Moreover the same brush takes place on the north dip, the hade of the fault dipping about 40° N. W. The vertical portion of the middle outcrop is largely twisted, and in the lower workings of Dr. Smith's mine the rooms have developed perfectly

the almost right angled bend in the ore-bed, changing it from a flat to a vertical one and without break. There is very little appearance of the Ore sandstone throughout the little synclinal basin, although it is reported as underlying the ore in the mine.

Dr. A. M. Smith's slope is sunk on the north outcrop of the Sand Vein, or rather the slope passes through the vertical part of the bed; through the overlying slates, and strikes the bed again where its dip has been reversed in the basin. The breasts in this mine are 21' apart and are driven in from the gangway 4'x12' and then widened out to 21'. The gangways are 6' wide at the bottom, 3' wide on top and 7' high. The breasts are driven up on the rise of the bed for about 35 yards, the miner taking out the ore from one side going up and the other returning, thus leaving along the main gangway pillars 21'x12' for support. The average output per month in 1888 was about 500 tons, although between September 1st, 1887 and September 1st, 1888, between 10,000 and 12,000 tons had been mined.

The mine was opened in July, 1887, and the first shipments made in September, and it was the only really active mine in the whole of Union and Snyder counties during the season of 1888.

Gangways have been run on the north and south sides of the basin for some distance westward, keeping in the central flat portion of the trough and veering towards one another, leaving a wedge-shaped mass of ore between for future development. All the water drains through these gangways eastward to the shaft where it is lifted 50' to the surface.

The ore averages about 50 per cent. of metallic iron and while it may not maintain such excellence, the conditions are all favorable for obtaining a large amount of excellent soft fossil ore at comparatively light expense and of sufficient purity to be readily marketed throughout the district.

The *Bloomsburg Iron Company* own the leases on these lands, Dr. Smith sub-leasing from them.

The Sand Vein has been opened in several places and drifts along its main outcrop to the north, where it is usually

found to be more lean and to furnish a larger percentage of hard fossil ore.

Dr. Smith has a new drift close to the Beaver line upon one of the Bloomsburg Iron Company leases, which cross-cuts the overlying shales for 137 yards and which would furnish about 30 yards of breast, the bed dipping about 30°, N. W. here. The upper 12 yards however, at the outcrop, had been formerly pretty thoroughly removed. It was expected that this drift would furnish about 400 tons per month, although the ore to be taken from it will not find as ready a sale as that from the basin further south.

There are several additional openings along this range between Smith's and the tramroad leading south from Adamsburg. The bed will furnish from 25'' to 30'' or 35 per cent. ore.

The regular north outcrop of the Sand Vein facing the valley has been formerly worked in a number of places in this township between the Beaver and the West Beaver township line.

J. F. Middlesworth's property was actively worked up to June, 1875, opened by Dr. J. B. Conrad east of Dr. Smith's mine on the same outcrop and close to, if not in, Beaver township.

The bed was opened by a cross-cut through the overlying Clinton shales, 60' long, on a dip of 30° N. W. The ore was largely a medium soft fossil, 26'' thick, carrying a central band of Jack 6'' thick, yielding from 16 to 20 per cent. of metallic iron. The bottom bench of this ore, 10'' thick, was of excellent quality, yielding, by analysis, over 50 per cent. of iron, .337 of phosphorus and only a little over 8 per cent. of insoluble residue; but the upper bench was much leaner and it is doubtful whether the average of the ore regularly mined furnished more than 40 per cent. of metallic iron.

Messrs. Swengle & Dunning worked the same bed in 1875 on property of Robert & Michael Dreese about $\frac{1}{2}$ a mile south of Adamsburg, taking out the outcrop for about 150 yards. A slope was afterwards driven at right angles to the dip of the bed through the overlying shales, cutting

the vein about 22" thick on a 35° north dip. This opening yielded ore analyzing 48 per cent. of metallic iron, .326 per cent. of phosphorus and 15 per cent. of insoluble residue. The Danville beds were also opened here, but found very thin.

The *Reuben Dreese* property was opened about the same time and mined by the same parties by a tunnel a short distance further west and about a mile southwest of Adamsburg, close to the point where the tramway branches to enter the ore synclinal to the south. The Ore sandstone is well seen here 22' thick, and the Sand Vein averaged about 20" in thickness on a 30° north dip, yielding breasts about 15 yards in height. It will be seen that the ore bed is gradually becoming thinner going westward on this range ; but at the same time it contains a less amount of Jack, here largely an argillaceous ore, which was formerly mined and accepted by the iron masters, but which would be generally rejected at the present time, and therefore has lead to the abandonment of most of these operations.

The *Romig & Brackbill* properties were formerly opened in the gap of the ore ridge through which the tramway extends to the ore basin farther south, and near them the old Shaumbach tunnel was located in 1875. All these openings are likewise closed and are said to have developed the Sand Vein with about the same characteristics of thickness and quality as found upon the last described property. The ore mined was largely soft fossil.

West from this point in this and West Beaver townships the Sand Vein ore bed has never been found to exist with good quality and mining thickness, and although the Danville ore beds furnish good surface indications as far west as the Mifflin county line they have never been mined and cannot be relied upon to furnish as handsome an ore as found in the ore basin south of Adamsburg.

The *Lower Helderberg limestone* makes but a single outcrop in the southern portion of Spring township extending east and west as a high ridge north of the railroad and Beaver creek and most largely developed in the vicinity of Adamsburg. The corresponding outcrop on the north

side of the Northumberland synclinal has not been quarried at all and creates a much lower ridge capped with loose chert of the Oriskany sandstone.

In the gap of Beaver creek, north of Adamsburg, a very imperfect but instructive section of No. VI and No. VII can be obtained on the west side of the creek. The former is massive; slightly opened along the roadside and about 100' thick, though not continuously exposed. Geologically above it on a N. W. dip of about 40° there are about 100' of sandy calcareous Stormville shales ending upwards with a rib of blue flint, representing the Oriskany sandstone, from 25'-30' thick. Overlying this after a short interval of decomposed slate there is a band of reddish-yellow slate streaked with black seams and about 10' thick, with a wavy structure. The exposure has been made in quarrying the different beds for road purposes. The same flinty character of No. VII was noticed in the gap north of Beavertown, where the underlying Stormville shale was largely covered by a mantle of white chert from the decomposition of higher outcrops of the Oriskany sandstone.

Markle's quarry is a long side hill cut on the east side of the Beaver creek gap just north of Adamsburg, where the limestone dips about 35° N. W. and has been opened in a number of continuous but shallow cuts, in all about 200' long, nowhere exposing more than 40' of stone. Operations have been confined largely to the upper part of No. VI and the eastern end of the exposure, as opened, is fully 100' higher in elevation than the kilns at the western end of the quarry.

The loose stone along the outcrop is largely gathered and burned for farm use, coal here costing \$2.75 a ton. The ridge here is bold and sharp and an excellent opportunity is presented through the gap made by Beaver creek for opening an extensive quarry at this point. The limestone is of good quality.

The first quarries west of Beaver creek are opened on the summit of the ridge in close proximity to one another, south from the house of Mr. A. Snooks. The ridge is of monoclinical structure and a number of quarries of more or

less importance are opened so as to form practically a continuous operation for several hundred yards from the outcrop. The principal ones, having kilns in any condition fit for burning, are as follows from east westward: 1. A. Gross. 2. Henry Manbeck. 3. Obergast. 4. Isaac Ulsh. 5. Wm. Stuck and, 6. Emanuel Snooks.

There are perhaps a score of additional quarries in which some little work has been done, the ridge being farmed out in small lots to individuals. The limestone crops conspicuously, without any sandstone cover, so that the stone is readily quarried in one long cut 1000'–1200' in length to the gap of a small stream flowing north to Middle creek, which has brought about the erosion of the overlying Oriskany sandstone. In the first 400' along the outcrop at the eastern end of the hill the quarries are deeper on account of the facility for reaching the limestone beds from their eastern end. In these quarries there is about 60' of stone exposed on a dip of N. 18° W. 45°. Some of the beds are excellent, but the ridge is capped by some shaly limestone which is not directly quarried but which, in being undermined, is very apt to fall down and be burned with the better beds below. There are no special features further west, most of the quarries being very shallow and working principally upon some good blue beds from 10'–20' thick, near the top of the massive portion of the exposure. The opportunity for developing here is exceptionally fine but has not been apparently taken advantage of, owing to the number of individual operators.

Amos Mitchell's quarry is open over a mile further west and about half way up the southern flank of the ridge, a short distance east of the road crossing to Middle creek. It is a small opening worked only for a local supply of lime and presents about 30' of fair stone on a dip of 30° N. W.

About 300 yards west of Mitchell's, and on the west side of the road crossing the ridge, there are three more quarries opened before reaching the West Beaver line, as follows: 1. A. Ulsh. 2. R. Felker and S. Sellers. 3. D. Pontius and H. Felker.

These quarries are all opened on the same beds, rather

high in No. VI, and do not extend for more than 125' along the outcrop. Ulsh's is the largest, exposing about 30' of stone on a dip of N. 20° W. 20°; 8' of good blue stone on the bottom, one foot of shale, one foot of blue limestone and the balance thin blue beds, somewhat shaly, from 2"-3" thick. The two other quarries have hardly developed the lowest bed at all, so that, commercially speaking, the lime burned here would not rank very high. However, the opportunities are just as favorable here as elsewhere for getting good stone, if properly taken advantage of, the dip into the hill being the only bad feature. The more massive beds could be opened further down the flank of the ridge.

The central portion of the township, between the two Oriskany ridges on either side of the Northumberland synclinal, is entirely occupied by the Marcellus, Hamilton and perhaps a portion of the Genessee measures. The dips are everywhere slight, not exceeding 25° on the north and south sides of the valley and lying almost perfectly flat for nearly a mile in width in the center; and as these rocks in this portion of the county are distinctively slate they have been largely corded and exhibit few good outcrops.

20. *West Beaver township in Snyder county.*

This township has been divided nearly in half by the erection of Spring out of its eastern portion and now makes a rude right-angle triangle at the extreme west end of the county, bordering on Mifflin county. Its north line is about 2 miles long on the Jack's mountain anticlinal, extending from near the center of the interior Hudson river slate valley to a knob of Oneida sandstone at the northwest corner of Spring. Its western line is about 6 miles in length nearly due north and south, its south line making an obtuse angle with the western line, west of McClure, and extending for 3 miles southeast to the Oneida crest of Shade mountain along which it is continued for about 2½ miles to the Spring line. It has a mutual eastern line with Spring and an area of about 15 square miles.

McClure is a thriving village and railroad station, situated in the upper Salina valley near the Mifflin county line,

and on the divide between the waters of the Susquehanna and Juniata. Bannerville is a smaller village about 2 miles northwest of McClure in the Devonian slates of the Northumberland synclinal basin.

The *drainage* of the township is entirely eastward through numerous small branches of Middle creek, which rise in this township.

The *structure* of the township is largely the same as that of Spring, with the exception of the absence here of the ore synclinal basin which rises rapidly from Adamsburg and expires before reaching the West Beaver line, so that in this township the main ore ridge approaches much closer to the mountain with the effect of stiffening the dip.

The *rock series* extends upwards from the No. III Hudson river slate to the Devonian measures No. VIII, the former being exposed upon the crests of both the Jack's mountain anticlinals, and the latter in the trough of the Northumberland synclinal, which passes almost directly through the center of the township.

The *Medina sandstone* is poorly exposed in the gaps of two small streams cutting the south flank of Jack's mountain north of Bannerville, the white Medina being by estimation about 500' thick here. These same rocks are not exposed at all in the southern portion of the township, which is equally true of the underlying Oneida sandstone. Great quantities of bowlders, however, show everywhere.

The *Ore sandstone* was seen in Ulsh's gap about one-fourth of a mile above the old mill, on the Jack's mountain outcrop, with a dip of S. 25°, E. 40°; but neither the Sand Vein nor Danville fossil-ore beds have been uncovered here. The Bloomsburg red shale outcrops west of Krepp's gap on this side of the valley with a dip of 40° S. E., but its outcrop is largely concealed by the immense amount of *débris* brought down from Jack's mountain through these two gaps. On the south side of the valley these rocks make a distinct red band everywhere south of the railroad, made prominent by contrast with the gray lime soil of the upper Salina creating the valley through which the railroad runs.

The *Lower Helderberg limestone* was once opened on its

northern outcrop on property of Mr. D. Hassinger, but the quarry could not be located and was only worked for local farm use.

On the south outcrop, just after crossing the Spring township line, there is a series of openings about three-quarters way up the flank of the ridge whose product is all hauled out on the north side of the ridge for fertilizing the slate farms along Middle creek. There was no work being done here when visited and it was almost impossible to find out the ownership of these quarries, although the names of Messrs. *Ulsk*, *Grick*, *Goss* and *Harbster* were mentioned as four operators.

The first quarry on the east is about 50' long and 20' deep and exposes about 20' of light gray-blue limestone near the very top of the massive portion of the formation. The quarry was in wretched condition, grass grown and apparently abandoned. The stone was very much weathered and rather siliceous.

Quarry No. 2, next west, was in even worse condition and developed the same strata. *Quarry No. 3* was about 30' wide and showed about 15' of fair stone, which had been ruinously developed in spots.

Quarry No. 4 was in better condition than any of the others. It was about 50' long, showing about 40' of stone, half of which in the center are thin but good dark blue beds, with a somewhat twisted stratification. The quarry, however, has been worked very unevenly, which indeed is true of all the others, where development seems to have been made upon the first fairly good beds met with after crossing the summit of the ridge, so as to avoid as far as possible the adverse haul that would be necessary in carrying away the products of lower and better beds. There are three more small openings still further west, all of which have practically reached the limit of economical development on the beds which they have exposed.

Paul Haines' property shows a small quarry opened near creek level a little west of the last openings and opposite the railroad station at Robb's mills. It shows about 15'-20' of white limestone dipping 25°-30°, N. W., which

have been sparingly quarried and burned in open ricks and are said to have made a strong field-lime. These beds are fully 100' geologically below the quarries opened near the top of the ridge and while of better quality they are still not so good as beds which might be opened midway between the two.

Weiland's quarry alongside the public road a short distance west has been opened in the same strata and stripped for 100' along the road. Some of the beds are merely lime-shales, but they are quarried and burned on account of their accessibility in preference to going higher on the ridge for better but more expensive stone.

Half mile further west and beyond the brick school house there are several quarries opened well up the ridge as follows: 1. Middlesworth, now abandoned; 2. John Felker; 3. I. & M. Middlesworth; 4. R. & J. Smith and P. Knepp; 5. Unknown; 6. Fisher; 7. H. Ulsh. The ownership of the last three quarries is uncertain as all the quarries were idle and very little information could be obtained concerning them. In common with all other openings in this part of the range they are only operated from time to time for farm use, and are generally opened where the stone can be most readily developed, regardless of its character.

Quarry No. 1 shows 25' of the top of No. VI limestone and has no bed in it over 2' thick. The stone is blue, but soft and shaly, weathering roughly and the dip about 25° N. W. The Felker quarry is small and but slightly opened in the same bed.

The *Middlesworth quarry No. 3*, is one of the best on the hill. It is 50' long and shows about 30' of limestone, none of them very thick or massive, but furnishing a good firm stone, especially in the bottom 10'. The quarry only needs a little development in lower stone to insure a good series of beds.

The *No. 4, or Bennerville quarry*, as it is best known, is on the west side of the road crossing the ridge and also shows an equally good section and quality of stone; but it has not been worked for some time and therefore presents a rather unattractive appearance. The other quarries

further west are a counterpart of those just described and are all small. They reach to within a few feet of the top of the ridge and the low dip creates a terrace upon the higher Oriskany backbone to the north.

From Adamsburg to McClure there is not a single water gap or break in this limestone ridge, which rises from 200'-250' above the valley and railroad with an unusually steep slope in its southern flank, which in a measure has no doubt militated against the extensive development of its limestone beds.

At *McClure* there are a number of quarries, and the lime industry has been pushed rather vigorously there, owing to the extensive building operations which have been carried on in the town. The limestone ridge is gapped here by a branch of Middle creek which forms at once a natural means for attacking the beds and an avenue for distributing the burnt lime to the slate valley to the north. On the east side of the ravine there are but two kilns, but the following quarries from east to west :

1. C. Nolt and J. Dreese. 2. D. B. Hassinger. 3. J. O. Goss. 4. R. J. Smith. 5. J. D. Ulsh. The outcrop of the limestone seems to have been purchased in lots by these parties, each having from 30'-50' in width. Sometimes one or more lot owners combine and erect a kiln; at other times they work quite independently with or without kiln. This policy is adverse to any systematic or well devised operation and the result is seen in the irregular, badly-worked, and expensive quarries on both sides of the creek.

Ulsh's quarry, nearest the stream on the east side of the gap, exposes about 30' of stone, near the top of No. VI on a 30° N. W. dip. The bottom 20' are good; but the beds generally are thin.

The other quarries on this side have furnished merely outcrop stone and had not been sufficiently developed to warrant an expression of opinion regarding their future.

Good facilities exist here for economical work. The quarries are near the railroad; consequently can get cheap coal and distant markets for their product; but up to the present time no one man seems to have done more than open

a small quarry for his personal use or petty sales, and the region as a whole is without a single first-class kiln.

On the west side of the gap and along the north bank of Middle creek there are ten or twelve individual kilns in a distance of 350', each of which is supposed to represent a quarry.

This property originally belonged to Mr. Wm. Deckert, who sold it off in lots, from time to time, to the following parties from east westward: 1. I. Shirey and P. Hoffman. 2. Joseph Klein and J. Kaley. 3. Levi Klein and partner. 4. O. A. Baker and D. Yetter. 5. S. and J. Yetter. 6. J. Culpetser. 7-12. Unknown.

The *Baker quarry No. 4* was the only one active during August, 1888. The eastern quarries facing the gap have largely developed the upper division of the limestone formation and the western ones' lower beds.

The *Shirey quarry No. 1* has probably been most extensively developed; but in the center of the group there is a splendid exposure of the whole series comprising over 100' of the massive division of No. VI. The uppermost beds are those which are most sought after, both from ease of development, safety and economy; but there are excellent beds in the lower portion of the group, while not so massive as similar beds seem to be on the Susquehanna and Juniata. Under top beds of shaly stone, 15' thick, there is good blue stone for fully 30', not all massive but occurring in three main divisions of nearly equal thickness separated by thin bands of lime shale. It is this stone that is most eagerly sought after, and it is largely obtained by stripping off the upper lean and impure beds. Underneath this massive division there is a dividing band of shales or soapstone separating the lower division. This portion does not contain the same massive beds shown at Winfield and Selinsgrove.

The individual beds are thin and many of them siliceous and slaty, rendering the exposure very uneven. The dip is everywhere uniform about N. 20° W. 25°.

Crossing to Bannerville along the Middle creek road and past the M. E. church, good exposures of the Marcellus

black slate are seen inside the limestone ridge east of Geo. Kaleys' place.

Just before reaching the creek a splendid exposure of Hamilton slate and sandstone shows 100' thick on a 30° north dip, creating a high sharp ridge. Genessee yellow fissile slate on a 10° N. W. dip makes a broad strip of valley land north of this ridge to and beyond the church, where there is a central low rounded ridge of blue, black and gray slate, marking the position of the Northumberland synclinal with converging dips 10°. These dark slates are well exposed near the old hotel, and the road west to Bannerville is almost constantly upon them. This village is situated on a small branch of Jack's creek which drains westward into the Juniata and is the only exception to the eastward drainage in the county. The divide is about one mile east of Bannerville.

Taking the Musser valley road north from Bannerville, the yellow Genessee slates are first seen on 40° S. E. dips, beyond which the road gradually climbs over a low Hamilton sandstone ridge to Hassinger's place, near which there is a little Marcellus slaty green limestone exposed along the road to the south of the Oriskany sandstone ridge.

The Northumberland synclinal is again well exposed along the Spring township line, a little north of the Lutheran church, where its trough is filled with the same olive blue and black slates, creating a low ridge between the forks of Middle creek.

There are four townships lying south of the Shade mountain anticlinal between the Susquehanna and Juniata county, which will now be described.

21. Washington township in Snyder county.

Washington township lies south of Middle creek and west of Penns township, and is one of the largest and richest townships of Snyder county.

Its boundaries are somewhat irregular, being rather octagonal in shape, with an area of about 25 square miles.

Middle creek forms its principal eastern line in common with Penns township, and at the same time drains about

seven-eighths of the township through branch streams flowing eastward.

A small triangular area at the extreme south corner and a little territory near the base of Shade mountain along the Perry township line, are drained by upper branches of Mahantango creek. The *structure* is extremely simple and very regular, all the rocks dipping southeastward from the northern end of the township away from the *Shade mountain* or *Selingsgrove anticlinal*, whose axial line passes in a northeast and southwest direction close to its northern border and crosses Middle creek just below Kantz's mill. To the north of this line there are few north dips, but exceedingly gentle, as the axis is a very broad and regular one.

The *Shamokin synclinal* occupies the high ground in the triangular-shaped area on the south, but the Devonian measures held in the basin there are not well exposed, so that the exact position of the axis can not be well determined.

Freeburg, nearly in the center of the township, is the only place of importance, and is situated in a fertile valley of upper Salina shales upon the north bank of a good-sized tributary of Middle creek, skirting the north base of the Firestone ridge.

The *rock series* in this township extend from the top of the white Medina sandstone No. IVc up to and including the Chemung division of No. VIII, the former being exposed slightly in the nose of Shade mountain at the mutual corner of Washington, Franklin and Perry townships.

The lower Clinton rocks, between the Medina sandstone and the Ore sandstone, are excellently exposed all through the northern portion of this township on the crest of the south flank of the Shade mountain axis; and at one time the purity of the *Bird Eye fossil ore bed*, as well as the many advantageous circumstances attending its flat dip, led to a very large development of this bed in nearly every little branch which cut down beneath its outcrop. Many of these openings were visited when active by Mr. J. H. Dewees, and a description of them, with analyses of the ore then being mined (1874), will be found in Report F, p. 26, *et seq.*

Along the road entering this ore area, leading north from Freemont and crossing Shade mountain to Meiser, the Bloomsburg red shale is seen making a low ridge just below the mill in Perry township. A short distance further north, opposite Good's grist-mill, the Ore sandstone makes an independent ridge three-quarters of a mile from the main mountain, showing a small outcrop on a 30° south-dip. No appearance of either the *Sand Vein* or the *Danville fossil ore* bed were noticed, and both the Ore sandstone and Bloomsburg red shale make much higher and more prominent ridges east of Mahantango creek than they do in the gap and to the west, where they become more or less merged into the flank of Shade mountain.

Henry Liester's mine openings are located a little further north on the east side of the creek, and about 40' above water level, where the dip has already fallen to only 5° S.

The *Bird's Eye fossil ore bed* has been worked here between walls of slate, and though only found from 7"-10' thick, its good quality and low dip caused a large development of its outcrop for some distance up and down the stream. All the openings are abandoned now, the last shipments having been made to Union furnace, where it was sold at high prices. The drifts were not extended more than 25 yards into the hill; but the low dips gave a great length of breast.

John Mengle has opened the same bed in several places further north, a small ravine dividing the two properties. The bed has the same character here and was mined out in large blocks of medium soft fossil ore, full of parallel seams, which assisted considerably in mining it and give it an exceedingly attractive appearance on the ore pile.

The ore found here was of excellent quality, the bed still rising gently northwards towards the crossroads at Weller's old Black Horse Hotel. The rise of the anticlinal here has carried the ore bed to daylight; but it almost immediately folds over the arch, and occurs upon all the head waters of the streams flowing northward into Middle creek.

P. Weller's farm was largely opened, the ore bed lying nearly flat there, and furnishing a great amount of outcrop

from which six or seven thousand tons of ore have been cheaply mined. Most of the work, however, has been confined to short drifts near the outcrop, where the ore bed could be readily reached and was found leached to an excellent soft fossil ore. It is highly probable that a large amount of ore still remains untouched between the many ravines centering here, the small size of the bed and the increasing hardness of the ore under good cover rendering its development however more expensive.

Dark red blocks of the Iron sandstone show profusely on the first ridge going north from J. C. Weller's towards Meiser, and this is the same ridge before noted in the description of Franklin township, which furnished the *block ore* to the old Beaver Furnace at Paxtonville. There are several additional openings in the Bird's Eye fossil ore bed along the Middle Creek township line.

The *W. Ripka property* (formerly Emanuel Duck) has ten different openings on the Bird's Eye bed, which is here a hard fossil ore, and was being mined during 1888 by S. Krebbs, of Danville, on a 15 cent royalty. The ore mined went to the general market; but mostly to Danville. The bed averages about 8" and is capped with a hard purplish-red slate and has a floor of greenish slate, both of which adhere so closely as to require every car of ore to be hand-picked at the pit mouth to remove this slate before the ore would be accepted by the iron masters. As this operation practically necessitates the entire attention of one mason at each main drift, it adds considerably to the expense of the ore.

In August, 1888, the output was not over 175 tons a month, furnished by eight miners two ore-dressers, and a teamster. The mining rate was \$2.15 a ton, after which the expense of hauling the ore two miles to Meiser station had to be added, as well as the royalty, so that the ore could not have cost less than \$2.50 or \$2.75 delivered on the cars.

The mine is developed by parallel gangways carried in several hundred yards from the outcrop about 5' high and 6' wide. The ore is taken out in consecutive rooms, 18' wide, everything being robbed from the ends of these cham-

bers as the mining is carried back to the gangway. About 2 $\frac{1}{2}$ of top slate was being blasted down which also adds to the mining expense.

There is no fixed limit to the length of breast, as the bed dips only 5° N., but the average will probably be about 60 yards. As soon as each 18' room has been carried from gangway to gangway it is gobbled up with the top slate and supported with posts along the main traveling ways, so that the process is an advancing one, all ore being taken out near the outcrop before a new room is started.

The ore is very hard to mine, notwithstanding it carries the same parallel seams which divide it into blocks as before mentioned, for the roof slate under cover becomes as hard as sandrock. This roof is first blasted and after it is removed the ore bed itself must be removed in the same manner.

The "dressing" of the ore, or the removal of slate, at the mine mouth costs from 20 to 22 cents per ton, and hauling 37 cents a ton. An analysis of the Bird-eye fossil ore from this property yielded as follows (see Report F, p. 27):

Iron,	45.125
Sulphur, . . . . .	.015
Phosphorus, . . . . .	.407
Carbonate of lime,	10.928
Carbonate of magnesia,	2.497
Insoluble residue,	12.855

The *old Pontius mines*, situated immediately across the ravine from Ripka's and a little further north, were being worked under a lease to Swenk & Meiser. Here the dip has increased to fully 20° northward and consequently introduces another feature of expense. The bed, however, is above water level for some distance down the ravine to Middle Creek township, which has been taken advantage of as far as possible.

The outcrop has been exhausted from the forks of the road east for four or five hundred yards. The present ore is of medium quality, though all hard, and under increasing cover as the mines are being operated northwards. The outcrop itself has been worked clear over the divide and down the ravine leading to Kremer, so that the bulk of the

cheap ore has been largely exhausted. The soft fossil ore originally taken from this property was of very high quality, both on account of its richness in iron and its general purity; but that being mined in 1888 could not have yielded over 40 per cent. of metallic iron.

These mines are operated in precisely the same manner as Ripka's, and the ore bed shows the same characteristics of roof and floor, requiring dressing and blasting.

Bickel's mines are situated at the head of an east branch of the Kremer ravine, about $1\frac{1}{2}$ miles southeast of that village, and near the public road to Freeburg. The ore has been developed here on both sides of the anticlinal, and is the same Bird-eye fossil already described. In the openings on the north side of the anticlinal the dip is fully 20° to the northwest, and the gangways have been driven eastward into the side hill, giving about 25 yards of breast. The ore is of good quality, though hard and calcareous.

There are six independent gangways between creek level and the point of the ridge in a distance of about 500', one above the other; the last three are closer together, giving smaller breasts.

There was no work being carried on here when visited; but the ore blocks at the different drift openings were about 8" thick which may be taken as the thickness of the bed. These blocks seem to be rather more free from the roof and floor slates than that mined further west, and much of it is said to not require "dressing." The increased dip, in connection with the depth of the ravine, is somewhat of an advantage here, as it allows the ore to "run down" the breasts, saving that much additional labor.

Mining was paid for about \$2 a ton here and if "dressing" is not required it should be put at the pit mouth for 50 cents a ton cheaper than at Pontius & Ripka's mines. The ore bed rises southwards under light cover, and is again opened in several places on the south side of the hill facing the ravine flowing towards Kremer. Here the cover of shales is not over 30' and the dip about 5° , so that a considerable amount of soft fossil ore has been mined at this point. These openings are on Andrew Bickel's property

about 2 miles north of Freeburg, and an analysis of the soft ore yielded (See Report F, p. 27).

Iron,	50.500
Sulphur, . . . . .	.024
Phosphorus, . . . . .	.257
Insoluble residue,	15.220

A short distance (300 yards) further south the bed is again opened on the south dip but not now worked. An old drift had been opened close to the public road on an increased dip of 10° southward.

Information obtained after the examination of this field from Messrs. P. & W. Bickel at Freeburg put the output of their mines at about 100 tons a month from four active drifts, most of which was sent to C. L. Bailey & Co., Harrisburg. Ore dressere are largely required, and the ore was hauled to Kremer, Station 1½ miles, at a regular contract price of 40 cents per ton.

F. C. Moyer's opening is still further south and nearer Freeburg, on the west side of the public road, and is said to have been developed on the block ore bed. The drift was entirely fallen shut and nothing could be seen of the ore or accompanying rocks; but the opening is certainly north of the Ore sandstone ridge and in measures too low for the Danville fossil beds.

The Bloomsburg red shale shows crossing the Freeburg road south of the cemetery, spreading over a wide belt on a dip of about 20° southward. On the road leading east from here to the red brick school house in Penns township on Middle creek, the Clinton olive shales, with some red bands, outcrop on a general dip of S. 10° E. 25°. The Ore sandstone is also exposed just near the turn of the road northwards on a dip of S. 20° E. 12°, rising northward along the ravine to arch over the Shade mountain anticlinal, and showing one massive ledge of grey-brown sandstone, 6'-8' thick, underlaid with shale.

Neither of the ore beds associated with this rock seem to exist in workable conditions at this point. The underlying lower Clinton shales show further north on the crest of the anticlinal with 10° dips; but neither the block ore nor the Bird's Eye fossil ore bed extends this far east.

South of Freeburg there is a small local anticlinal in the upper Salina measures, which reverses the dip for a short distance and slightly affects the outcrop of the overlying Lower Helderberg limestone. It broadens the limestone belt for nearly a mile eastward; but dies away long before reaching Middle creek.

Near the end of the ridge along the road leading from Kantz into Firestone valley, a small exposure of limestone was seen in a small quarry dipping S. 18° E. 30°, from which point an excellent quarry could be readily developed.

The *Oriskany No. VII* is not well exposed here, although its chert bowlders cover the south flank of the ridge as well as make its crest all through the township.

A short distance west of Kantz and near Miller's grist-mill, the upper Salina lime slates become quite massive and calcareous, olive-green in color when freshly broken, and weathering brown.

Limestone quarries.

Edward Bassler's quarry is opened in the flank of the Firestone ridge just south of Miller's mill, having one active kiln with a capacity of 200 bushels. The quarry is not large and the beds are quite cavernous, one seam about 4' thick showing a stalactitic structure and exposed for the length of 50' on a 50° S. E. dip. The quarry is about 50' long and 20' deep and at the opening the measures are dipping steeply northwest and cut by cleavage planes, probably the effect of the anticlinal mentioned south of Freeburg. South of this roll in the quarry there are about 18' of thin blue beds streaked with calcite, which are largely quarried, the bottom 10' being the best. A bed of splintery soft limestone makes the roof and possibly occupies the position of the "soap-stone" layer in the Union county quarries. The lime made sells only for farm use.

The *Rausch quarry* is about 100 yards further west and has been idle for several years. The same cleavage shows in the first beds met with at the opening; but above them and to the south, there are about 20' of the same beds developed in Bassler's quarry. Above these the measures

are shaly and the "creep" of the hill above has curved them into irregular beds, worthless for quarrying. It was no doubt due to the heavy covering of soil which led the proprietors to work their quarry at one time by drifts, one of which extended southward and the other eastward, so as to avoid the crest of the hill. The operation could not have been very economical, and no quarry in this section of the range displayed such a quality of stone as to warrant such methods.

Joseph Deal's quarry is about $\frac{1}{4}$ of a mile west, and when visited in August, 1888, was just being cleaned out after a long idleness, under a lease to James Haines, who proposed to burn lime for farm use. The quarry is about 100' long and the dip of the beds is very regular and not over 20° - 25° towards the southeast.

The same blue beds of the eastern quarries are exposed here at the bottom of the quarry, over which lie 25' of thin shaly stone containing an occasional good bed. Only the bottom stone is burned.

A second larger and more extensively worked quarry is opened on this same Diehl property, a little to the southeast and on the east side of the ridge, where a small stream has cut down through the Oriskany sandstone chert, making a wide cove in the underlying limestone. The quarry was quite abandoned and its kiln dismantled; but some excellent stone overlying that developed on the north side of the ridge has evidently been taken from the large opening, 125' long and 35' deep, on a dip varying between 30° to 60° . A total thickness of about 30' of stone shows at this point, generally blue, but in rather thin beds near the top of No. VI.

Sprigman's quarry, on the north side of the ridge, is $\frac{1}{2}$ a mile west of Diehl's and a short distance from Freeburg. It is a small opening, but active, and shoots its stone down from an upper ledge of good blue limestone, which should occur geologically in the interval of rock between the two Diehl quarries.

The *Freeburg quarries* in the point of the ridge north of the local anticlinal are operated by four different parties as follows: 1. *Hilbish & Miller*, one kiln. 2. *Bassler & Glass*,

one draw kiln. 3. *Miller & Bickel*, one kiln. 4. *Batdorff*; the latter near the road, being very small and not active.

There is some good limestone exposed in all these quarries although the total section is small.

Hilbish & Miller's quarry is a side cut about 50' along the face of the ridge and exposes 20' of stone in which there are two good blue beds near the bottom, each about 6' thick and above from 8'-10' of shaly limestone. Coal is worth \$3 a ton here, one dollar of which represents haulage from Selinsgrove, while lime sells for 7 cents a bushel.

Bassler & Glass' quarry lies immediately west and is quite similar in its appearance, exhibiting about 30' of a rock-section and slightly deeper. Both quarries have about an acre of ground apiece, and both are susceptible of improvement upon greater development.

Miller & Bickel's quarry is next west and idle. Comparatively little good stone was seen in this quarry, where there was some showing of gypsum mixed indiscriminately through the opening.

All of these quarries are opened in only medium stone, the best part of the lower beds of No. VI being still under cover.

On the road leading south from Freeburg over the ridge to Firestone valley, the junction of No. VI and No. VII is seen on the crest of the ridge in a limestone dip of 35° S. E. Lower down the ridge, but still south of the small subordinate anticlinal axis, there are two small limestone quarries, the most westerly being

Daniel Boyer's, where two kilns were formerly supplied with stone from a quarry 60' long and 15' deep. Very little good stone shows here, the larger part of the development being in the transition measures between the upper Salina and Lower Helderberg.

This whole ridge from Middle creek to Freeburg is sparingly developed, and the best stone can only be reached in a few of the wind-gaps, or at the extreme eastern end of the ridge, unless the overlying Oriskany chert and Stormville shale is first stripped off. The rather gentle dip soon

carries any good beds outcropping on the north flank quickly under cover.

G. C. Moyer has the first quarry in this ridge west of Freeburg, located just at the bend of the road leading over the ridge from S. G. Hilbisch's farm. It has been idle for years and was only developed to a limited extent, showing a cut about 50' long in which 35'-40' of limestone is exposed on a dip of S. 5° E. 70°. This steep dip and the covering to be removed in working, probably led to its abandonment. The opening is in the bottom members of No. VI and the stone is thin-bedding and shows some cleavage.

S. Hilbisch's quarry is perhaps three-quarters of a mile further west along the ridge, about 100 yards south from the road and worked only for local farm use. It shows some fair stone in thin beds near the bottom of No. VI on a 65° S. dip.

John Hepner's old quarry is situated at the base of the hill west of the road leading over the ridge and about 2 miles from Freeburg. It was originally opened in the upper Salina lime shales and finally passed through these by a narrow cut into the bottom members of No. VI, which show shaly even yet and rather impure. The dip is about 30°, S. 10° E. and the stone lean and poor.

West from here to the Perry township line, there are no other quarries. The ridge apparently declines in height, owing to the rise of the floor of the Klopperdale valley to the north, between this ridge and Shade mountain, and whose summit is not far from the Washington-Perry line. The Limestone Ridge crest from Hepner's quarry to the Perry township line is still well wooded with chestnut and oak timber, and is only slightly cultivated along its northern flank to the width of one field.

The *Devonian rocks No. VIII* are not well exposed. The Hamilton slate and sandstone however, make as usual a sharp-crested and prominent ridge, running parallel through this township to the Firestone Ridge, and separating the Firestone and Knight's valleys. It contains some rather massive sandstone beds upon an average dip of about 45°, S. E., the hill containing them declining westward.

The *Marcellus black slates* are exposed through the Firestone valley north of this ridge, while the Genessee slates occupy the Knight's valley to the south. The Chemung rocks create a high ridge along the Chapman line and further west on the waters of Mahantango creek in this township fill the trough of the Shamokin synclinal.

22, Chapman township in Snyder county.

This is a large township extending for about 10 miles along the Susquehanna river and occupying the southern corner of the county, south of Washington and east of Perry township, and divided by the Mahantango creek from Susquehanna township of Juniata county. Its area will not fall far short of 25 square miles.

Port Treverton on the Susquehanna opposite Herndon is the principal place in the township, a village strung along the river bank for nearly a mile, but not having a large population.

Chapman and *McKee's Half Falls* are two smaller places further down the river bank whose prosperity has declined somewhat with the stagnation of business along the Pennsylvania canal.

Meiserville, situated on Mahantango creek, about 1½ miles above the forks of the stream, is another small village.

Drainage of the township is all south and eastward into the Susquehanna river. Mahantango creek is the principal stream in this section of the county but it drains a comparatively small portion of this township, which contains only small streams, rising in the high land along the Washington and Perry township lines and flowing directly into the river. While not of great importance themselves, they create deep and narrow valleys in the generally soft Devonian measures, which occupy four-fifths of this township, each branch furnishing a natural location for a public road, with which the township is plentifully supplied.

The *structure* in the main is simple, consisting of the *Shamokin synclinal* of Catskill and Chemung rocks on the

north, and the *Georgetown anticlinal* axis on the south below McKee's Half Falls, which elevates a small area of the Oriskany and Lower Helderberg rocks near the junction of Mahantango creek and the river.

Between these two main flexures, however, there are several subordinate anticlinal and synclinal *rolls*, none of which can be traced west into Juniata county; but which have sufficient strength along the Susquehanna river to duplicate and spread the outcrops of the Devonian measures through a belt of country 4 miles in width.

The *Catskill rocks No. IX* occupy a triangular-shaped area about 2 miles in width along the river, and narrowing to a point 3 miles further west. They are largely red shales and sandstones and are best exposed in the bluffs along the river. South of the aqueduct which carries the canal over on to the Isle of Que, there is a *splendid exposure* of these red rocks for 400 yards along the road on dips varying between 35° and 45° S. 15° E., with a slightly steeper 50° dip at the aqueduct and school-house, and a similar one at the south end of the exposure, where the higher beds have a greenish-gray cast. Elsewhere they are uniformly red and consist of about one-half sandstone and one-half shale, very regularly bedded and some of them furnishing excellent building-stone.

After an interval of 10 or 15 yards south of this exposure the dip flattens for a short distance to 25° , but soon increases again in red and gray sandstone and shale to 40° and 45° .

The upper or central portion of the formation occupying the trough of the basin, is less massive; but the top layers have been somewhat *quarried* a short distance south of the public road leading west and up the ridge, where they show massive greenish-gray and red sandstone suitable for building purposes. The entire *thickness* of the Catskill rocks exposed on either side of the Shamokin synclinal in this township cannot be less than 3500' and may reach 4000 on careful measurement.

The exact position of the synclinal cannot be positively

located, owing to the great erosion of the measures in the south leg of the synclinal facing the river; but it cannot be far south of the first dwelling house met with south of the aqueduct, inasmuch as occasional ledges of rock seen going further south, show steep northwest dips. There are good exposures however between the two roads leading west and at Witmer's store, where shale and sandstone dip 45° N. 15° W.

In a short $\frac{1}{2}$ mile south the rocks begin to lose their red color in the transition Catskill-Chemung rocks, which appear on dips of N. 20° W. 50° . Here the limit of the Catskill rocks may be placed, assuming their base to be fixed at the lowest red beds seen.

The *Chemung rocks* to the south, extending down nearly to Port Trevorton, are quite shaly and iron-stained, and occur on steadily declining dips of from 35° – 15° , and with a thickness of about 2000' including the Portage division. They are well exposed and make a practically continuous section, consisting of five or six hundred feet of greenish-olive shale on top, and a succession of gray, green and brownish sandy-shale beds, 1400 or 1500 feet thick at the bottom, which beds west from the river are responsible for the ridge-land characterizing the topography of this township.

A section of the stream from Chapman to Port Trevorton shows first some grayshales occupying the crest of a small *anticlinal*, with dips of about 35° each way, gradually declining northward to Rhinehart's house, where the synclinal occurs with northwest dips of only 10° , and southeast dips of 60° . These are largely the lower Chemung and Genesee shales, the latter just coming to daylight at Port Trevorton, where anticlinal reverses the dip and brings in the Chemung rocks going north.

The *Marcellus black slate* is well exposed near the forks of Mahantango creek in the south end of the township on a dip of 40° – 35° N. 12° W. Opposite the mill and north of Arnold's blacksmith shop, there is a fine exposure

of the Marcellus black slate and Hamilton sandstone, and also some shaly impure limestone south of the blacksmith shop, which is probably Marcellus and shows some indication of *carbonate ore*. The dip here is about 50° N. W.

The *Hamilton sandstone* makes a prominent ridge whose rocks are well exposed again on the river about 1½ miles above McKee's Half Falls and perhaps three-quarters of a mile above the ferry. The exposure here contains a good deal of black slate; but it is quite massive and causes ripples in the Susquehanna river. Going north to Chapman, the road ascends geologically into higher measure passing over the upper Hamilton and the Genessee divisions, the dip keeping nearly uniform until the synclinal is met with at a small creek beyond the blacksmith shop and brick hotel with southeast dips of 60°.

Through the central portion of the township the upper portion of No. VIII is frequently seen in individual exposures. Going up the first road below Port Trevorton, gray sandstone and shale are seen dipping S. 25° E. 60°, not far north of the synclinal between Port Trevorton and Chapman. There are many exposures of shales going up to the school-house, a short distance south of which the Port Trevorton axis is developed on north and south dips of 15°.

The *junction of No. VIII and No. IX* was imperfectly seen on this road just before reaching Stahl's saw-mill. The same formations come together on the north side of the basin near the Lutheran church, where the dip is about 20° E. S. E.

The Chemung shales and sandstones occupy a strip of country to the north, well exposed at J. Fisher's on a southeast dip of 35°, and extend north along the river to within 300 yards of Penns creek.

Neither *Oriskany* nor *Lower Helderberg rocks* are exposed in place, being largely eroded by the junction of the creek and the river; but making an anticlinal ridge further west in Juniata county.

23, Perry township in Snyder county.

This township makes an irregular area of about 25 square miles lying west of Washington and Chapman townships and between the West Mahantango creek and the Medina crest of Shade mountain. Its western line, in common with West Perry township, is a straight one 5 miles in length between the mountain and the creek, and its north line along the mountain is also straight and 2 miles in length. Its eastern and southern lines however make many angles, the former cornering first on the Ore-sandstone ridge; then on the Hamilton ridge east of Mt. Pleasant mills; and then on the Chemung sandstone ridge 4 miles west of Port Trevorton. Here it makes a right-angled bend and extends to Mahantango creek north of Meiserville, following that stream to its forks, about $1\frac{1}{2}$ miles from the river.

Mahantango creek carries away the entire drainage of the township south and eastward into the Susquehanna river, the west branch dividing the township from Juniata county, and the east branch flowing through it from the Klopperdale valley on the north to below Meiserville on the south.

Freemont is a beautifully situated village in the northern part of the township, located in the Shamokin synclinal between walls of the Oriskany sandstone of the Firestone ridge.

The *structure* of the township consists of the Shade mountain anticlinal which marks its northern line, from which the rocks dip southward in successively higher strata to the Firestone ridge north of Freemont. The *Shamokin synclinal* passes through the town and has become so shallow here as to contain only the Marcellus black slate of No. VIII.

The rapid rate at which this synclinal axis rises coming westward may be inferred from the fact that on the river, only about 8 miles east of Freemont, it contained in addition to the entire No. VIII formation, at least 3500' of No. IX, so that at Freemont over 7000' of these rocks have been eroded.

The *Slenderdale anticlinal* of Juniata county expires just south of Freemont in the Marcellus black shale, and rising westward like the Shamokin synclinal it elevates a spur or knob of Oriskany sandstone and Lower Helderberg limestone on the West Perry line, southwest of Freemont.

Going down the Mahantango creek, one of the river synclinals is passed a short distance north of Troutwell, holding Chemung rocks No. VIII. An anticlinal of these same rocks succeeds just south of the village, and a second synclinal along the Chapman line north of Meiserville. From here south the rocks all rise to the southeast towards the Georgetown anticlinal beyond the township limits, in Juniata county.

The *rock series* extends from the Medina white sandstone No. IVc of Shade mountain, up to the base of the Chemung rocks No. VIII in the Troutwell synclinal.

The *Clinton measures*, holding the Ore sandstone and Iron sandstone, outcrop between the base of Shade mountain and the Klopperdale valley; but the exposures are very meager, owing to the increasing dip of the rocks and the approach of these measures towards the mountain flank, upon which they really make a terrace.

The *Bloomsburg red shale* makes a distinct band of red land east and west through the township from Garman's saw mill on the east to the west Perry line. No ore has been opened in any part of the Clinton measures in this township, although there can be but little doubt of the presence of the *Bird's Eye fossil* ore bed in just as good condition as it is in Washington township, only the steeper dip here prevents an economical development in the absence of all water gaps.

The *upper Salina lime shales* create a fertile strip south of the lower Salina red beds, upon dips of from 40°-60° S. E. The valley is quite elevated here, and is locally called the *Hiester valley* though essentially a continuation of the Klopperdale valley of Washington and Penns townships.

The *Lower Helderberg limestone* makes a very promi-

ment ridge in this township by reason of the greater erosion of the lime shales to the north and the Marcellus slates on the south.

Limestone quarries.

Garman's quarry is the first opening west of the Washington line, located a short distance east of the road and gap leading through the ridge to Mt. Pleasant mills. The opening is an old one, about 100' long and 40' deep, exposing 45' of good limestone beds at the bottom of No. VI, on a southeast dip of 35°. The good beds are interleaved however with shaly ones, and though there are excellent facilities for working from the end of the ridge in the gap where a judicious selection of beds could be made, there has been no attempt to do so, and all operations here have been practically abandoned.

West of Mahantango creek the limestone ridge assumes a more commanding height.

The *Freemont limestone quarries* occur through a distance of about a quarter of a mile along the north flank of the ridge west of the public road leading into Hiester valley. They consist of about 15 different openings, equipped for a large output, but for lack of a more extended market, only worked periodically for a local supply of farm lime.

The quarries in order from east westward are as follows: 1. Jacob Dreese, two kilns. 2. Heiges, one kiln. 3. S. Arbogast, two kilns. 4. Chas. Botts. 5. F. Traup. 6. J. Reichenbach, one kiln. 7. Yerger, one kiln. 8. Nameless. 9. Nameless. 10. S. and H. Bickart.

All these quarries are located on separate lots originally owned by S. Arbogast, and sold to individuals who now own about 50' each along the outcrop.

Nos. 1 and 2 are practically one quarry 80' long. The dip is steep towards the southeast with an average of about 50°, the quarry showing 45' of the section towards the bottom of No. VI and containing stone of a good quality.

No. 3. Arbogast's quarry, was actively worked in August, 1888, showing an opening about 70' long and exposing 40' of blue stone, making a decided arch, the south

side of which, dipping only 10° or 15° and containing good beds, was not being developed. The northwest dip on the north side of this arch amounted to 50° ; but is only local and displays a very ordinary stone spoiled by cleavage.

Nos. 4 and 5 make one opening, 100' long, exposing only outcrop stone and as yet undeveloped and of no commercial value. Both quarries have been abandoned.

Nos. 6 and 7 also make one quarry, 100' long, and sparingly developed in practically the same beds.

No. 6. Reichenbach's quarry was actively developing beds dipping northwest about 50° , extending the anticlinal roll before mentioned. Only about 100' of limestone have been uncovered, although the face of the quarry has been cleaned to the height of 20'.

No. 8 is a small hole next west, showing about 15' of stone on the northwest dip, cut up with cleavage and of poor quality yet.

No. 10. Some little distance west there is a quarry about 350' long, six lots of which are owned by S. and H. Bickhart, one lot on the east end now being owned by them. It makes decidedly the largest and best quarry in the group. The general dip is still northwest; but the anticlinal can be seen forming at the west end of the exposure, where some excellent blue stone was being obtained.

None of these quarries will get good working beds, until they have blasted through this comb and entered the hill on the regular southeast dip, where the beds are free from the cleavage exhibited along the crown of the arch, and for some reason appear to be more smooth-grained and regular than the same beds on a northwest dip. The bed, however, will soon take cover on the south dip, necessitating stripping; and it was to avoid this expense no doubt that developments have been confined to the outcrop.

Henry Mengle had two kilns and a quarry in operation lower down the flank of the ridge, upon the final southeast outcrop of the beds, where one or two good beds aggregating 15' in thickness have been developed for a considerable length, but limited depth.

In the gap north of the white frame church at Free-

mont, the *Oriskany sandstone* is exposed on a south east dip 30°, largely shale but carrying some flint and chert, in all 40' thick.

The *Marcellus black slate* is exposed for over a mile south of the Oriskany ridge along the road down Mahantango creek. Some impure greenish limestone shows sparingly in the town of Freemont belonging to the Marcellus horizon, and dipping southeast into the Sunbury synclinal.

The Marcellus slates have yielded thoroughly to erosion and create a wide flat narrowing west of Freemont between the two Oriskany sandstone ridges. Just south of the village they dip 60° S. E. and after passing over the Slenderdale anticlinal, show again at the first crossroads, dipping only 35°. A short distance below H. Fisher's, thin limestone again outcrops on the road apparently dipping stiffly 70°, S. E.. The horizon of this bed should be somewhat higher at Freemont.

Shadle's mill and house, 1 $\frac{3}{4}$ miles south of Mt. Pleasant Mills, are built upon an outcrop of Hamilton sandstone dipping 35°, S. E. and making a noticeable ridge east and west bounding the Buckwheat valley of this and West Perry township on the south.

The *Genessee yellow fissile shales* are next seen further south, succeeded just north of Reichenbach's by an outcrop of flaggy sandstones, blue and gray in color, and possibly representing a portion of the *Portage* division. These rocks again show below the next house somewhat wavy, with a dip varying between 30° and 60°, but averaging about 40°, succeeded by yellow shales and some thin bands of reddish sandstone in the transition measures of the Chemung group on decreased dips of 30° extending south to a right hand branch of the creek.

The *Chemung sandstone* shows on the south side of the synclinal at the school house near Troutwell on a 10°-15° N. W. dip and with steep southeast cleavage planes. South of the school the yellow shales come in on a reverse dip, but lie comparatively flat, folding over a broad anticlinal arch, making a high ridge here and finally sink southward beneath the Chemung sandstone again, which is well

exposed on a 15° - 20° S. E. dip, about 100 yards north of the red bridge crossing Mahantango creek at Minnich's grist and saw mill. The dip soon increases to 40° in an almost continuous exposure, and is then reversed in a wide flat synclinal with 10° dips. Towards Meiserville, the north dip increases somewhat; and opposite Meiser's mill, blue and black slates dip 30° - 35° N. W.

Half a mile below this on the creek, where the Perry road crosses into Chapman township, there is a fine exposure of the (Portage?) rocks dipping N. 16° W. 30° , making high bluffs along the west side of the creek and exposed for some distance along the stream. Still further south the Genessee and Hamilton measures come in on similar dips, until crossing Mahantango creek in Juniata county the Marcellus slates outcrop on the flank of the George-anticlinal.

24.-West Perry township in Snyder county.

This township has rudely the shape of a right-angle triangle, the base of which makes its northern line, extending along the crest of Shade mountain for 12 miles, while its perpendicular line on the east is 5 miles in length, extending from the mountain south to West Mahantango creek. Its hypotenuse divides the township and county from Juniata, extending along the upper waters of Mahantango creek for 7 or 8 miles by the meanderings of the stream, and 6 miles further in a straight line across the valley and up the flank of the mountain to the north Oneida crest of the anticlinal. Its area is roughly 30 square miles.

Its *drainage* is almost entirely eastward through branches of Mahantango creek to the Susquehanna river, although Lost creek takes its rise in the Spiegelmeyer slate valley occupying the summit and the anticlinal of Shade mountain, and flows southwestward to the Juniata.

The *structure* is largely a continuation of that in Perry township, although the township lines do not extend far enough south to include the several rolls and basins at Troutwell and Meiserville.

The *Shade mountain anticlinal* begins to develop rapidly in the northeast corner of the township, and after lifting the red Medina No. IVb to daylight on its crest for a little over 3 miles, it brings up the Oneida sandstone and conglomerate No. IVa, splitting it in turn 3 miles from its first appearance to admit of the Hudson river slate No. III valley, which extends for 4 miles to the Juniata line between opposing walls of the Oneida sandstone.

The crest of the arch through this slate valley is evidently very flat, for along the road leading over the mountain from Adamsburg to McAlisterville two small detached knobs of the bottom Oneida conglomerate remain near the Juniata county line to attest the *former* continuation of the *unbroken arch* across this slate valley, which has now been generally eroded 200' or more beneath the enclosing crests.

This feature is exceedingly interesting and rare, and is illustrated upon the colored county map.

The *Shamokin synclinal* continues as a narrow basin west of Freemont, holding along the Perry township line, a small wedge of the Marcellus slate, west of which the enclosing walls of Oriskany sandstone extend a little over a mile from the eastern line to end in a high spur along the road crossing this ridge to Hannibach creek. The ridge itself is continued for 2 miles further west, but now totally occupied by the lower Helderberg limestone until at the M. E. church north of Richfield the limestones in turn are eroded, and the synclinal becomes very faintly exposed in the upper Salina lime shales of Hiester valley.

The *Slenderdale anticlinal* lying immediately south and along the Perry line quickly elevates the upper Salina lime-shales on its crest, curving gradually northwards towards the Shade mountain and along the Juniata line brings up a narrow strip of the lower Salina or Bloomsburg red shales on its crest for 2 miles before leaving Snyder county. All the rocks south of this line dip southeast, bringing down in turn No. VI, No. VII, and the bottom of No. VIII.

The *rock section*, therefore, extends from the No. III slate in the Spiegelmeyer valley upwards to the Hamilton slates and sandstone, and possibly a little Genessee on Mahantango creek.

Good exposures of the *Hudson River* slates and all three members of No. IV are wanting in this township for lack of water gap to expose them, and although the Ore sandstone makes a long straight terrace ridge for nearly 9 miles through the township it is nowhere well exposed nor has it furnished anything but fair outcrops of its two accompanying ore strata.

The *lower Salina* (Bloomsburg) red shales can be traced without difficulty by reason of the deep red soil which they create along the north side of the Hiester valley and south of the Ore sandstone ridge, but actual outcrops are exceedingly rare. Ravines cut gaps of more or less prominence through both the Bloomsburg red shale and the Ore sandstone measures, but none of them are of sufficient size or depth to create good exposures of these measures. The upper Salina rocks having considerable outspread through this township by reason of the duplication brought about by the Slenderdale anticlinal, and in consequence there are some excellent farming lands exhibited there between the Ore sandstone ridge and the Flintstone ridge.

The Hiester valley, lying north of the Shamokin synclinal, while consisting of the same rocks existing on the arch of the Slenderdale axis, is eroded 100' to 150' lower topographically than the valley on the south side of this basin, by reason of the steeper monoclinal dips which everywhere occur there.

The *Lower Helderberg limestone* in the north leg of the Shamokin synclinal has been opened in several places about a mile west of the Perry township line on both sides of the public roads.

Limestone quarries.

Widow Garhart's quarry east of the road, is one of the largest showing, a long narrow side hill cut with 35' of stone exposed on 40' S. E. dip. The stone is poor and the quarry in bad condition.

A. Hackenberg's quarry is about 100 yards west of the road; small and with the same characteristics. Both of these openings have evidently been idle for some time and

in addition to them are two small quarries opened close to the creek partly in the upper Salina and partly in the bottom of No. VI.

Near the top of the ridge at the road crossing there are three dismantled kilns on the east side, which were once supplied from three small holes now also abandoned. Developments were very meager here, only sufficient to show a thin and rather shaly series of bed in the upper part of No. VI, dipping from 50° - 60° S. E. and close to the line of the Shamokin synclinal.

West of the public road there are the following quarries, opening in order from the east westward: 1. Mitterling. 2. J. G. Honberger. 3. Schaeffer. 4. Bodgeger. 5. Strawser. 6. Gordon. 7. Schraeder.

The first four quarries are practically one, and extend for about 250' along the ridge, and all show a rather poor grade of brittle stone on a northwest dip of 50° . They are sparingly developed; the stone is broken and irregular, and what little work has been done so far has rather tended to destroy than enhance the commercial value of the quarries.

No. 5, *the Strawser quarry*, shows some little improvement both in the quality of the stone and the character of developing it; but the Gordon and Schrader quarries, practically one opening 75' long, 30' deep, are the only ones showing a first-class quality of stone and well developed as far as they go.

The lime industry must naturally languish here, from the fact that coal for burning must be hauled, at the expense of \$2 a ton, all the way from McKee's Half Falls on the Susquehanna river, confining the use of lime almost solely to the quarry owners and a few local farmers. Even with this great expense added to the use of lime as a fertilizer, the excellent appearance of the farms hereabouts fully justifies the use of quarry products, and a more general extension of its use to the slate valley further down Mahantango creek would eventually improve the condition of the lands there.

The *Oriskany sandstone* for the most parts is eroded from the ridge west of the road crossing; and at the ridge is of

synclinal structure, a removal of the top soil here would expose a magnificent series of limestone beds to economical development, a fact which cannot be too strongly emphasized as bearing directly upon the agricultural interests in this section of the county.

J. Graybill's quarries are located at the extreme western end of the ridge north of the M. E. church, where two kilns are operated upon stone taken from a small quarry at the roadside on northwest dips of about 25° on the south side of the synclinal. The old quarry, further east, shows a dip of 60° , N. W.

The limestone ridge on the south side of the Slenderdale axis extends for 3 miles east of the Richfield Gap to the Perry township line; but no quarries have ever been opened on it, owing to the fact that its crest and flanks are thickly covered with chert rock from the overlying Oriskany sandstone.

Both Nos. VI and VII are well exposed north of the U. P. church in the Richfield gap, on 40° S. E. dips, where No. VII is probably 40' thick. The latter rocks are again well shown north of the blacksmith shop on Hannabach's run.

The *Marcellus black slates* fill the Buckwheat valley to the south of this ridge, between which and West Mahantango creek the Hamilton measures create a prominent ridge extending west into Juniata county. Along the north base of this ridge the Lower Hamilton shales outcrop on dips of 60° , S. E., but exposures generally are meager and unsatisfactory.

CHAPTER VI.

*Mifflin county.**25. Armagh township in Mifflin county.*

This township, one of the largest in Mifflin county, occupies the extreme northeast corner of the county. Bordering on Center county and Union county, on the north and east, it occupies the extreme eastern end of the Kishacoquillas valley. Its northern boundary is largely formed by the crest of Paddy's mountain, with a portion of the Long mountain spur in the extreme northwest corner. Jack's mountain is its southern border, its long straight crest making a high bounding wall, 11 miles in length, and separating this township from Decatur and Derry townships on the south. Brown township lies to the west towards the center of the Kishacoquillas Valley.

Armagh township averages about 14 miles in length and about 6 miles in width, thus giving it an area of about 84 square miles.

Nearly half of its area is occupied by mountain spurs, which, as the map will indicate, take the form of the letter W thrown upon its side, the inside lines being occupied by Strong's and Beatty's Knobs, with Paddy mountain on the north and Jack's mountain on the south forming the two outside and longer strokes of the letter. Between these spurs the three divisions of the Kishacoquillas valley extend like the fingers of the hand, narrowing from the western township line towards Union county, on the east.

These three divisions of the valley are known as the Havise valley on the north, Triester valley in the center, and the New Lancaster valley on the south. All have the same anticlinal structure and are composed of the same rocks, the Trenton and Chazy limestones and the Hudson river slates.

Milroy is the most important village of the township, situated at the end of the Milroy branch of the Pennsylvania railroad, on Laurel creek. Siglerville and Lockes Mills are additional hamlets, small, but very beautifully located on branches of Honey creek; the first at the entrance of Triester valley, about $3\frac{1}{2}$ miles east of Milroy; and the second about 2 miles south from Siglerville at the entrance to the New Lancaster valley.

The entire township occupies one of the most picturesque portions of the county, comprising an exceedingly diversified topography, due in part to the drainage of Honey creek and its numerous branches, and in part to the structure of the geological formations occurring there.

This township is largely drained west and south through Honey creek to the Kishacoquillas creek, and by this parent stream to the Juniata at Lewistown. The extreme northeastern corner of the township is drained eastward through Penns creek and its tributaries, Panther and Swift runs, to the Susquehanna; but the area so drained makes an exceedingly small proportion of the whole township.

The geological structure of the township is exceedingly simple, consisting, first, of the three anticlinal divisions of the main Kishacoquillas valley, separated by two synclinal mountains ending in Strong's knob and Beatty's knob. Second, the Jack's mountain monoclinical on the south and the Paddy's and Long mountain synclinals on the north.

These structural features are virtually an extension westward of similar saddles and basins existing in Union county, and which have been referred to in some detail in the general chapter upon the geological structure of the district.

All the mountain area of the township is composed of one or the other member of the same formation, IV, Oneida and Medina. An inspection of the colored geological map will readily show the distribution of the several members of this triple group throughout the township.

Thus in *Jack's mountain* on the south all three members are shown, occupying distinct bands on the map running east and west, dipping to the southeast and passing under

the Lewistown valley. These same rocks once arched completely over the New Lancaster valley, as they are indeed actually seen to do further east in Union county, to form the synclinal of Beatty's knob. The knob itself, forming a high triangular area just east of Lockes Mills, is composed of the gray Oneida sandstone. About 2 miles east of the end of this spur, the Oneida sandstone is split to receive the red Medina sandstone, which overlies it geologically and by reason of its more ready erosion usually creates a flat and sometimes an interior valley between the Oneida forming the terrace, and the white Medina sandstone, forming the main backbone of most of the mountain ridges of the district.

Beatty's knob being a synclinal, the dip of the rocks all converge towards a central line, those on the north side dipping north.

Strong's knob structurally presents exactly similar features, the rocks arching over Triester valley and forming a synclinal basin in this mountain. A reference to the map however, will show that this synclinal basin is somewhat deeper than that of Beatty's knob, and as a necessary consequence it contains a larger and wider area of the white Medina sandstone.

Paddy's mountain on the north shows again a repetition of the same rocks and with similar structure; but its synclinal is deeper than either of the two already mentioned, and shows the further peculiarity of deepening on the east and west sides of the township and a shoaling up towards the center. Thus in going over the mountain through McLellan's Gap in the Havise valley, after passing over the gray slates and shales of No. III, the Oneida sandstone No. IVa makes quite a bold outcrop at the first bend of the road passing north from the valley with dips of about 70°, N. 25° W. Proceeding still further the red Medina sandstone and slates No. IVb are also well exposed on the same dip, a small stream cutting quite deeply into them around the head of which the old mountain road leads. The Medina white sandstone No. IVc comes in still further up the mountain slope, first on a dip north, and then just beyond

the Centre county line on a south dip, so that the synclinal here formed is composed entirely of the white Medina creating a wide flat, along which the county line runs. This flat is a water-shed from which Panther run flows eastward to Penns creek and Laurel creek flows westward to finally emerge at the Milroy gap and join the waters of Honey creek. From this flat also the mountain gradually divides into two parts both to the east and the west, caused by the gradual deepening of the synclinal, and soon has separated sufficiently to permit of an area of the lower Clinton shales No. V in the valley between the two component parts of the mountain.

To the west of this sand-flat the southern division assumes the name of *Paddy's mountain*, whilst the northern portion is known as *Long's mountain*. A small anticlinal, entering from Centre county, causes a further duplication of the white and red Medina strata in the extreme north-west corner of the county, which is well exhibited along the Milroy and Bellefonte pike.

The two areas of *Clinton* rocks just mentioned, contained within this mountain area, are the only rocks of that formation which exist in this township; and owing to the very wild and wooded condition of both these valleys it was not possible to obtain any good outcrops or to estimate the total thickness of the Clinton rocks occurring there. It is not probable however, that the *Ore sandstone* member of No. V with its fossil ore, exists in either valley; nor was it possible to ascertain any facts relative to the condition of the lower *Iron sandstone* member in this part of the field or the ore which sometimes accompanies it.

The colored map will show what a considerable portion of the township is occupied by the *lower Silurian* limestones and slates Nos. II and III. The limestone belt is nearly 3 miles wide along the Milroy railroad, and in going south from Milroy to the Brown township line on Honey creek, both the Triester and the New Lancaster valley anticlinals are well exposed.

The *Triester valley axis* crosses the railroad only a short distance south of Milroy and a little below the road leading to Siglerville. The crest of the anticlinal shows dips of N. 20° W., 40° and S. 20° E., 60°. Going east along the Siglerville road, the north dips decline in strength to 20° in good blue limestone, well exposed in the vicinity of Ramsey's and McNitt's houses, and on the west side of the stream. The No. III slate is met with on a 20°, S. E. dip just after crossing the streams at F. McClintic's place, but the *cleavage planes* in the slate dip from 70° to 80° to the southeast and must not be taken for the real stratification. The road-cut in these slates is an extensive one. The slates are generally shaly and brown in color, although containing several bands of hard calcareous deep blue layers, which are largely made up of an impure limestone. The north end of the exposure exhibits the slates brushed up and folded, they are very much crushed. There may be a small *fault* here, north of which the dip is about 60° N. W., but it is small and insignificant, and does not appear to have any lateral extension.

The Triester valley anticlinal is also well marked at Siglerville, passing just south of the school house and exhibiting there a splendid exposure of excellent blue limestone. On the east side of a small creek in a *quarry* about 150' are seen, dipping S. 30° E., 70°. This may possibly be an overturned dip, as in the next 200 yards and near the bend of the road, the rocks do not dip more than 35° or 40°. There are several *sink holes* in this part of the valley along the crest of the anticlinal, interrupting the visible flow of the stream just as is the case along the main creek south of Milroy.

About 2½ miles east of Siglerville the limestone of the valley is completely covered up by the next higher formation, No. III Hudson River shales and slates, which continue from that point east to occupy the valley exclusively into Union county.

At the forks of the road 1½ miles east of Siglerville, a small exposure of limestone with dips of 25°, N. W. and 40°, S. E. serve to once more locate the position of the

anticlinal. The last exposure of limestone was seen just east of the school house, where it outcrops along the road and has been quarried considerably for farm use. Its quality is generally excellent, although no very massive beds are seen.

Beatty's knob, as seen from this point, shows a very low Oneida terrace, extending up the valley and enclosing the much higher Medina formation in the center. The south dip of these sand rocks, therefore, must be quite gentle.

The *New Lancaster valley axis*, between Beatty's knob and Jack's mountain, is not nearly so strong a flexure as that of Triester valley, as is evident from the fact that it only succeeds in elevating the limestone measures to a little beyond Locke's Mills, while the more northern axis has kept its arch crowned by these rocks for nearly 2 miles further east. Along Honey creek this axis is seen between the railroad station and the school house, just east of where Honey creek leaves the township.

Near the contact of the limestone and slate the former dips towards the southeast about 40° . At McFarlane's saw mill the dip is about the same, opposite Honey Creek station 35° , and in an excellent exposure at Smith's quarry on the east side of the railroad just above Honey Creek station, the limestone, 125' thick, dips with great regularity 30° or 40° to the southeast.

Limestone quarries.

Smith's quarry is actively worked through most of the year, both for paving and road purposes, as well as for farm fertilizing. The limestone has a dark blue color through most of the quarry, is well jointed and shows quite a distinct cleavage.

The dip is soon reversed going north, being 50° N. W. at the school house near the intersection of the Locke's Mills road, and 25° N. W. in *Naginney's south quarry*. Still further north along the pike the dip is again reversed on the north side of the succeeding synclinal to about 5° S. E. in *Naginney's upper quarry*, where there is a splendid expo-

sure of nearly flat massive blue limestone beds with joints from 6'-10' wide and nearly perpendicular cleavage. This quarry was not in operation, but there is much good limestone contained in it, and the conditions should be favorable for working it economically.

Continuing this section still further north, the south dips on the south side of the Triester valley anticlinal are found to gradually increase to 10°, 15° and 25°, up to Siglerville road, beyond which, toward Milroy, exposures are scarce and the dip uncertain. One good face of Trenton limestone however is exposed on the west bank of Laurel creek nearly opposite the Milroy hotel, dipping N. 25° W. 43°, which serves to establish the structure at this point.

Naginney's cave.

The waters of Laurel creek sink between Milroy and Honey creek in several places, but more especially is this noticeable in the vicinity of Naginney's cave, where the limestones are peculiarly cavernous. The cave itself is a natural well about 25' deep, with steep walls formed of limestone dipping from 8°-10° towards the southeast. The mouth of this cave is now considerably filled up with rubbish and *débris*, but the entrance was sufficiently open to expose the stalactitic character of the formation, and to suggest the possibilities of a great opening beyond. In the vertical opening to this cave 80'-100' of limestone is exposed, largely magnesian in character, but containing some good fat limestone beds near the top. This cave somewhat resembles the well known *Penns valley* cave in Centre county, where, however, there is an abundant stream of underground water coursing through the cavern, which has been eroded from limestone dipping at angles of 65°.

The character of the limestone in the vicinity of Naginney's cave can be fairly well shown by the two following partial analyses made by Mr. R. H. Lee Jr., of the Logan Iron and Steel Works, and kindly submitted by him for use :

Naginney Upper Quarry. Limestone No. II.

	<i>Top Vein.</i>	<i>Middle Vein</i> (Glamorgan flux).
H ₂ O,	2.82	—
SiO ₂ ,	11.93	2.20
Al ₂ O ₃ ,	5.28	1.22
Fe ₂ O ₃, . . . . .	.30	—
CaO,	31.43	52.82
MgO,	10.87	.986

It is not known exactly from which portion of the extensive exposure at this quarry the samples were taken; but the results show in a general way the fact that both magnesian and fat limestone occur in the lower Silurian formation of the Kishacoquillas valley, in close proximity to one another, just as has been demonstrated by innumerable analyses in other parts of the state where the same formation occurs. In this special locality the middle portion of the exposure seems to be the best, and carries the least amount of silica and magnesia; but no casual inspection of the quarry exposed would enable the most careful observer to detect the different varieties of stone without the aid of chemical analysis, for which there was no provision.

The New Lancaster Valley axis maintains its strength fairly well beyond Locke's Mills, carrying the slate of No. III on its back well into Union county. The valley is not travelled beyond Swartzell's sawmill, and the exposures to the east of that point are very unsatisfactory and meager. Just east of Locke's Mills the slates along the road dip N. 40° E., 10°–15° in Beatty's knob, from which the rather gentle character of the anticlinal may be inferred.

From Locke's Mills down Honey creek the public road is always in limestone. Only one exposure however was seen, just beyond the first bridge, showing a blue slaty limestone of Trenton age, dipping about N. 15° E., 40° into the synclinal.

Leaving the forks of the road to Honey creek station, and taking the Milroy road, a beautiful ledge of limestone shows at creek level, dipping only 10°, N. 50° E. The slates in this trough extend to within a short distance of the road, and as the road turns north towards Naginney's, the lime-

stones are seen to lie perfectly flat in a bluff on the west side of the creek.

The *Havise Valley anticlinal* attains its greatest strength in this township, elevating northeast of Milroy an oblong area of limestone about 3 miles long, and in its widest part a little less than $\frac{1}{2}$ a mile broad. This area of limestone closely marks the position of the anticlinal axis, which passes east into Havise valley and finally into the White mountain spur of Union county; westward its course is not so plainly marked, being somewhat overshadowed by the *Slate Ridge fault* in Brown township; but it crosses Laurel creek about a mile north of Milroy, and closely follows Lingle valley to its head, and thence into the Broad mountain range of Huntingdon county.

In the road and along the dam back of Moore's (?) grist mill at the mouth of Havise valley, the *No. III slates* dip 10° and 15° towards the southeast. This is not far from the line of the Strong's knob synclinal, for in a short distance south towards Siglerville, the slates are well exposed on a 30° , N. W. dip. Between the mill and the limestone area just described, the slates dip from 60° – 65° towards the southeast, the first outcrop of limestone showing along the road near Shaw's mill, and a little east of Wagner's house, with a dip of S. 30° E., 52° . The limestone area occupies an extremely thin strip of land at this point and it is doubtful whether it extends far beyond Shaw's mill. The road from Moore's mill directly west to Milroy runs close to the southern outcrop of the limestone area for about 2 miles, showing one dip of 50° , S. E. in an exposure just west of the school. Where the road begins to turn south beyond Thompson's house and runs across the synclinal, the slates of No. III are almost continuously exposed to Milroy, dipping first 40° to the south and gradually flattening to 25° near the synclinal. The first north-dips on the south side of the synclinal axis are at angles of about 10° , but going south towards Milroy this dip increases to 30° and 40° . In the half mile along which these slates are exposed they exhibit several subordinate flexures of no very

great lateral extent, and all having less strength and regularity than in the main axis. The slates have been largely dug here for road purposes for which they seem to be admirably adapted, many of them being quite sandy. In going up Laurel creek north to Milroy these slates are again passed over, making a broad flat with comparatively few exposures along which the Milroy pike has been laid.

The *Oneida sandstone* is splendidly exposed in the Laurel Creek gap, exhibiting an overturned southeast dip of 80° and showing at least 200' thick. The normal dip of this rock at this point is to the northwest, and its *overturn* in the gap may be associated with the effects of the *Slate ridge fault* some 3 or 4 miles further west. Much of the Oneida sandstone at this point is conglomeritic, being made up of small red and white rounded pebbles, occurring in separate beds, distinct from the more fine-grained sandstone layers. It forms a terrace ridge much lower than the main Medina crest of Paddy's mountain occurring further north.

The pike extends for some distance in a *red Medina valley* between the two mountain ranges, and just before reaching the base of Paddy's mountain, lays bare an excellent exposure of the No. IVb red sandstone and slate in a small quarry, where the rocks have been worked for repairs to the pike. The dip at this point is N. 38° W., 40° , but the slight exposure of the *white Medina* sandstone is strangely enough again *overturned* at an angle of 80° to the southeast, and varies between 80° to 90° , north to the junction with the Clinton rocks No. V, whose lower sand and shale members dip about 85° towards the northwest.

A short distance north of this contact line, where the pike crosses the creek, the Clinton *Iron sandstone* is exposed upon a similar dip and beautifully shows in its curving strata the structural effects of the district. A synclinal axis succeeds a short distance north, occupying the valley of Laurel creek and coincident with the main axis of Paddy's or Long's mountain. Ascending the crest of this mountain to the Centre county line no exposures of the

Medina white sandstone were seen, and only one of the Medina red sandstone which has been already mentioned dipping 50° towards the southeast.

The small area of the *Clinton rocks* occupying the valley of Penns creek in the extreme northeast corner of the township has already been referred to. This is a triangular shaped valley narrowing gradually along Panther run, and about one-half a mile wide at the Union county line between Paddy's and White mountains. It is altogether about 4 miles in length and does not seem to contain any Clinton rocks even as high as the Iron sandstone member, and consequently no iron ore.

The Lewisburg and Bellefonte railroad, which occupies this valley as far west as Paddy's mountain tunnel exhibits some few rock exposures in its cuts; but they are so much crushed and covered with *débris* from the mountain that they are of slight service in delineating the special features of the Clinton formation in this part of the field. The railroad tunnel is driven through the white Medina sandstone No. IVc, and issues on the north side of the mountain in a valley of the red Medina No. IVb. The first dips of the *Medina white* at the north portal of the tunnel is S. 20° E., 60° – 65° and the entire formation here seems to be composed of a white and brownish sandstone, close grained and with irregular joints, about 200'–250' thick. At the south portal the dip is 80° to the southeast, beyond which there is a sharp local roll in these Medina rocks with a north dip of 55° and a south dip of somewhat greater strength.

The same rocks appear again in White mountain on the south side of the synclinal, with dips of about 65° to the northwest; and along the tramway extending from the tunnel through the Swift run notch there is a good exposure of both IVc and IVb N. 29° W. 59° . Immediately behind this gap the central ridge IVa takes its rise before splitting westward to enclose the Havise valley.

26. *Brown township in Mifflin county.*

This township lies immediately west of Armagh and in a large measure copies its structural and geological features. Like Armagh it has Jack's mountain for its south bounding wall, the southern township line extending along the Medina crest of that mountain for about 6 miles. By reason of the offset in Huntingdon county the north township line along Long mountain is only about 3 miles long, giving the township a roughly trapezoidal shape. In a north and south direction, between crests of the two bounding mountain walls, the township is about $7\frac{1}{2}$ miles wide, and as its width will average about 5 miles its area may be roughly set down at about 40 square miles.

Drainage. With the exception of a small branch of Stone creek, watering the narrow Clinton valley between Brush ridge and Long mountain, the entire drainage of the township is into the Kishacoquillas creek and thence to the Juniata.

Reedsville is the most important village in this township, situated close to the junction of the slate and limestone and immediately north of the Logan gap in Jack's mountain. At this point the main Kishacoquillas creek receives its two important tributaries: Honey creek from the east draining the large township just described; Tea creek from the north entering the valley from Broad mountain through Cooper's gap, about 3 miles northwest of Milroy.

Anticlinal axes.

Kishacoquillas valley has a quite uniform width of about $2\frac{1}{2}$ miles, flanked on either side by the Hudson river shales and slates No. III, dipping northwards on the north side into the Broad mountain and southwards on the south side into Jack's mountain. The valley itself in this township shows two distinct anticlinals, the western prolongation of the Triester and New Lancaster valley axes. The former is well exposed on Tea creek, about $\frac{1}{2}$ a mile south of the junction between Nos. II and III, making a very even and regular arch in the limestone, with equal dips of

30° north and south. The latter axis extends westward from Honey creek station in Armagh township, passes into Brown township about $\frac{1}{2}$ a mile north of the railroad through quite a distinct limestone ridge, and crosses the Reedville-Milroy pike a short distance south of the Presbyterian church, with south dips of from 40°-55°, but without satisfactorily exposing the north leg of the anticlinal.

Between these two axes along Tea creek there are several *subordinate rolls* as indicated by the dip arrows on the map. Thus south of the Triester valley axis the dips increase to 70° before being reversed in a small subordinate axis with dips of 50° to the northwest and 80° to the southeast. This latter dip is almost immediately followed by one of 30°, which dip seems to continue with some minor rolls and *crimples* as far south as the Presbyterian church. From the church south to the Tea creek crossing the dark blue and more massive beds of the formation crop in ledges several hundred feet in thickness upon a pretty regular dip of S. 40° E, 45° to 55°, all the way to the junction of the slates at Reedsville.

The *Trenton limestones* near the junction of No. III seem to be much lighter in color than through the central portion of the valley, and some of the more massive ledges furnish most excellent building stone and sprawls for pike improvement, for both of which purposes they are considerably quarried. Much of this limestone, which occurs in such advantageous position and contains many excellent smooth grained beds, free from siliceous matter, should be found capable of furnishing excellent furnace flux.

Probable fault and overturn.

It would appear, after constructing a section along Tea creek, that without the explanation which a small fault would afford, the accumulation of limestone beds on the south side of the anticlinal is much greater than on the north; and unless this be explained either by a fault or by an almost excessive overturned dip, it is hard to account for an accumulation of limestone amounting to nearly 3000' in thickness here, not exposed to that extent elsewhere in the Kishacoquillas valley.

A section further west along Coffee run, from the woolen mill northwest to Barr's postoffice shows no such condition of affairs. The limestone crops out almost continuously from the pike to the headwaters of the small stream, first at angles of 40° to the south, and declining gradually in strength until, at Taylor's and S. Yoder's houses near the source of the stream, the dip is not over 6° . The southeast dip continues however for 200 yards still further along the road, at which point the anticlinal axis, corresponding to the New Lancaster flexure, is exhibited in a flat arch with dips of 2° north and south, made up of thin ribs of blue and gray magnesian limestone. The limestones seem to become more white in color, more magnesian and siliceous as the crown of the anticlinal is approached.

The *Logan Iron Company's quarry*, a mile further north, shows a small exposure dipping N. 35° W., 25° , evidently on the north side of the Triester valley axis, and now abandoned for better and more readily obtained stone.

On the road due south from Barr's, however, the axis itself is well exposed with dips of 80° north and south. Between this point and the No. III slates north of the village, the dips declines to 60° and 50° , but not so rapidly as on the south side of the anticlinal, where, in less than $\frac{1}{4}$ of a mile, the inclination is only 5° to the south, followed by one of 2° to the north, marking the line of *synclinal* between the two anticlinal axes. The New Lancaster valley axis shows here dips of 10° and 15° north and south and is gradually curving towards the southwest in obedience to the general structural features of the district.

Although Brown township has such a considerable area of limestone, there are no large *quarries* at the present time despite the facts that along Tea creek many excellent opportunities exist for the development of this industry.

Section in Logan Gap.

Logan gap in Jack's mountain, through which the Kishacoquillas creek finds egress from the valley to the Juniata river at Lewistown, presents one of the best sections of the

rocks overlying the limestone found anywhere in the district.

In approaching the gap along the Bellefonte pike from Logan to Milroy, the top member of No. IV, the *Medina white sandstone IVc* is excellently exposed at Mann's Axe Factory, dipping about 60° towards the southeast and a little more than 800' thick.

This rock is a light gray rather fine-grained sandstone, very hard and massive and weathering brown on the surface. It creates the main outside crest of Jack's mountain, facing the Lewistown valley, rising to elevations of about 2000' A. T. The township line dividing Brown from Derry, runs along the crest.

These rocks continue northwards about to the railroad station, beyond which the *red rocks* of the middle member IVb, appears on the same dip and continues to a point north of the toll house in the gap. They largely consist of a red argillaceous thinly laminated sandstone, which weathers much more rapidly than the white and gray sandstone above and below, and therefore give rise to a depression along the mountain crest. These rocks were carefully measured by Mr. Dewees and his party in 1874 and are reported in Report F as being 1280' thick.

The *Oneida red conglomerate* next appears upon a conformable dip, being a red and somewhat massive sandstone containing large pebbles, and has been largely quarried for use in constructing the factory dam. They are about 300' in thickness, and are underlaid by an equal amount of the *Oneida gray sandstone*, greenish-gray, hard and fine-grained rock, portions of which contain specks of oxide of iron, so that the whole lower member of No. IV is about 600' to 625' in thickness. This member dips about 45° - 50° towards the southeast and presents many massive ledges which should be very suitable for building purposes. Jack's mountain is here a monoclinical; consequently the different members of this formation succeed one another conformably and upon practically the same dip.

The *Hudson River black slates* succeed the Oneida sandstone just south of the railroad upon emerging from the

gap, and extend to a little beyond Reedsville, with dips declining from 50° to 35° in a belt over half a mile wide. They consist largely of bluish and yellowish gray slates, interbedded with thin bands of hard flaggy sandstone, and some little yellowish gray shale, with a total thickness of about 950'.

The *Utica slates*, making the lower member of No. III, about 1350' thick, are prominently exposed along the railroad cuts at Reedsville. They are generally dark in color and contain a good deal of bituminous matter, a fact which has unfortunately led to the expenditure of much money in futile attempts to discover coal in them. They likewise show very perfect cleavage planes, but they display a tendency to break up into small rectangular pieces soon after exposure, and do not seem to have any beds serviceable for roofing purposes.

They are immediately succeeded and underlaid by the top or *Trenton member* of the great limestone formation, whose rocks are well exposed for nearly a hundred yards along the north side of the pike east of the woolen factory near the road leading to Greenwood furnace. They present some good soft blue limestone beds, but are most shaly in character. The pike runs about on the strike of the rock through Brown township, and owing to the erosion of the Kishacoquillas creek through the softer slate rocks between the pike and the mountain, the limestones create an upland with many *sink-holes* and a rolling topography.

The north side of Brown township is largely occupied by the Medina and Oneida sandstone with the exception of the narrow Lingle valley in which the No. III slates occur, and the valley of Stone creek still further north, which is occupied by the lower Clinton shales and slates.

Paddy Mountain fault.

The geology and topography of this section of the township is somewhat confused by the Z-shaped fault which has been already mentioned in the chapter of structure. In going up the left-hand branch of Laurel creek, the Paddy

mountain range to the south of this creek is seen to gradually but steadily decline westward, until first its Medina crest and then its Oneida terrace are cut off in succession by the fault which at this point has a course of about N. 50° E. There is a low wind gap here, over which the wood road leads into Lingle valley, which at this point is in reality a high plateau encircled by the Oneida sandstone of Brush and Lingle mountains, whose convergence in Huntingdon county takes the name of the Broad mountain.

This plateau, known locally as the *Slate ridge*, has an anticlinal structure and rises to such a height as to fairly overlook the Brush ridge terrace mountain, which declines in elevation eastward, just as Paddy mountain does going west, until the point of *fracture* is reached. In other words a reference to the colored map will readily demonstrate that Brush mountain and Paddy's mountain were, at a time prior to the fault, one and the same ridge; and that after they had been torn asunder, Paddy's mountain was first forced southwards along the hade of the *fault* nearly 2000', and then pushed towards the southwest for nearly 6800.'

The shape of this *fault* is very peculiar, and though of considerable magnitude it does not seem to have had any appreciable effect upon the mountain south of Lingle valley, where the rocks lie in a normal and very gentle synclinal basin. This fault is shown more accurately upon the topographical map of the Seven mountains constructed by Mr. C. E. Billin, and a closer and more detailed instrumental study of the territory in Huntingdon county, intervening between this fault and the Stone mountain fault may serve to associate these two great breaks as one and the same fracture.

The slate terrace on the north side of Lingle mountain is very high and steep, so that the dip towards the southeast probably reaches 55° or 60.° The Oneida sandstone however, forming the crest of the outer ridge, dips only 35°, and the old wood road leading south through Cooper's gap to the valley passes through an interior valley of red Medina

sandstone and shale, displaying the Stone mountain or Milroy synclinal beautifully in south dips of 60° , flattening gradually to 5° or 10° , and finally showing dips of about 35° northwest on the south side of the synclinal.

This is also the dip of the Oneida conglomerate and sandstone so beautifully exposed in *Cooper's gap*, a wild and rugged notch in the mountain giving egress to the waters of Tea creek. Nearly 300' of these rocks show in an uninterrupted exposure, much of it massive and pebbly, and never dipping at greater angles than 35° . The ridge joins the Lingle mountain terrace about $1\frac{1}{2}$ miles east of the gap, forming the usual dome or knob so familiar a feature at the ends of all the synclinal spurs of this district. This point is known locally as *Straley's knob*, partly in Brown and partly in Armagh township and almost directly in line with Strong's Knob, 6 miles further east.

27. *Union township in Mifflin county.*

This township is in many respects a counterpart of Brown township just described, the main difference being the absence of much of the Broad mountain range which is here thrown into Huntingdon county.

Its northern line, separating it from Huntingdon county, is about 6 miles long following the different crests of Stone mountain. Its south line similarly follows the crest of Jack's mountain, and is about 5 miles in length, and between these two mountain walls, the township is about $4\frac{1}{2}$ miles wide. Its area approximates 25 square miles.

Structurally considered it is normally made up of a great anticlinal wave occupying the Kishacoquillas valley, with two monoclinical ridges of sandstone on the north and south; but this typical structure is modified to some extent by a continuation of the flexures already described in Brown township.

The *Triester valley anticlinal*, which was last noted as passing a little south of Barr's P. O., is but faintly visible in this township, and seems to die out completely before reaching the Menno line. It is, however, seen to make a notch in the outcrop of limestone just east of the public

road leading across the mountain from Belleville to Greenwood furnace, which is further confirmed by a satisfactory exposure of limestone near the western end of this little notch and west of the school-house, which shows a dip of 55° to the southeast. West of this point it seems to be entirely lost in the wide strip of slate outcropping along the base of Stone mountain; or its presence may be obscured by the Stone mountain fault.

The *New Lancaster valley* anticlinal enters the township along the pike west of Kishacoquillas P. O., and, keeping a southwest course, passes a little north of Yoder's G. M. and directly through the old Greenwood furnace ore banks. The first exposure of limestone on the pike dips about 35° to the southeast. About $1\frac{1}{2}$ miles west of the Kishacoquillas at the bend of the pike, the axis is well exposed with dips of about 30° in each direction. The limestones are exposed here about 50 yards along the road. They have a gray-blue color; are somewhat siliceous and occur in very thin beds.

The *Zook quarry*, about 1 mile east of Belleville and close to the north side of the pike, has been sparingly worked to supply the local demand for farm lime. The stone is hard and blue and occurs in thin ribs, none of it very attractive in appearance; but when burned it is said to make an excellent farm lime.

Greenwood ore banks.

In the vicinity of Belleville the dip is northwards at angles of from 15° – 20° , declining in strength to about 10° going southward to the anticlinal axis at the old Greenwood ore bank. This old mine was formerly actively worked and a considerable quantity of pipe-ore was conveyed from here across the Stone mountain for mixture with the fossil ore beds mined in the vicinity of Greenwood furnace; but it was abandoned many years ago, partly on account of the cost of mining and partly on account of the exhaustion of the ore. Like similar deposits in the Nittany and Penns valley districts of Centre county, the *Belleville ore* was found in pockets in the limestone, of varying size and per-

sistency, and from the very nature of the deposit it is not of course possible to say what amount of ore still remains at this point. But in the absence of any railroad communication and the expense of hauling the ore across the mountain to Greenwood, it is hardly probable that this deposit would receive any more attention in the immediate future than it has in the past.

Prof. Rogers in his first report, makes mention of a number of localities in the Kishacoquillas valley where, in former times, a very fair quality of limonite ore was mined; but, with the exception of the Greenwood bank, none of them seem to have furnished any quantity of ore, and in most cases all signs of the old workings are obliterated.

Limestone quarries.

Along the road from Belleville to the Union Mills on the Kishacoquillas creek most excellent exposures of limestone occur, dipping S. 55° E., 68° and 65° . North of Belleville the limestone dips towards the northwest about 15° , and in a small bluff on the north side of the creek on the Yoder farm, it has been quarried somewhat for farm use on a dip of N. 55° W., 10° . It has a blue-gray color, is hard and yet shows a slaty structure, looking more like a baked calcareous slate than good limestone. Only about 15' of rocks is exposed here in thin ribs from 6" to 8" thick. *In Hartzler's quarry*, still further north, the softer blue Trenton limestone comes in a 25° dip, well exposed, where some excellent fluxing stone has been quarried and conveyed to Greenwood Furnace.

A short distance north of this the *Utica slates* show along the road, but only one satisfactory outcrop was noted about 500 yards from the mountain, dipping 60° to the northwest. The same slates are seen on the road leading across the mountain from Barr's P. O., and outcrop well up the mountain road. In the valley they are so much decomposed and broken down that no satisfactory dip was observed, but as the road ascends higher into the Hudson River slates and thin sandstone about 100' of measures are exposed, dipping N. 22° W., 70° , not far from the junction of No. IVa.

The Stone Mountain fault.

The *Stone mountain fault*, though more largely affecting Menno township and Huntingdon county, passes diagonally through the northwest corner of Union, and thus accounts for the narrow strip of slate extending eastward between the two gaps of the mountain. The course of the mountain here is about N. 46° E., and that of the fault N. 33° E. This great fracture, which has split the mountain and slid the two divisions past each other for a mile, has already been minutely described in Report T³, p. 337, and its full effect is very clearly brought out on the colored map accompanying this report. On the south side of the mountain, close to the Union-Menno line, its effects have been severe enough to overturn the measures completely, well shown in a good exposure of the Hudson River slates just north of the Sutertown road which dips S. 20° E., 50°.

Perhaps 200 yards north of the road massive ledges of the No. IVa Oneida sandstone outcrop on either side of the stream, and dip S. 15° to 20° E. 35° to 40°, striking with the ridge. This little gap is exceedingly interesting, and while the structure of the district is by no means perfectly clear, the exhibition at this point throws considerable light upon the effect of the fault in the south ridge. The movement violent enough to overturn the mountain rocks 60° beyond the vertical, seems to have been confined to the immediate vicinity of the fault, passing just a short distance to the north of the terrace ridge along the little stream watering the gap between these two ridges.

In a distance of only 3 miles, and certainly only 5 miles to the east, the rocks in this same terrace ridge maintain their normal north dip with great regularity. And the same thing is true of the slates in the valley below as well as in the red and white Medina sandstones occurring above the Oneida rocks.

In the north division of the Stone mountain, or that part lying north of the fault, the rocks dip normally northwards at angles of 60° and 70°, and it would seem as if the whole southern portion of the mountain, after the break, was shoved bodily forwards and upwards along the upturned

basset edges of the main mountain mass lying west. The terrace of this westward mountain is the very summit of the gap and the highest point in the road abuts against the end of the crest of the mountain coming from the east, the fault line passing just at their junction. But the terrace of the eastern mountain, which is composed of the same Oneida sandstone and conglomerate forming the terrace of the western mountain, runs on westward from the road-crossing for about 2 miles, where it also is cut off by the fault. A line joining these two points will practically determine the line of fracture.

The position of the fault westward is concealed in the slate valley, although it is probable that it rapidly expires before reaching the latitude of Allison's gap, in Menno township.

28. Menno township in Mifflin county.

The township is the most western of those forming the Kishacoquillas valley in Mifflin county, although the valley itself continues westward for six or eight miles into Huntingdon county before being enclosed by the junction of Jack's and Stone mountains. These two mountain ridges are about $4\frac{1}{2}$ miles apart in Menno township and form respectively the southern and northern township lines. The northern boundary is about $4\frac{1}{2}$ miles long, while the Jack's mountain line is almost 7. The two ends of each of these boundary lines are joined by straight lines, giving the township practically the same area, 25 square miles, as that of Union township and a similar shape, only that the trapezoid is here reversed, the short side being on Stone mountain and the longer of the two parallel sides on Jack's mountain.

The geology of this township is almost an exact reproduction of that of Union, all the formations of the latter simply being continued a few miles further west without changing their character or relation to one another. The valley shows but one anticlinal axis, and by reference to the dip-arrows on the map, it will be seen that it is gradually declining in strength as the two opposing mountain walls

slowly approach each other. The crest of the arch bends more and more towards the southwest in the six miles through this township, and it is marked by a series of *sink-holes* as well as by frequent exposures of limestone with opposing dips. Entering on the east from Greenwood furnace ore-bank, it reaches Kishacoquillas creek about midway between the pike and the southern outcrop of the limestone, and keeps this geographical position until it passes out of the county at the west end of the township.

The arch is broad and flat, with steeper dips however on the south side than it has on the north. In consequence of this the limestone belt, which averages about two miles in width, is divided unevenly by the anticlinal, three-fourths of it lying on the north side and one-fourth to the south.

Along the pike near Annville the north dip is scarcely more than 10° or 12° . The limestone is slightly quarried north of the Amish church and south of Matier's S. M., dipping at the latter place about 20° to 25° towards the northwest. Near the village of Allenville there are numerous good exposures and some few small *quarries*; but none of them show a very extensive rock-section although all show a good smooth limestone.

There are some few exposures, mainly in the *Trenton* member of the limestone formation, along the back valley road which is alternately in slate and limestone all the way to the Union township line. South of Allenville the dip of the limestone on the south side of the axis is about 35° .

About $\frac{1}{2}$ mile east of the McVeytown road over Jack's mountain a good exposure of limestone was seen in a field on the south side of the public road where some excellent beds, 30' to 40' thick, have been quarried on a dip of S. 30° E., 45° . Very nearly the same strata outcrop for a mile or more east along this road and have been opened in a number of small quarries all of which show about the same dip.

There is a fine bluff of blue limestone about 50 yards north of the road on the property of *Samuel Wills* and about $1\frac{1}{2}$ miles east of the brick school house. The dip here is S., 35° E. 52° ; the stone is good and somewhat massive, which is not generally the character of these upper

limestone measures through the Kishacoquillas valley. A short distance west of the brick school house there was an old pit showing limestone dipping about 40° to the south-east, and some little wash *hematite ore* of the pipe variety was strewn around the mouth of the opening; but the indications of the presence of ore in considerable quantities at this point were rather negative.

The *Hudson river slates* are not very well exposed along the Jack's mountain side of the valley; but in addition to the outcrops already mentioned in describing the Stone mountain fault there is an excellent exposure just west of D. Hooley's house on the north side of the public road and apparently dipping N. 55° W., 40° . Another exposure northeast from this point and nearer the mountain shows a dip of 25° to the southeast, being *overturned* to that amount by the action of the Stone mountain fault.

Along the road leading north from Allenville across Stone mountain, the first good outcrop of No. III slates was seen in the rear of the Allenville factory, where the side hill has been bared by a long slide and the slates 50' to 75' in thickness have been well exposed. The gap here bears east along the strike of the rocks gradually ascending the mountain and showing the various outcrops of slate and thin sandstones dipping about N. 50° - 55° W. 40° - 30° , the latter near the junction of the slates and the Oneida sandstone No. IVa.

There is here a good section of the *transition measures*, slates and thin sandstone beds before the massive gray sandstone ledges of the Oneida group are met with. The latter becomes more conglomeritic towards the top of the formation, just as they do in the Logan gap section; but the conglomerate and accompanying sandstone is either gray or white, very little of the reddish variety seen in Jack's mountain being exposed here. The terrace mountain is about 675' above the valley; and between it and the main Medina sandstone backbone of the mountain there is a wide flat of the red Medina sandstone and shale in places so ferruginous as to have encouraged prospecting for iron-ore. All these attempts proved futile, as did also the ex-

plorations for coal in the Utica and Hudson river slates at the base of the mountain near the entrance to Allison's gap.

29. Decatur township in Mifflin county.

This township lies wholly within the Lewistown valley and therefore shows a very different geological aspect than any of the townships so far described. Like them, however, it has mountain walls bounding it; Jack's mountain on the north for a distance of 7 miles, separating it from Armagh township, and Shade mountain on the south for a distance of 9 miles, dividing it from Juniata county. Union county lies on the east, its two sides making a re-entering angle with the apex not far north of the Lewistown and Sunbury railroad. The west line of the township runs roughly north and south at right angles to the north and south lines, and is about $4\frac{1}{2}$ miles long. The area will not fall far short of 36 square miles.

Decatur and *Belltown* are two small villages in the northern portion of the township towards the base of Jack's mountain; and *Lillyville*, near the Derry line, in the Hamilton slate valley at the base of Flagstone ridge.

Painterville, *Soradoville* and *Wagner* are three villages and stations along the Sunbury and Lewistown railroad which are gradually building up independent populations.

The drainage of the township is entirely westward through Sack's creek to the Juniata river, the main stream receiving two considerable tributaries from the north, watering the Lewistown valley, as well as a number of smaller streams from Shade mountain on the south.

Structurally considered the township is one broad synclinal basin. But the Lewistown valley and Decatur township show subordinate saddles and basins which modify the regularity of its structure.

A cross section between the two mountains along the Union county line would merely show a normal synclinal basin, carrying a small portion of the Chemung group

forming a low central ridge, and succeeded north and south by the Genessee, Hamilton and Marcellus slates and sandstones; the Oriskany shale and sandstone; the Lewistown or Lower Helderberg limestones and shales; the Salina and Clinton marls, shales and sandstone, with the fossil-ore beds; and finally the Medina sandstone, forming the crest of each mountain. In other words the valley has the simple structure of a boat, each mountain forming a side.

This structure along the western township line however, is modified by the occurrence of *two anticlinal rolls* entering from Derry township, which carry on their backs a very limited thickness of the upper Salina lime shales. Both these axis gradually sink eastward, first burying the Lewistown limestone No. VI and then the Oriskany No. VII, whose sand rocks make two prominent knobs in the valley north of Lillyville.

Geologically this township begins about where the Kishacoquillas Valley township left off; that is to say the lowest rocks found here, making the crests of Jack's and Shade mountains, are among the highest found in the Kishacoquillas valley; and the section is continued from them upwards in the geological scale to the Hamilton rocks of the Devonian epoch No. VIII.

The Medina sandstone, as has been stated, makes the crest of Jack's mountain dipping south, and also of Shade mountain, where in the gap south of Wagner station, the dip is almost due north at an angle of 55° .

The Clinton rocks make a terrace upon the flank of each of these mountains, and although the outcrop of the *Iron sandstone* member of this formation is frequently indicated by boulders of altered fossil ore, yet no openings have ever been made, nor are the opportunities very favorable. The *Ore sandstone* lower down on each mountain forms a low terrace, especially well marked on Shade mountain. In Mitchell's gap, south of Wagner station, the Ore sandstone is from 20'-25' thick, much of it quite massive.

Formerly the *Sand Vein ore* was opened experimentally on both sides of this gap, dipping at high angles on the north and proved to be an altered fossil ore, alternating with clay seams. In the next gap, about a mile west, the Ore sandstone is again well exposed. Its thickness is about the same as in Mitchell's gap, but its layers are not so massive and are rarely over a foot in thickness. The *lower Salina* (Bloomsburg) red shales are well shown in this gap and are probably 150' thick.

The Gibbeney mine is located about $\frac{3}{4}$ of a mile still further west, and in an old drift close to the abandoned road over Shade mountain the Sand Vein has been sparingly developed, about 112 tons having been shipped to Logan. This drift is now entirely fallen shut; but the ore was reported to vary from 6" to 22"; contained about 40 per cent. of metallic iron, and 25 per cent. of siliceous matter. The dip is about 60° to the north. If the quality of the ore would justify its development a sufficient amount of breasts could be obtained here to make the workings profitable. The "Sand rock" underlying the Sand Vein is a coarse ferruginous rock at this point, about 3' thick, and beneath it the *Danville ore beds* seem to be represented by a considerable outcrop of soft fossil ore.

About a mile south of Painter's station mention is made in Report F of a tunnel driven about 80' through the lower Salina shales, cutting the Sand vein about 12" thick, which was found to be composed of fossiliferous limestone and hard fossil-ore. The opening was abandoned on account of the leanness of the ore and the inaccessibility of the opening.

From this point westward there are no further openings on Shade mountain.

No developments have ever been made in any of the Clinton fossil ore beds along the flank of Jack's mountain between the Snyder county line and Logan gap, although many of the outcrops are of such a character as to warrant the belief that good ore may yet be found there.

The Logan Iron and Steel Company own a very large range of this mountain flank, extending for some 8 or 10

miles east from Logan gap ; and as they have always supplied their wants from other localities, there has been no occasion to institute developments in this portion of their territory. The Clinton rocks rise well up the flank of the mountain, so that the dip will be quite steep, and wherever the ore ridge has been cut down by small mountain streams a considerable quantity of favorably located soft fossil ore should exist. Owing to the high dip of the rocks (50° - 60°) the space between the mountain and the Limestone ridge is greatly contracted towards the Union county line, and as there are but few water gaps in this ridge, the ore in the mountain is not very accessible.

The Devonian rocks No. VIII occupy nearly half the area of the township and have a total thickness approaching 2500' on the eastern end. Westward from this point the synclinal valley shoals up, so that west of Lillyville only the Marcellus and Genessee slates are contained in the trough between the railroad and the Flagstone anticlinal ridge to the north ; while the narrow vale between this ridge and the second anticlinal before mentioned contains only the Marcellus black slates, here largely concealed by sand drift from the two Oriskany ridges.

At *A. Bishop's* place in this vale some *carbonate iron ore*, decomposed at its outcrop to hematite, has been found ; but no openings have been made. It is probably an eastern extension of the valuable bed so successfully mined at the *Townsend mine* of the Logan Iron and Steel Company in Derry township.

The crest of the ridge north of this narrow vale is composed of the Oriskany sandstone measures, here very largely decomposed and making a flat or plateau of white and yellow sand.

Bishop's limestone quarry, a little east of the road crossing, had developed some fairly good beds of a blue and gray, rather crystalline limestone, dipping S. 30° E. 50° . The quarry is small and is possibly located in Derry township. The limestone in the north leg of the anticlinal is

standing vertical, and the fold is a very tight one. The limestone is of course Lower Helderberg, No. VI.

The road east into Decatur hugs the south base of the *Oriskany* ridge which has here largely fallen into sand and shows no rock in place. The road bends twice north into the limestone measures of the Limestone ridge, at Sigler's and at the old mill site, where the limestone has been *quarried* considerably on its 60° S. E. dip.

Going south to Lillyville along the creek the first anticlinal is well marked at the school house; here however only strong enough to carry the brown and black Marcellus slates No. VIII on its back, dipping 40° and 45° towards the north and south.

Lillyville closely marks the main synclinal of the valley, and a shaft has been put down here to some depth under a false impression that the black and polished faces of the slate would eventually guide the prospectors to *coal*. It is needless to say that such an attempt will unquestionably lead to the same failures experienced elsewhere under similar circumstances; but no matter how frequently the warning is proclaimed that no commercial coal beds need be expected either in these slates or in the equally deceptive black slate beds of the Utica and Hudson river formations No. III, companies are organized through this and adjoining counties in the hope of finding a coal bed.

The *Freedonia mine*. East of The village of Decatur, on the north side of the valley, and close to the junction of Nos. VII and VIII, if not in the former, the old *Freedonia* ore bank shows an open cut 125' long and 20' wide, now filled with water, from which a considerable amount of rather lean hematite ore was mined. The *Oriskany* sandstone ridge rises only about 100' above the valley at this point. The dips are steep, which causes this ridge and the limestone flanking it on the north to approach closer and closer to the mountain. As the two prominent anticlinal flexures on the western side of the township subside

north of Lillyville, the main valley south of Belltown deepens to receive a larger section of the rocks of No. VIII; so that the central line of the trough is strongly marked by the presence of a prominent ridge of Hamilton sandstone, quite overriding the Oriskany ridge at Belltown where No. VII is thin and slaty.

The Belltown school is situated on the crest of a sandstone ridge associated with the Hamilton rocks, and a good view of the Clinton terrace on Jack's mountain can be had from this point. In Belltown proper the Marcellus black slate crops along the road, with a southeast dip varying between 65° and 80° , within 300 yards south of the Oriskany sandstone ridge. This is the only evidence that the anticlinal west of the village of Decatur is still in force at this point. The dip is almost immediately reversed going down Belltown run. Further east the Oriskany ridge becomes more and more subordinated to the Hamilton ridge as it approaches closer to the mountain.

The Medina IVc crest of Jack's mountain is gapped for the first time east of Logan gap near the Snyder county line.

Crossing the valley from this point to Wagner station the main synclinal is well marked on a 70° S. E. dip near D. Yetter's house by a good outcrop of slate in a branch of Jack's creek; and on a reverse dip of 35° N. W. in a good exposure of the same brown slates, 20' thick, just at J. Yetter's mill dam:

The Oriskany ridge on the south side of the valley is quite low, and is only indicated by the frequent occurrence of slaty sandstone boulders embedded in loose sand. No. VII cannot be over 50' thick in this portion of the valley. And hereabout, together with the limestone south of it, it must have a rather low dip.

The road from Wagner to Shindel runs along the north flank of this Oriskany ridge, which however is entirely obliterated in front of Oswell's and Mowry's gaps, and does not take form again until at the junction of the Lillyville road, where the Oriskany sandstone shows in a bluff

on the west side of Sack's creek about 40' thick, and dipping northwest and northeast 35°.

The Goss Bros' quarry of Lewistown limestone, immediately south of this point, on a conformable dip and on the north side of the creek. This quarry is very small and is opened in the lower portion of the limestone formation where the beds are somewhat slaty and impure. The Painterville gap in this limestone ridge shows a very flat dipping limestone outcrop 60'-70' thick, capped with a thin covering of the Oriskany sandstone No. VII.

It should be remembered by the people of Decatur township in seeking a development of the limestone measures through this portion of the valley, that the hill facing the creek and the railroad on the north, between Wagner and a point a mile west of Shindel, is not composed of limestone and sandstone at all, but of the No. VIII slate, and consequently they must seek for the limestone further north towards Jack's mountain. Immediately north of the Wagner tannery in a large sink-hole on the south flank of the Oriskany ridge the No. VI limestone dips 35°, N. W.

30. Derry township in Mifflin county.

This township lies immediately west of Decatur and though of somewhat irregular shape, it has for its main north and south boundaries the same two mountains. The north line along Jack's mountain is 6½ miles long; but the south line dividing the township from Juniata county only runs along the crest of Shade mountain for about ¾ of a mile, when it is offset in a southwest direction, corresponding to the Juniata county line, and reaches the Juniata river in "the Narrows" about 2 miles west of Grahamville.

The Juniata river forms its south line and a portion of its west line up to Lewistown, where the west line diverges northwards for 2 miles to the Ferguson valley road and is slightly offset there to the west before taking a parallel north course a mile and a half to the crest of Jack's mountain. The county therefore averages 6 miles in length east

and west, and 5 miles in breadth north and south, with an area of about 30 square miles.

Lewistown, the county seat of Mifflin county, although having its individual borough lines, is essentially a part of this township; whilst *Logan* on the Kishacoquillas creek and the Milroy Branch R. R., with its important iron and steel industries, makes another center of population. *Yeagerstown*, located on the pike immediately north of Logan, is strung out for nearly a mile towards the Logan gap, and is largely occupied by the employés of the Logan Co. and Mann's Axe Factory. *Maitland Station* on the Lewistown and Sunbury R. R. about 5 mile east of Lewistown is a village in the southeast corner of the township.

The Kishacoquillas creek flows in a southerly direction across the western end of the township from Logan gap to the Juniata river at Lewistown. A mile still further down the river *Jack's creek* enters, flowing westward from Decatur township along the railroad for 3 miles before cutting across the Clinton foot hills to the north base of Shade mountain.

The Logan and Lewistown sections, Report F, plates 7 and 8, were constructed in 1874, by Mr. J. H. Dewees and his assistants. Both these sections are illustrated in that report and both show two double synclinal ridges of Oriskany sandstone and shale, one known as the *Prospect Rock basin*; the other and more northern, as the *Dry Valley basin*. Both these synclinals hold small portions of the lower No. VIII or Marcellus rocks, whilst the anticlinal valley between them is occupied by the Lewistown or Lower Helderberg limestone No. VI.

North of the Dry Valley basin along the Kishacoquillas creek, there is an anticlinal of the Salina rocks, which, increasing in strength westward; brings to daylight in Granville township the underlying ore sandstone; and eastward, in Decatur township, passes through the most northern of the two anticlinal loops there, but so far decreased in strength as to be saddled only with the upper Salina marls and the Lewistown limestone.

Between this axis and Jack's mountain there is a regular

and normal synclinal holding the upper Salina shales, crossing the stream near the northern limits of Yeagertown; from which point successively lower strata rise (going up stream) on dips of 55° - 58° ; until at the entrance to the gap the white Medina sand-rock No. IVc complete the section.

South of Lewistown the same section which occurs between Yeagertown and the gap is duplicated, only with reverse dips, the rocks in this part of the field inclining towards the north and northwest at angles varying from 30° to 50° .

The *Shade mountain*, which is of anticlinal structure, ends at the Juniata river, which after passing its end just below Jack's creek, turns almost at right-angles eastward and flows through the narrow *synclinal* valley of lower Clinton rocks between Shade mountain and Blue Ridge known as "the Narrows."

There are no good exposures of the Medina sandstone in Shade mountain, although a vast quantity of loose boulders of this rock flank its sides and give an especially wild and rugged aspect to the "Narrows."

Jack's mountain is of similar rock, and the character and thickness of its three members as exposed in Logan gap have already been described in Brown township.

Lewistown itself is situated upon the upper Salina shale and marl, which is so calcareous at this point as to readily account for the great fertility of the soil here. The first ridge north of the town is composed of the Lewistown limestone No. VI, which (with the exception of one small anticlinal roll about 2 miles east of Lewistown, causing a slight reversal in dip and an interruption in the course of its outcrop) spreads directly eastward in a prominent ridge just north of the Lewistown and Sunbury railroad into Decatur township. The crest and north flank of this ridge is everywhere composed of the Oriskany sandstone and shale, which, with the underlying limestone at Lewistown, dips from 40° to 45° to the northwest. Both of these formations are well exposed on the Milroy pike near the toll-house, and are succeeded northwards by a band of Marcellus black slate with a similar dip.

This slate in its turn is overlaid by a siliceous "*cement rock*," 10' or 15' thick, which at one time was *quarried* by Mr. Stratton for the purpose of producing *fire-brick*. Although this material made a good clay, the fire-brick resulting from its burning was found to contain too large a percentage of sand mechanically mixed through it, so that in a hot fire the bricks were apt to run.

A small thickness of gray slate overlies this rock to a shallow and tight synclinal basin of only local importance, reversing the dip to 70° southeast. A small anticlinal roll succeeds this going north along the pike crested mainly by the cement rock, but exposing a little of the underlying black slate. The dips here are 25° to the N. W. 70° to S. E.

This synclinal basin of VIII is succeeded by a narrow strip of the Oriskany sandstone measures approaching the Mt. Rock G. M., showing dips of about 50° to the southeast and at the mill, by an excellent exposure of the Lewistown limestone and shale.

A narrow anticlinal valley of the upper Salina shales succeeds the limestone going towards Logan, and they in turn sink beneath a synclinal of limestone making the middle of the three limestone ridges between Lewistown and Logan and capped by isolated areas of the Oriskany sandstone.

This hill is synclinal in structure, like that at Logan, and between them there is an eroded valley of the upper Salina shales and marls which create a very fertile belt of farm land passing right through the center of the township.

The Logan synclinal holds only limestone at the creek; eastward, as the basin deepens, the hill splits first to receive a central ridge of Oriskany sandstone which in its turn is divided to receive the narrow tongue of Marcellus slates in which the Townsend iron mine is situated.

It is almost impossible to describe minutely the various structural features of the valley here, for there are many subordinate flexures which are wholly of a local character, but which for a space exercise a very important influence in affecting the economical features of the township. With the colored map in hand, however, and an inspection of the dip-arrows, it will be readily seen how the same rocks are

repeatedly folded in the center of the valley, but finally rise upon each side of it on the flanks of Jack's and Shade mountains.

The *Clinton rocks* proper occur only along the flanks of these two mountains, none of the subordinate axes having been strong enough to lift the Ore sandstone member of this group to daylight between the two main opposing outcrops which create terrace ridges on the inside flanks of the mountains.

Mann's Factory Mine. The *Ore Sandstone* is about 20' thick in front of Logan's gap, and 25 years ago the Messrs. Mann opened the Sand Vein ore bed on the bank of Kishacoquillas creek, where it is reported to be about 18" thick, but mostly hard ore. The Danville beds (lying beneath or further north than the Ore Sandstone) were also found at this point, three in number and spread through about 15' of rock. The largest was from 12"–15" thick, and an analysis of the ore that came from them is given as follows in Report F, p. 17:

Iron,	26.100 per cent.
Sulphur, . . . . .	.051
Phosphorus, . . . . .	.544
Carbonate of lime,	47.018
Carbonate of magnesia,	2.240
Insoluble residue,	9.610

An old abandoned drift is still partially accessible at about 40' above water level on the east side of the stream. At this point a gangway was driven some distance into the hill and is said to have developed soft ore entirely. The bed dips 56°, south, and was from 16"–18" thick, about 12" of which was good rich ore. Above this bed and separated by a thin stratum of sand-rock, another bed of fossil ore was found. None of these points could be verified, as the drift cannot now be entered. A specimen of the ore was taken from the opening whilst it was actively worked, and yielded as follows:

Iron,	46.900 per cent.
Sulphur, . . . . .	.005
Phosphorus, . . . . .	.310
Insoluble residue,	22.880

These analyses are inserted here merely to give an idea of the character of the ore formerly found at this point, for it is claimed that there still exists a very large body of ore here; and being so advantageously situated for working there does not seem to be any good reason why an active operation should not be maintained here if it would pay to work such fossil ore beds of equal thickness anywhere else in the county.

Some prospecting was once done south of Midland station about 4 miles east of Lewistown on the Shade mountain outcrop of the Ore sandstone, which proved a good soft fossil ore corresponding to the Sand Vein dipping about 40°, northwest, and from 16" to 18" thick. No ore however was shipped from here.

The *Danville ore beds* were also said to have been opened "16 inches thick and of good quality." West of this point to the Juniata no developments have ever been made, although Jack's creek in gapping the Ore sandstone ridge should offer an excellent opportunity for opening the fossil ore beds on their end if they existed here of sufficient thickness and quality.

Above or inside of the two opposing outcrops of the Ore sandstone there is a varying width of the upper Clinton and lower Salina (Bloomsburg) shales, which make a moderately good farm land and are largely cultivated; but the farm lands *par excellence* through this valley are those underlaid by the next highest series of rocks, the *upper Salina shales and marls* *Vc*, which outcrop along the base of the limestone ridges on either side of the valley as well as between two of these ridges to the east of Logan.

In many parts of Mifflin and Juniata, these *upper calcareous shales* are frequently interstratified with bands of red shale so like the Bloomsburg red shales of the *lower Salina* group as to make it difficult to subdivide the two groups on the map by any intelligent system of coloring. In Union and Snyder county the Bloomsburg red shales make a distinct horizon wherever they occur, as there are rarely any red bands occurring in the upper Salina rocks between the Bloomsburg shale and the Lewistown limestone.

Both members of the Salina group, as well as the lower Clinton rocks are exposed on the Kishacoquillas creek in the vicinity of Yeagertown. North of the village the soil is generally gray, largely due to the decomposition of the calcareous shales of the upper Salina group here reposing in the synclinal. At the Ferguson valley road however there is an excellent exposure of the Bloomsburg red shale with some thin sandstone and a little olive and blue slate all dipping S. 30° E., 75°. About 100 yards further north and nearer the grist mill, a reverse dip of 75° to the northwest is seen in similar measures, although the olive and green shales predominate here and really make the crest of the Ferguson valley axis, under which the Ore sandstone and its fossil ore beds lie buried at least 400'.

The Ferguson valley road practically divides the Bloomsburg red shale from the upper Salina measures, although some few red bands are seen between the road and the limestone ridge to the south. The latter rocks show generally thin bedded blue limestone and shale dipping S. 35° E., 35°. Ascending the ridge they become thicker, until near the summit some good limestone beds outcrop, although it is probable that the best beds of the series have been eroded at this point. Lime, however, is quarried and burned at a small *quarry* on the summit of the ridge where the stone is somewhat twisted and is both shaly and siliceous.

Along the south base of this ridge the limestone and shales dip fully 70° to the northwest, so that the synclinal basin containing the limestone measures is very much compressed at this point.

This section is repeated on the next ridge south, only here the entire limestone series is present, the hill being capped with a small outcrop of Oriskany sandstone. The south dip in this ridge is about 50°; but the north dip is very steep, if not slightly overturned. A test drift had been put in at this point through the Stormville shales a little beneath the Oriskany sandstone outcrop on *Hort's property* with the object of finding iron ore. It does not seem to have been successful.

The succeeding anticlinal south only carries the Salina lime shales ; but in the flank of the next ridge to the south the limestone shows in good condition, dipping steeply southwards and largely quarried for road purposes as well as lime burning for several hundred feet along the pike.

Limestone quarries.

At the *Stratford quarry* here about 60' of good limestone is quarried and burned for farm and plaster purposes. The dip is about 50° to the southeast ; therefore the good stone has a tendency to bury itself beneath the ridge.

At the *Mt. Rock grist mill* several massive beds are exposed in a section of limestone and lime shales aggregating nearly 350' in thickness. The Oriskany sandstone south of this point is about 30' thick and is too hard and cherty in character to be serviceable for glass purposes.

Logan Iron and Steel quarry. The most important quarry opened in the Lewistown limestone in this township is that of the Logan Iron and Steel Company, who obtain from it their furnace flux. This quarry is located immediately back of their furnace, and is situated geologically exactly in the synclinal basin, the rocks lying very flat at the opening and rising north and south from its center. All their furnace stone is obtained from the middle division of the Lewistown limestone, the formation being naturally divided here into three members: 1. An *upper member*, about 10' thick; 2. A *middle member* of good pure limestone from 50' to 60' thick, and solely used for obtaining the furnace flux; 3. A *lower member* 20' thick. The upper bed is very fossiliferous, and shows a high percentage of alumina and siliceous matter, the lower member is very siliceous. So that it may be said that all the good limestone is confined to the central member, about 60' thick.

Mr. R. H. Lee, Jr., chemist, reports the following to represent the usual average character of this central member of the formation *as a furnace flux*, and only in respect of the silica, alumina, iron and phosphorus present in the raw limestone.

SiO ₂	1.580 per cent.
Al ₂ O ₃	1.004
Fe ₂ O ₃ . . . . .	.237
Phos. . . . .	.016

The furnace of this company was remodeled during the summer of 1888 and shows the following dimensions now: Height, 50'; bosh, 9'; hearth, 5'. There are four tuyers, each 4". Height of bosh above bottom, 16', and an output of from 18 to 20 tons a day.

The furnace was built in 1862 and has been largely run upon coal-blast charcoal iron since the time of its erection. Since its alteration it has been put on coke, and the ore charge during the summer of 1888 was a mixture of roasted Townsend carbonate ore, Ferguson valley fossil ores and some mill cinder.

Townsend ore bank.

The *Townsend ore bank*, from which the largest percentage of the ore supply for this furnace was being obtained during the season of 1888, is situated on the Townsend farm of the Logan I. and S. Co., in the narrow valley on the eastern side of the township between the two Oriskany sandstone ridges. It is about 4 miles east of Logan.

The ore occurs immediately above Oriskany sandstone, a thin clay seam being the true foot wall; and the clay, by reason of local rolls, occasionally enters in wedge shaped masses into the bottom ore. The hanging wall is a smooth black slate, making a firm roof, so that the timbering in the mine is nowhere very extensive. The scarcity of good lumber, however, makes the little timbering that is done an important item of cost. The ore is a *carbonate of iron* and rather sulphurous, the iron pyrites occurring irregularly in thin flat seams through the ore mass rather than in any finely disseminated crystals through the ore lumps. Consequently when roasted (by which about one-half the total percentage of sulphur is eliminated) very little coal is required after the fire is once started, the burning sulphur completing the operation of roasting.

Very little oxidation has taken place in the surface ore as only about 5' or 6' of the bed has been altered to oxide

below the outcrop. But in the large abandoned open-cut workings, immediately east of the present shaft, a very large portion of the ore deposit had been converted into oxide, and was nearly all mined as wash *hematite* ore. This large cut was 200'x60'x60', and its great width (60') was no doubt due to local rolls on each side of a distinct local anticlinal axis, which was just beginning to develop itself at the east-face workings of the new mine when visited in May, 1888, about 70 yards east from the shaft.

The present shaft has been sunk from a point well up the flank of the ridge, 100' deep to the ore-bed and 8' further for a water-sump. The normal dip of the ore-bed is fully 80°, towards the southeast; and as the shaft is situated but a short distance in front of the outcrop there will not be over 115' to 125' of breast-work in the mine above its present level. The ore above the first level had all been worked out, while that in the second had been developed in May for 30 yards west and 70 yards east of the shaft towards the old open cut working.

The underground gangways are driven along the hanging-wall which forms the best and most secure guide, and the bed developed in the lower workings showed usually from 6' to 9' in thickness, although in places the ore mass swelled out in bunches over 20' thick. The foot-wall had not been reached at all places, so that it was not possible to say what the true average width of the ore-bed would be; but in any event the deposit is one of great value to the company, and one of great interest geologically as tending to show the richness of the *Marcellus ore* throughout this district, and the importance of an intelligent search for it.

The ore-bed looked better in the west gangway of the mine than on the east side of the shaft, where the ore seemed to contain some little admixture of clay. Throughout this lower level however, the ore body presented an exceedingly attractive appearance, and gave every indication of maintaining a persistent workable thickness well beyond the limits of the workings at that time. Fully $\frac{1}{2}$ and perhaps $\frac{2}{3}$ of the ore mined from the shaft is lump-ore, which is taken directly to the two roasters situated at the mine; the

balance of the ore is put through washers before roasting. Until exploitation had demonstrated the presence of a suitable body of ore here, mining had been carried on in a rather primitive manner; but during the early summer improvements were projected for the more economical handling and washing of the ore, so as to permit of its being delivered at the furnace 4 miles distant at a minimum cost.

In the absence of any railroad connections all the ore, after being roasted, is hauled to Logan by 6 horse teams, carrying from 4 to 6 tons each, and costing about 55 cents a ton to deliver. The Logan I. & S. Co. were mining about 500 tons a month at this point; and since the mine was regularly equipped for active development in 1830, it has furnished about 60,000 tons for use in the manufacture of the well-known Logan irons. The analyses of this ore, kindly furnished by Mr. R. H. Lee, Jr., shows the surface ore to contain from 31 to 37 per cent. of iron; 30 per cent. silica; and 0.5 to 3 per cent. of sulphur.

The 100' level shows about 40 per cent. of iron; only 6½ per cent. of silica and about 3 per cent. of sulphur, while the roasted lump-ore gives from 55 per cent. to 57 per cent. of iron, 12 to 16 per cent. of silica and about 1 per cent. of sulphur. These analyses of Mr. Lee's can be best shown in tabular form:

<i>Towsend Mine Carbonate Ores: Unroasted.</i>		<i>R. H. Lee Jr., Chemist.</i>	
<i>Average ore near surface.</i>		<i>Lump.</i>	<i>100' level.</i>
SiO ₂	31.20% 30.09%	29.98%	6.43%
Al ₂ O ₃	7.35 7.40	.099	2.65
P	0.097 —	—	—
H ₂ O	8.56 —	—	—
Fe	31.37 —	37.44	39.41
CaO	— —	—	1.12
S	— .437	3.14	2.93
<i>Roasted Lump-Ore from 60' level.</i>			
FeO		79.19	81.96
Al ₂ O ₃		4.38	2.22
SiO ₂		12.42	16.25
P		.137	.162
S		.896	1.12
Iron		55.43	57.37

It requires about $1\frac{3}{4}$ tons of raw ore to make a ton of roasted, and the latter variety is alone conveyed from the mine to the furnace.

Other indications of ore have been noticed on properties east and west of the Townsend farm; but no developments have been made as yet. There is also some little outcrop on the south side of the little synclinal valley, but the surface specimens appear to be rather siliceous.

On the south side of the main valley there is a good exposure of the *Lewistown limestone* in the rear of the *Lewistown water-works* dipping N. 20° W., 50° , and a similar one on the east side of the Kishacoquillas creek nearly opposite. Though once sparingly quarried at the point, the beds are very thin and impure, and occur near the bottom of the formation.

East of this point the Lillyville road crosses both the Lewistown and Oriskany outcrops and run through the main synclinal valley here occupied by the Marcellus and Hamilton slates. The Oriskany sandstone, making the crest of both ridges enclosing this valley, is very fine-grained and not over 40' thick. Its outcrop in the south ridge doubles upon itself about 2 miles east of Lewistown, with the effect of widening the valley eastward towards Maitland Station. A short distance east of doubling, a central ridge composed of Hamilton sandstone and shale rocks occupies the valley between the two Oriskany ridges and maintains that position eastward through Decatur township.

The gap in the limestone ridge north of Maitland exposes the *Lewistown limestone* opposite the old mill-dam, where 30' or 40' of good stone, associated with the middle member of the formation, dips N. 25° W., 30° . South from here a small anticlinal roll reverses the dip just at the mill, but is soon followed by a flat basin and then a 25° N. W. dip; all of which serves to broaden the outcrop of this good limestone and presents it in the gap to very favorable development.

Henry Stein and *Thomas Arnold* have opened *quarries* on the last (25°) rise and on the east side of the public road. The former was temporarily abandoned; but the latter quarry was being actively worked and displayed two principal divisions, an upper gray and rather siliceous limestone 20' thick, and a lower dark blue limestone, some of it showing a conchoidal fracture, in all 70' thick, in beds from a few inches to several feet thick. The burned stone from this lower division is largely used for plaster lime and fertilizing purposes. Mr. Arnold stated his output at from 20 to 25 thousand bushels per year, using a ton of pea coal for every hundred bushels of lime. The prices during last season were 6 cents "for run of quarry" stone and 10 cents for "screened lime."

There is no Oriskany sandstone capping the ridge at this point and no evidence of it in the gap, and if it exists at all it is entirely as shale. The limestones make a fine bluff on the south side of the ridge facing the railroad, and are underlaid by some buff-colored magnesian limestone. The upper Salina marls and shales occupying the valley of Jack's creek through which the railroad runs.

Going north from the Dunkard church in the valley, the synclinal is well marked by outcrops of brown ferriferous shales (No. VIII) just above the brick school-house with converging dips of 60° . North of this the road bends sharply eastward around the point of a narrow ridge, showing thin bedded but hard gray sandstone belonging to the Hamilton division dipping 80° to the southeast, and creating quite a terrace ridge upon the flank of the Oriskany ride to the north.

The *Marcellus slates* lie between these two ridges. In ascending the plateau which they create, outcrops of the *Marcellus limestone* and some little *hematite ore* were noticed, corresponding geologically to the Townsend ore located in the next valley to the north. The Oriskany sandstone in this hill, which is known locally here as the "*Flagstone ridge*" is considerably iron-stained, and rather coarse grained. The Lewistown limestone and the upper

Salina shales occur along its north flank and about a mile to the east fold over the anticlinal axis as before described, subsiding there beneath a high knob of the Oriskany sandstone east of Stroup's place.

31. *Granville township in Mifflin county.*

This township lies immediately west of Derry and with some minor differences simply continues its geology westward.

Jack's mountain forms its northern boundary for 6 miles and Blue Ridge its southern boundary for about $8\frac{1}{2}$ miles.

The Juniata river divides Granville and Derry townships from the county line as far west as Lewistown, and from that point north to Jack's mountain these two townships have a common dividing line.

The western line is somewhat irregular. Leaving the Medina crest of the Blue Ridge near Minehart's gap, the line is a straight northwest one for 2 miles to the Juniata river a short distance west of Anderson station. Thence it follows down the river a short distance to the mouth of Strode's mill run, thence following that stream north for about 2 miles to the crest of the third Oriskany ridge north of the Lewistown and McVeytown pike. From the summit of this ridge the line is again straight for nearly 2 miles to the summit of Jack's mountain at the Belleville road.

Its area may be roughly set down at 40 square miles, averaging a little over 6 miles each way.

The *Juniata river* flows sinuously through the southern portion of the township in a fertile plain of Salina rocks.

Strode's mill creek, rising in the Ferguson valley ore ridge, flows directly across the measures to the river at Lockport.

Ferguson valley, like the valley of the Juniata, is composed of the lower and upper Salina measures, largely lime-shales and marls, but containing a number of thin bands of red shale, especially in that portion nearest the base of the Ore Ridge.

There are no villages of any importance in this township, though its ores, rocks and farm products make it one of the richest townships in the Juniata valley.

Structurally it is as much broken up as Derry township to the east of it; and yet, bearing in mind the key to the structure already explained there, the confused mass of ridge and valley land in the center of the township will reduce itself to perfect order and simplicity.

Between the Lewistown valley and the Ferguson valley there are 3 synclinal ridges, containing Oriskany sandstone No. VII, and a small thickness of the Marcellus slates No. VIII in narrow valleys eroded between the several ridges.

The rock series of the township is comprised between the Medina rocks No. IVb and c in the two bounding mountains, and the bottom layers of No. VIII.

Just northwest of Lewistown the first Oriskany ridge is split along the center for nearly two miles and contains therein a slate valley of Marcellus rocks; but this little valley narrows rapidly until the two opposing walls of the ridge come together and furnish the *magnificent section of grass sand-rocks* quarried by the Juniata Sand Company about 4 miles west of Lewistown. A little anticlinal flexure north of their quarries serves to spread the outcrop of this sand-rock over a broad plateau 350 to 400 yards wide. The final dip on the north side of this ridge is to the northwest, the sand-rock passing down beneath a second Marcellus slate valley, which begins at the Derry township line north of Lewistown and extends southwestward as a narrow strip coincident with the *Ross Ore Bank synclinal* north of McVeytown.

This narrow valley is best known under the name of "Squaw Hollow," in this township and as "Dry Hollow" further west.

The succeeding anticlinal north of this basin carries the upper Salina lime shales on its crest for three miles west of the Derry township line and beyond that it is an arch of the Lewistown limestone to the Oliver township line. In this latter township it again increases in strength sufficient to bring up the Salina measures, so that at a point some-

where along Strode's mill creek this anticlinal is most depressed.

The high rough ridge to the north of it forms the third basin ; but it contains no slate, being composed entirely of the Oriskany sandstone measures tightly folded and eroded at the eastern side of the township where the two public roads cross it into Ferguson valley.

This basin is known best as the *McGurk synclinal* in Granville township, and corresponds with the *Logan synclinal* containing the Townsend ore-bank in Derry township, and with the *Dull and Bradley Ore Bank synclinal* in Oliver township on the west.

The north flank of this ridge is composed of the Lewistown limestone and shales, usually dipping toward the southeast, though at varying angles. Ferguson valley lies immediately north from here, and as already stated contains the Salina rocks dipping towards the southeast and passing conformably under the Lewistown and Oriskany measures to the south.

The *Ore Ridge anticlinal* lying immediately north of Ferguson valley and between it and Jack's mountain has become strong enough to elevate the Ore sandstone on its crest $2\frac{1}{2}$ miles west of Yeagertown and about one-half mile from the Derry line. The rapid rise of this axis may be inferred from the fact that along the Kishacoquillas creek this same Ore sandstone cannot be less than 400' beneath water level, so that in $2\frac{1}{2}$ miles this rock has been sufficiently elevated to make a prominent ridge containing a double outcrop of the Sand Vein-ore-bed.

In a little over 2 miles from its eastern end the anticlinal is further split along its crest, and westward begins to develop a narrow synclinal, duplicating the two exterior outcrops of the Sand Vein and presenting within a very narrow compass four outcrops of the fossil ore-bed, all of which have been proved and opened at various points along the range.

The synclinal between this ridge and the mountain, in coming westward from Yeagertown, rises at about the same rate as the anticlinal, and flattens at the same time, so that there is but a small thickness of the lower Salina shales exposed in it in the center and western ends of the township.

Between this axial line and the mountain there is another outcrop of the Ore sandstone and fossil ore, which occurs everywhere along the south flank of Jack's mountain and east of the Kishacoquillas creek forms the *only* outcrop of this rock and ore on the north side of the Lewistown valley in Derry and Decatur townships.

The Blue Ridge on the south side of Granville township carries a similar outcrop on its flank, only dipping north instead of south. It makes a prominent ridge along the base of this mountain, by which the Ore sandstone can be traced almost to the Juniata river, but before reaching the railroad it seems to double on itself around the Shade mountain anticlinal, for it is next seen a mile north of its mountain outcrop just on the crest of that axis dipping 60° and 70° to the north and south respectively. From that point it strikes eastward for a mile across the big bend of the Juniata river, touching that stream about midway between Mr. Miller's house and Lewistown Junction.

Chestnut Ridge.—In addition to the several outcrops enumerated, the Chestnut Ridge anticlinal, which originates somewhere in the plain west of Lewistown, likewise succeeds in elevating the Ore sandstone and its accompanying fossil-ores to daylight a little over a mile east of Strode's mill run, so that again there is a double outcrop of ore running from the eastern end of the ridge west into Oliver township.

Along Strode's creek the *Iron sandstone*, a still lower member of No. V, makes the crest of the arch with dips of 5° to 10° north and south. Here the dip of the Ore sandstone has increased to 15° in the north leg of the anticlinal and about 25° in the south leg.

The *Sand Vein ore* was at one time slightly mined in this gap, but most of the work done was in the nature of stripping. The *Ore sandstone* is about 15' thick at this point and quite massive, which character it maintains throughout the ridge to the west. Beneath it there is about 20' to 25' of siliceous shale, under which the *Danville ore-bed* group occurs, calcareous and fossiliferous, and about 9' thick. It

contains two ore beds, but neither of them seem to have been rich enough to warrant their being mined much. The upper one is said to have been about 16 inches thick, but was very largely a hard fossiliferous limestone containing little iron.

The *Sand Vein* was once very actively developed along its southern outcrop between Lockport and the eastern end of the ridge, the Glamorgan Iron Company being the last lessees of the property. Some 45,000 tons of ore were mined here for the Lewistown furnace prior to 1873; but there was no record obtained of what these mines furnished during the last 15 years. The bed was about 15" thick and must certainly have been a very good ore. Stopes from 30 to 50 feet were made from water level to the top of the ridge, all of which space furnished soft fossil ore. In addition to this fact, the south dip after the bed passes beneath the water level, is so very gentle going towards the river, that a large quantity of soft ore was obtained by stripping the overlying shales and lifting the ore as in a quarry.

No developments have been made along the Blue Ridge and it is highly probable that the fossil ore beds here are both thin and siliceous. The same is true in a great measure of the Jack's mountain outcrop, although a considerable quantity of fossil ore marks the presence of the Sand Vein ore bed on the mountain and would suggest the propriety of developing it. However there are but few gaps along the mountain flank to afford natural access to the ore bed by entering it from the ends, and the presence of much more favorably located ore in the anticlinal ridge of Ferguson valley has no doubt deterred any very extensive exploitation along Jack's mountain.

Ferguson Valley Ore Ridge.—At the extreme eastern end of the ridge the *Keever ore bank* was opened on the northeast dip of the *Sand Vein*, which was found 16 inches thick, but with a rather shaly bottom. It was found largely as hard fossil ore and not rich in iron, so that the opening was soon abandoned. In the next mile west the ore ridge

is low and affords very little stoping ground ; and most of the mining formerly carried on there was in the nature of stripping the small amount of soft fossil ore occurring above water level and then abandoning the locality for some fresh outcrop. The dips of the ore bed are about 35° northwards and 20° southward.

Felker opening.—The first opening on the southeast dip is on property of the Rev. Mr. Felker, from there in order westward are W. R. Graham's three openings on both dips ; John Snyder on the south dip ; Joseph Snyder on the south dip ; the Phillips or Cuppel's openings on both the south and north dips of the *south* anticlinal, and finally the series of openings on the south dip on the property of George McKee. In all of these openings the *Sand Vein* furnished a medium quality of soft fossil ore from 16" to 2 feet thick.

Phillips' opening.—The only active operation carried on in this entire ridge during the season of 1888 was that of Mr. Phillips on the old Cuppels property. The drift he was working was situated on the east side of the road leading across Jack's mountain to the Kishacoquillas valley. The opening is about 20' above the level of the road and perhaps 50' above the little stream which cuts through a portion of the Ore ridge here sufficiently to expose the several outcrops to east attacks. The gangway is driven eastward for about 30 yards on a north and nearly vertical dip in the south leg of the narrow synclinal here present. Then it crosses through the "Soap Stone" slates contained in the synclinal and strikes the north leg of the ore basin on a 60° S. E. dip, and has been carried further east on this bed perhaps a hundred yards and considerably stoped. The bed is about 16" thick here, occasionally carrying a thin seam of slate, 5" or 6" from the bottom ; and near the ends of the breasts where they are stoped out to the outcrop some 70' above the level of the gangway, the bed was seen to stand nearly vertical. On the south side of the ridge the ore is from 20"—24" thick, but there is very little room for stoping before the outcrop is reached.

Only four miners are at work here in May, 1888, obtaining an output of about 8 tons a day, all of which was

taken to Logan furnace. In part of the mine a rotten brown sandstone, a few inches thick, corresponding to the *Sand Rock* was seen to occur between the ore and the Ore sandstone. Beneath the latter Mr. Phillips reports that he has found two seams of ore close together each about 3'' thick, which may correspond to the *Danville beds*.

This mine is $6\frac{1}{2}$ miles from Logan, where, during the last season, the ore was laid down at a cost of \$2.20 a ton, divided nearly equally between mining and hauling.

An analysis of the lump ore from the Phillips mine, made by R. H. Lee, Jr., gave :

Fe,	46.89
SiO,	24.00
P, . . . . .	.372

The *McKee mines* near the Olive township line were abandoned about 2 years ago and were last operated for the Glamorgan Furnace Company, of Lewistown. A number of abandoned openings were seen on both sides of the Ore ridge. An old water level drift was driven eastward on the south outcrop, all the way to the Cuppels' line, a distance of about 40 rods and pretty thoroughly stoped out. The north outcrop at this point furnished only hard ore and has therefore been worked to a very limited extent.

The ore bed is from 15''-18'' thick, occasionally containing a small band of slate or *Jack* near the bottom of the bed, which carries about 16 per cent. iron and 58 per cent. insoluble residue. The southeast dips in the Ore ridge here amount to about 45°, and the Sand Vein yields about 36 per cent. iron and 35 per cent. insoluble matter.

In the synclinal the dips are not over 25°, so that the two central outcrops are much further apart here than where Phillips works them further east. On the north side of the ridge the dip is about 45°, while the mountain outcrop inclines southwards at an angle of about 30°. The *Ore sandstone* here is from 15'-20' thick.

Much information is given by Mr. Dewees in Report F, Chapter VI, pp 59 *et seq.*, concerning the various developments along this Ore ridge. He certainly had many opportunities of studying the ores and their associated rocks, for

during his inspection of the field many of the banks were in active operation, supplying ore to the Lewistown furnaces and perhaps to the outside trade.

As before mentioned, the Phillips mine was the only active one during 1888 and it was found practically impossible to enter many of the old openings which had been abandoned and allowed to fall shut.

Limestone quarries.

The *Lewistown limestone* beds have not been developed to any extent in this township, although they make three distinct bands outcropping in an east and west direction through the center of the township; one along the south flank of the southern Oriskany synclinal ridge, and the other two upon either side of the northern synclinal ridge.

Col. Wm. Willis' limestone quarry is situated about a half mile west of Lewistown and a short distance north of the pike near the base of the ridge, and is opened in the middle member of the limestone formation. About 600 to 800 bushels per month are quarried here for building and fertilizing purposes. The land is leased by Mr. W. Lash and the quarry is opened just near the crown of a small anticlinal roll, which is beautifully preserved in the lower part of the quarry and may have some connection with the Chestnut ridge axis, which, 3 miles further west, elevates the Ore sandstone to the surface, as already explained. At the quarry the limestone dips are N. 35° W. 50°-55° and S. 35° E. 30°; but above the crown of the arch there is an irregular wedge-shaped mass of limestone, as if the arch had been *broken and squeezed* together, and which has somewhat retarded the development of the quarry. The beds beneath this wedge are much more regularly arched. When seen during May, 1888, none of the stone exposed at this quarry seemed to be of first-class quality. The top stone was ribby, somewhat siliceous, and about 40' thick, beneath which there was some 20' of more massive beds which the quarrymen called "cement beds" and which after being burned furnished a lime which does not swell nor set well. The bottom layers along the arch

seemed of better quality ; but for reasons already stated they had not been developed. The quarry is about 100' long and has been worked for some time. Some of the beds are quite fossiliferous. Burnt lime sold here for farm purposes at 6½ cents per bushel ; building lime 15 cents per bushel.

Owen's quarry, about a mile west of the Juniata Sand Company quarry and just beyond the small anticlinal roll which duplicates the Oriskany and Lewistown formations along the pike the limestone is opened in a small quarry on Owen's property, dipping N. 38° W. 45° and exhibiting a medium quality of stone, poorly exposed. West of the first small stream going towards Strode's Mill, the limestone is reversed locally with a southeast dip of 60°.

The strip of country immediately south and west of this point through which the dirt road passes is composed of the upper Salina lime shales, furnishing a rich and fertile soil. These same rocks are well exposed along Strode's Mill run, north of an excellent exposure of the Bloomsburg red shales at the mill dam which dips northwards at angles of about 50°.

Northwards from this point the Salina marls become more and more limy approaching the first synclinal ridge. The lower member of No. VI limestone outcrops with increased dips of fully 80° near the saw mill, where the massive middle members are first well exposed making distinct ledges over which the creek falls to the saw mill. The limestone has been slightly quarried here and shows an excellent series of beds from 4'-8' thick, and in all about 80' thick.

Limestone quarries.

Spangler's quarry.—Along the road from Lewistown to Ferguson valley Jacob Spangler's limestone quarry is first met with on the south flank of the first ridge : dip about 50° N. W. The quarry is opened in the middle member of the formation, although but a small portion of the series is developed. The stone shows a dark blue color and is of even texture, well suited in every way for both building

and farm purposes. It is, however, more largely quarried for road ballast. The Lewistown limestone shales come in on the top of this quarry, showing a thickness somewhat over 100'. The middle ridge north of this point is much higher than either of the two others.

At *J. A. Shaw's*, near the south base of this central ridge, the lower part of the middle Lewistown division is exposed on the crest of an anticlinal with dips of 60° and 40° north and south. Limestone forms the crest of the third ridge at the road crossing, and north of Snyder's blacksmith shop shows a dip of S. 30° E. 30°. A little south of the crest the main member is partially opened 20' thick upon the same dip.

L. Aurand's limestone quarry is about $\frac{1}{2}$ a mile west from the blacksmith shop and just south of the new school house on the Ferguson valley road. It has been opened in the north leg of this synclinal and shows about 40' of thin and cherty beds on a S. 35° E. dip of 25°. One band, about 10' thick, divided into layers, from 6 inches to 1 foot in thickness, shows a fair quality of dark blue stone; but the balance is rather inferior. This quarry now belongs to Mrs. A. Kochendoffer, and is operated entirely for local farm use.

On the crest of this same ridge some $2\frac{1}{2}$ miles further west and south of the new Ellen chapel, the middle division of the limestone formation is exposed on a dip of S. 30° E. 80°, and in the gap in this ridge along the western side of the township through which Strode's Mill run flows, the limestone formation outcrops between the Ferguson valley road and the small mill dam but nowhere very well exposed.

Glass-sand quarries.

The *Oriskany sandstone measures* are very well exposed in all three ridges of this township, and attain a thickness of over 100' in addition to the Stormville shale formation which is usually associated with No. VII and occurs between the sandstone and the top of the Lewistown limestone formation No. VI.

The *Juniata Sand Co.* have made the largest developments in the Oriskany sandstone in this township and their quarry or mine, situated a little over 3 miles southwest of Lewistown on the north dip of the first or Prospect Rock synclinal ridge, is one of the oldest glass-sand operations in this district.

A new tunnel or drift has been recently started at this quarry at an elevation of about 34' vertically below the old tunnel. It is about 300' long and passes entirely through the first Oriskany sandstone synclinal into a southeast dipping bastard limestone on the north side of the basin.

This tunnel is about 100' west of the old opening. The first 150' passes through the Stormville shale, dipping about 50° northwest; the balance largely through the Oriskany sandstone. The southeast dip of this rock at the end of the gangway is about 80°, but it must soon be reversed and dip northwards inasmuch as the narrow valley to the north of this ridge is of synclinal structure and filled with the Marcellus slate No. VIII. Near the end of the gangway, entries have been driven over 700' towards the east and 100' towards the west, both upon the southeast dip of the formation. These entries are about 10' to 15' wide, although the sand-bed quarried is from 90'-100' thick. This thickness is fairly well maintained throughout the workings, though in places a portion of the bed, sometimes amounting to half its thickness, is so discolored by oxide of iron as to render the sand from it useless for the manufacture of glass.

The main gangways are stoped upwards between large pillars which are left to support the roof. In addition to this the top is supported by heavy timbers, which are lagged and packed to prevent any movement of the sand. Additional caution must be observed in the workings, on account of the numberless cleavage planes, which run irregularly through the bed and create a tendency to break up the rock into uneven masses. Chambers of various sizes, according to the condition of the formation, are run at right angles to the main entries in working the deposit, and between these chambers, which are from 20'-30' long, massive pillars are left to support the overlying measures.

The sand rock must be blasted in mining ; but in falling it readily breaks into fine sand, which only requires a little crushing and washing to prepare it for market. The output during 1888 varied between 1200 and 1500 tons per month, all of which is carried across the valley and the river to a siding on the railroad at Grantville Station, about $1\frac{1}{2}$ miles distant, by means of a tramway, conveying iron buckets, with a capacity of about 125 pounds each of dried sand. This tramway is described in detail in Report F, pp. 79 and 80, as well as the plant used for washing and drying the sand.

The old tunnel at this quarry has been entirely abandoned, and the material from the new tunnel is conveyed to the washer by means of a short incline, passing thence into the original drying houses, as formerly. The entire operation is a very simple one and does not require any skilled labor. In May 1888 about 26 miners were employed at the quarry at a dollar a day.

The following analysis of this sand, made by Mr. A. S. McCreath, for Report F, shows its general character :

Silica,	98.84
Alumina, . . . . .	.17
Oxide of Iron, . . . . .	.34
Oxide of Manganese,	trace
Lime,	trace
Magnesia,	trace
Loss on ignition, . . . . .	.23

99.58

J. Walters' sand-quarry is situated just outside of Lewistown on the south flank of the first ridge, the rock dipping N. 5° W. 20° in an exposure of about 40' thick, much of it showing only loose sand. The material in this quarry is so much discolored by oxide of iron that the deposit is only worked and used for mortar sand. The low dip of the rocks at this point has exposed the sand rock to a side drainage, which largely accounts for its discoloration derived from decomposition of the ferriferous No. VIII slates overlying the formation at this point.

J. Burns' sand-quarry is a large, but abandoned open-

ing formerly worked near the top of the ridge about 200 yards east from Walter's quarry and in the same strata. Like the latter, the stone is largely discolored from the same causes. Both openings are south of the road running east to Logan, and the low dip of the rock in them accounts for the inferior height of the crest they form.

The Oriskany sandstone on the next crest north is magnificently exposed at Prospect Rock, where the formation creates a series of *pulpit rock* formations rising 35' or more above the top of the hill and showing a thickness of sandstone varying between 60' and 80' dipping southeast at angles of about 80°. This exposure is one of the best and the most interesting in the county, and is a place of resort for the people of Lewistown. The sandstone is *very fossiliferous* here, though apparently not of as good quality as that so largely quarried at the Juniata Sand Co.'s mine.

Going north along the Belleville road the Oriskany sandstone at Mutherbaugh's at the base of the middle ridge dips steeply northwest, and at the turn of the road beyond Armstrong's dips southeast, 60°, enclosing a Marcellus slate valley known as the Dry or Squaw Hollow synclinal.

No. VI iron ore.

The *McGurk ore banks*, formerly worked for the Glamorgan Iron Co., extend for nearly a mile along the north crest of the third or north synclinal ridge, about midway between the two roads crossing from Lewistown into Ferguson valley. These old openings are now all abandoned and filled up; but a considerable quantity of limonite-ore, apparently occurring near the junction of the limestone and sandstone Nos. VI and VII, was formerly mined here from a large number of small deposits individually of no very great extent and rather pockety in the character of the occurrence of the ore. Though all filled up now, there is much testimony going to indicate the presence of considerable quantities of ore in many of the old cuts; but the steep southeast dip of the rocks and the associated ore, has tended to carry the development well under the hill;

and as the roof of all these old pits is very soft and treacherous, it renders mining at this point very expensive, as it necessitates an ever increasing amount of stripping as the operations are advanced. Several of the cuts are 30' to 40' wide and over 100' in length, and even if the deposits have been pretty generally exhausted the dimensions of these openings would seem to indicate the fact that they had furnished a large quantity of wash-ore in the past. This fact is the more important, as the McGurk deposits seem to be *the only occurrence of iron-ore at this horizon* upon a commercial scale so far found in the district; for though these central sandstone ridges give evidence of many similar outcrops, none of them have ever proved worthy of development, either by reason of the chemical quality of the ore found in the test pits or of the quantity collected at any one point. Other deposits of iron ore have been found in these ridges, but they all seem to be associated with the bottom layers of the Marcellus slate formation, overlying the sandstone rather than underlying it, as seems to be the case at the McGurk bank.

Marcellus iron ore.

The *Moore ore bank*, an old opening situated about 3 miles northwest of Lewistown, in the south dip of the Marcellus slate and limestone and in the Squaw Hollow synclinal, is one of these ore deposits which seems to be more closely associated with No. VIII than No. VII. It was opened by the Logan I. & S. Co. in 1871 and though abandoned now, it furnished quite a large quantity of brown hematite ore from the surface to a depth of 80', no carbonate ore having been met with. The following analysis (McCreath) shows the character of this ore:

Iron,	44.700%
Sulphur, . . . . .	.008
Phosphorus, . . . . .	.165
Insoluble residue,	19.950

Like the Townsend bed, situated in a similar geological position in the No. VIII slates of Derry township, this ore bed was of varying thickness, with an average somewhere

between 3' and 6 feet, but swelling in one place to 16' in thickness. At the outcrop the bed dipped gently towards the south; but at 40' beneath the surface it stood perpendicular; and at greater depth was *overturned* with a dip of 80° to the north. When abandoned, the bed was only about 2' thick and the deposit is *remarkable* from the fact that this bed of carbonate ore had been so completely altered to brown hematite to such a great depth from the surface.

Further east in this same synclinal the *Marcellus ore-bed* was opened with workable size at another place, and contained a good quality of ore; but at 50' below the outcrop the bed was unaltered and all carbonate. Here it contained 38.700 per cent. of iron; .192 per cent. of sulphur and .574 per cent. of phosphorus, with only about 6½ per cent. of insoluble matter.

The limonite ore at the surface showed 43½ per cent. of iron; .021 per cent. of sulphur and .595 per cent. of phosphorus. This opening has likewise been long abandoned.

The *Minehart ore bank*, 4 miles southwest of Lewistown, in the south dip of the first or Prospect Rock synclinal ridge, was opened about 25 years ago by John Minehart and was worked about 15 years ago by the Glamorgan Iron Co. This ore-bed was a little over 6' in thickness, the ore occurring in clay derived from the decomposition of the Marcellus slate and occupying nests or pockets in the surface of the Oriskany sandstone. The general run of the ore was very siliceous, one specimen yielding, upon analysis, only 26 per cent. of iron, .046 per cent. of sulphur, .588 per cent. phosphorus, and 47.232 per cent. of insoluble residue.

Between Muthersbaugh's place on the east and Strodes Mill run on the west, the Squaw Hollow synclinal shows many abandoned ore pits, which at one time furnished more or less ore to the Lewistown furnaces and to the old Hope furnace, which stood many years ago near the forks of the stream above the entrance to Squaw Hollow on Strodes Mill run. None of this ore seems to have been of first-class quality, according to common report; but the openings in it are almost numberless, and being mainly worked to

shallow depths to utilize the oxidized surface-ore, it may be presumed that many of these old openings will be found to contain, at varying depths beneath the surface, a considerable body of carbonate ore.

32. Oliver. 33. Bratton. Mifflin county.

These two townships, lying immediately west of Granville and having Wayne township for their western boundary, may be appropriately treated together, inasmuch as they are bounded north and south by the same two mountain ranges which enclose the valley townships to the east and west of them.

The Juniata river divides them from one another; Oliver on the north and Bratton on the south. The Jack's mountain line on the north is about 8 miles long, and cuts diagonally across the mountain from the Medina crest at the Granville line to the summit of the Oneida terrace where it passes into Huntingdon county.

The southern line of Bratton township deflects from the southeast corner at Minehart's Gap from the south crest of the Blue Ridge or Licking Creek mountain, and passes southwestward for about 2 miles across Licking Creek valley and the Medina crest of the West Shade mountain, finally cornering on the high Oneida spur of the Black Log mountain anticlinal. From this point it follows the Black Log mountain in a straight line for a little over 7 miles to the southwest corner of the township, from which point the western township line strikes at right angles for 7 miles across the Lewistown valley to the crest of Jack's mountain.

It will thus be seen that the combined area of these two townships approximates 55 square miles, Oliver township being slightly the larger. The Juniata river flows through both townships from Manayunk or Ryde Station on the west to Lockport on the east, pursuing a sinuous course through the Clinton and Salina rocks, which are present through a large part of Bratton township, and the southern side of Oliver.

Mc Veytown, situated on the north bank of the river, about 7 miles by railroad west of Lewistown, is the only

important town in Oliver township; Bratton township is without any important village, although *Matawan*, lying immediately opposite McVeytown on the south side of the river, forms an important station for the supply of goods to McVeytown, and the shipment of products derived from Oliver township.

The geology of this combined area is in many respects precisely similar to that of Granville just described. The same series of formations are exposed here from the Oneida sandstone No. IVa in the two mountains to the Marcellus slates No. VIII in the narrow valleys between the Oriskany ridges in the center.

A section from mountain to mountain through McVeytown would show the Oneida and Medina sand rocks No. IV of Black Log mountain dipping northwestward and passing beneath the Licking Creek valley synclinal containing the lower members of the Clinton formation No. V, and rising again in the Licking Creek and Blue Ridge mountains. The latter range, however, is of anticlinal structure, both the crests being composed of the white Medina sandstone IVc, with an elevated anticlinal valley of the red Medina IVb, between the two crests.

The Blue Ridge mountain rocks therefore dip northwards: and, passing under the Lewistown valley with many saddles and basins beneath water-level, do not come again to daylight before reaching the north side of Oliver township, where all three members of the formation rise with dips of 40° and 50° to form Jack's mountain.

North of Blue Ridge, the section line would show an outcrop of the *Ore sandstone* group making a small terrace well up the flank of the mountain, and north of this a small roll in the lower Salina shales which serves to spread them over a wide belt between the mountain and the Chestnut Ridge anticlinal.

This latter arch again elevates the Ore sandstone measures just south of McVeytown and keeps them above water-level for about 5½ miles in both townships eastward to the Granville line. Between the western extremity of this ridge and the northern limits of McVeytown, the

Salina lower and upper rocks occupy a belt of country a little over a mile wide through which the river runs from its gap in Chestnut Ridge westward to the end of the anticlinal, a mile southwest of Matawan. Several anticlinal and synclinal flexures indent this area further west along the Wayne township line ; but at McVeytown there is only one small roll north of the Chestnut ridge axis. Three miles further east there is apparently no cessation in the northwest dip of the rocks between the Chestnut Ridge anticlinal and the first of the Oriskany sandstone ridges to the north.

The four ore basins.

North of McVeytown the plication of this central belt of ridges is augmented by the addition of a fourth synclinal on the north, between which and Jack's mountain runs the Upper Salina valley known as "Kansas."

In other words, there are four synclinal flexures between McVeytown and Jack's mountain, all of which contain the Oriskany sandstone and the Marcellus slate *except* the last, which does not deepen sufficiently to contain No. VII and No. VIII along the line of the section ; but does contain them between the McVeytown stream and the Wayne township line.

The first of these synclinals is known as the *McCoy Ore-Bank synclinal*, and corresponds to the Prospect Rock basin of Granville township. It is a tight fold of the Oriskany sandstone rocks, dipping from 50° to 60° northwest and from 70° to 80° southeast and containing between them a narrow strip of Marcellus slate ending a mile and a half further east and containing near the line of section the McCoy ore bank. No. VII is from 140' to 150' thick here, and forms bold *cliffs* outcropping on either side of the stream. This basin is succeeded northward by an anticlinal which for a mile on either side of the stream elevates the Upper Salina lime shales on its back, flanked by outcrops of the Lewistown limestone dipping 70° and 75° north and south.

The second synclinal, known as the *Ross Ore-Bank basin*, contains a much wider strip of the Marcellus slates No. VIII, and is the westward prolongation of the Dry or Squaw Hollow synclinal of Granville township. The Oriskany sandstone in the south lip of this basin does not seem to be quite so thick or as massive as in the first synclinal, although both lips of the basin assist in making high parallel ridges, between which the softer No. VIII slates have been eroded. The anticlinal to the north of this is still stronger than the first axis, and elevates upon its bank a still more extended section of the upper Salina marls and shales, dipping about 60° southwards and 80° northwards.

The third synclinal is known as the *Dull and Bradley Ore-Bank basin*, from the extensive mines worked in it a short distance east from the line of section. This basin shows a very limited thickness of the Marcellus slates, if, indeed, it contains any at all. North of this ridge the Ferguson valley ore-ridge anticlinal has so far subsided as to bury along the line of the section both the Ore sandstone and the lower Salina rocks, and shows only the top members of the upper Salina lime shales Vc.

The fourth synclinal shows first only a narrow basin of the Lewistown limestone rocks with converging dips of about 50°, but in less than one-half a mile westward it deepens sufficiently to receive the Oriskany sandstone and (near the Wayne township line) a narrow belt of the Marcellus slates.

Kansas valley, to the north of this ridge, is a monoclinical with dips of about 50° to the southeast, showing successively lower measures approaching the flank of Jack's mountain.

Fossil ore mines.

The *Ferguson valley ore ridge* maintains its character of a double anticlinal for nearly 3 miles into Oliver township, so that for nearly this distance there are 4 outcrops of the Ore sandstone and the Sand vein in this ridge in addition to the usual outcrop along the main mountain. The north

anticlinal of the ridge extends about one-half mile further westward (with the Ore sandstone exposed) than the southern anticlinal; but towards the western end of the ridge, as on the east, the stoping ground is limited by reason of the subsidence of both of these axis; so that the main development has taken place in the first mile and a half west of the Granville line.

James Shehan opening.—The first operation on the north dip of the north anticlinal west and north of Geo. McKee's ore bank is a small opening near James Shehan's house, where the Sand vein is about 12 inches thick, compact, siliceous and of a deep red color. It contains about 34 per cent. of iron and 35 per cent. of siliceous matter.

John Shehan's ore bank, is situated in a ravine in the synclinal between the two ridges and about one-half mile west of the McKee ore bank. The Sand Vein ore bed is here about 16 inches thick, and is got by means of a slope sunk through the lower Salina shales at right angles to their stratification on the north dip of the south anticlinal. Owing to the flat dip of the measure in this synclinal, the ore breasts were very short and there never was very much ore shipped from this point.

A short distance further west both anticlinals are gapped by a small stream, which has served to expose the ore beds to more favorable development.

The *McCord* and *Rothrock ore banks* are opened here, mainly upon both dips of the interior synclinal, a short distance west of the stream. The north dip in this basin is fully 75° and the south dip varies between 80° and 60° , making a narrow but quite a different basin of ore. The south dip of the south anticlinal, however, is only 35° , being much more gentle than it is a mile east at McKee's ore bank. The north dip of the north anticlinal varies between 35° and 40° , so that it will be seen that both these flexures form compound curves at this point.

The two outside ridges at their base are about 2,000' wide; the lower Clinton shales forming the crest of the southern ridge, while the Ore sandstone seems to perform a like office for the northern anticlinal. Some little development

was once made on the south dip of the south anticlinal where the ore was found 14 inches thick underlaid by a very ferruginous sand rock; but the main work was done in the basin between the ridges. On the south side of the basin the Sand Vein was about 14 inches thick, and maintained that thickness through several hundred yards of gangway. Some little shale was mixed with the ore, which at times depreciated its quality; but it showed usually a fair quality of medium soft fossil ore.

On the north side of the synclinal a *tunnel* a hundred yards long was driven through the overlying shales to the Sand Vein ore-bed, where it was found to have about the same thickness, although very changeable in quality.

No work was being done here during the season of 1888, although in the past several thousands of tons had been mined and shipped from these openings, the quality of which seems to have varied all the way from 30 to 60 per cent. of metallic iron, and from $7\frac{1}{2}$ to 43 per cent. of insoluble matter. Very little sulphur was found in the bed here, and its phosphorus ranged between .1 and .2 per cent.

John Rothrock's ore-bank is opened on the east side of the ravine upon the north dip of the south anticlinal, from which several thousand tons of ore have been taken from the Sand Vein 14" to 16" thick. The only analysis of this ore, made 15 years ago when the mine was actively worked, showed about $41\frac{1}{2}$ per cent. of iron; .034 per cent. of sulphur; .212 per cent. of phosphorus, and $27\frac{1}{2}$ per cent. of insoluble residue. Only a series of dirt banks and a few broken timbers remain at the present time to locate the extensive operations once existing in this vicinity.

John Kinzër's ore-bank is situated in the next ravine, $\frac{1}{2}$ mile southwest of the McCord bank, where the Sand Vein has been opened on a 65° N. dip in the southern anticlinal, the south dip of which remains at about 35° . Only a soft fossil-ore was produced here of only fair quality from a bed 12"–14" thick, an analysis of which showed 40 per cent. of iron, and $31\frac{1}{2}$ per cent. of siliceous matter, with about .23 per cent. of phosphorus.

All through this range the Ore sandstone is from 20' to 25' thick.

Nowhere do the Danville ore beds, though presenting in places a more or less profuse outcrop, seem to have been found sufficient good for development.

The Old Stackpole opening, whose ore was used at Glamorgan furnace, shows on the south side of the south anticlinal, a short distance west of McCord's, where a drift has been run through the overlying olive slates and the outcrop robbed for some distance east and west on a southeast dip of 30°. The ore breasts are very short here, and the ore itself is nearly all a lean hard fossil.

Some little development had been made on the property of Michael Aultz; and also at the John Allen property in a deep ravine about $\frac{1}{4}$ mile further west. But the two ore-anticlinals have become so depressed in this vicinity that it was not possible to get good stoping ground, so that comparatively little ore was ever mined there.

At *Peter Rush's house*, the ore ridge becomes almost imperceptible, the lower Salina red shales arching over the anticlinal and completely hiding the Ore Sandstone and Sand Vein ore-bed. From this point westward only the mountain outcrop is seen above water level, making a high terrace on the side of the mountain and a rather obscure ore outcrop.

The *Stevenson mine*, on the Cutman farm, is opened on this mountain dip of 70°, southeast, half way up the flank of the mountain and developed by a shaft a short distance east of Cutman's house. This mine was formerly leased and operated by Rosenberry; but during the season of 1888 some perfunctory work was done there by Mr. W. P. Stevenson of McVeytown, and by Mrs. Cutman. The shaft was 105' deep, sunk 23' vertically from the surface to the ore-bed and then following down the dip. It was not possible to get down the shaft at the time of visit, as the mine was not active; but the bed is said to be double here, 12 and 14 inches thick, separated by about 20 inches of white clay. The lower bench, however, is merely a ferruginous

“Jack,” the upper one furnishing most of the commercial ore. The bed has a yellow slate roof and a sandstone foot wall, and has been developed for about 50 yards east and west of the shaft. Preparations were being made for reaching this bed at a low level by means of a tunnel of considerable length driven across the measures, and thus provide for natural drainage and a more economical method of mining. It is claimed that this ore is one of the Danville beds, *beneath* the Ore sandstone, and that it is the same as developed at McGill's and Kinsler's further west, where the Sand Vein ore is very thin (6 in. to 8 in.) and where it is claimed that the Ore sandstone only 40' thick is separated from the Danville ore-bed by 20' of slate.

Chestnut Ridge, to the south, in Oliver and Bratton townships, shows a double outcrop of the Ore sandstone and Sand Vein, and in its central portion carries a small amount of the Iron sandstone, a still lower member of the Clinton formation, on the crest of the anticlinal. It is completely gapped by the Juniata river about 3 miles east of McVeytown, where the Ore sandstone on the east side of the river is well exposed on both north and south dips of 20° and 25°. On the west side of the gap the river has eroded the north dip and outcrop for nearly half a mile; but the south dip was at one time extensively developed by Mr. C. Dull for nearly a mile west of the river. The old drifts and outcrop workings are all abandoned now. The ore was of good quality and occurred in a bed from 12 to 16 inches thick, dipping from 25° to 35° towards the south. The ore here was largely hard fossil and the breasts were never much over 20 yards in height. Between the river and Strode's Mill run the openings are much more numerous.

The *Bremen*, *Bortle*, *Brower* and *Aurand* mines were all located in the south dip of the Sand Vein, which has been stripped at the surface through nearly its entire outcrop between Lockport and the river gap. Not a single operation was being carried on in this entire ridge during 1888; but common report speaks highly of the quality of the ore in the south dip of the anticlinal. It contained from 14 to 16 inches of ore, and the low dip (here decreasing considera-

bly after the bed passes beneath water level) has tended to furnish a much larger quantity of soft fossil ore than is usually the case where the beds dip at steeper angles. The Ore sandstone in this ridge is about 15' thick and very massive and beneath it there is 20' to 25' of siliceous shale, separating it from the Danville ore bed group. West of Strode's run, the north dip of the Sand Vein was almost entirely worked by stripping as it was found very thin there.

On the *property of S. Oliver* the Hope Furnace Co. mined the ore only 6 or 7 inches thick and west of this property several thousand tons were mined in the same manner for the Lewistown furnaces.

On the north flank of Blue Ridge the Ore sandstone is visible at many points, and the overlying Sand Vein shows a plentiful outcrop of altered fossil ore, but no very great effort has been made to prospect this portion of the field, partly owing to failure in the past and largely on account of its inaccessibility.

Along the stream issuing from Minehart's gap and really in Granville township, the Ore sandstone dips 30° north and is 15' thick. On the east side of the gap the upper Danville bed was exploited at one time found about 12 inches thick, but lean and calcareous.

The Sand Vein ore has never been opened and rumor reports it both thin and lean. West of Minehart's gap there are a great number of notches in the Blue Ridge crest, and the dip of the rocks seem to increase towards McVeytown with the effect of carrying the ore measures still higher up the mountain flank, rendering it very difficult to prospect them advantageously. Besides this fact there are no ravines east of the road leading into Black Log valley which have cut down the Ore sandstone terrace so as to expose the ore-beds.

The balance of Bratton township is composed entirely of the *Clinton* and *Salina* rocks. The red beds of the lower Salina group outcrop just below the McVeytown bridge on the river bank, dipping to the northwest 70°.

The Clinton lower yellow shales and lower lime shales both show along the crest of Chestnut ridge here whose anticlinal has decreased so much as to carry down the Ore sandstone before reaching the river southwest of Matawan. The lower Salina rocks show in the south side of the ridge dipping 40° southeast, and the back valley road to Lewistown runs largely through the valley of upper Salina lime shale showing green and olive shale beds, but containing also several thin beds from 2' to 4' thick, of impure limestone, which in places has been quarried and burned for farm use on account of its proximity to the place of consumption.

An excellent exposure of the *Bloomsburg red shales*, 125' thick in one uninterrupted exposure, was seen near the school house at Yoder's place. The dip is to the northwest at angles of 30° and 35° passing under the upper Salina measures in the synclinal, and succeeded southwards by lower Clinton red and olive beds, making an *anticlinal* with north and south dips of 60° and 70° near the forks of the road. This axis may mark the western extension of the great Shade mountain axis of Snyder and Eastern Juniata county although its force and importance died out in the great bend of the river south of Lewistown.

Limestone quarries.

The *Lewistown limestone formation* has nowhere been very extensively quarried through Oliver township, although the reason for this is not very clear. The most southern outcrop extends along the south base of the first Oriskany ridge in a very straight line from the magnificent exposure already described north of Strode's Mill to the northern limits of McVeytown, where it deflects slightly to the southwest and after making three laps along the Wayne township line it finally passes out of the township just north of Ryde Station.

S. Cauffman's farm, a short mile west of Strode's mill, has upon it a small quarry of rather impure limestone, opened near the base of the formation, and the ridge about 300 yards north of the pike and a little west of his house.

The limestone is next exposed in the gap made by a small stream entering the river near its gap in Chestnut ridge; several massive ledges of limestone outcrop here a little distance north of the pike dipping at angles of 85° to the northwest and with the very best facilities for opening a large and economical quarry in them. The exact chemical character of the stone here is not known by actual test; but many of the layers in the central portion of the exposure seem to present a series of good beds 40' or 50' thick and in every way suitable for quarrying advantageously.

The lack of railroad facilities is naturally against development of the limestone beds in this township, as compared to places where the quarry products can be transferred almost directly into cars; but many smaller operations might be advantageously started for the local supply of farm and plaster lime, as has been done in many other places in the district.

The Bloomsburg red shale crops out in the first ridge south of the pike between the gap and McVeytown, the road running through an elevated valley of the upper Salina lime shales. West of McVeytown the dip remains at very steep angles and in places is even overturned, until in about $1\frac{1}{2}$ miles it settles down to about 60° and keeps that angle almost to Wayne township. At this point there is a compound anticlinal roll which serves to spread the limestone formation over a belt of country nearly $\frac{1}{2}$ mile wide. But the effect of the twisting and crushing of the limestone seems to have been one deteriorating the quality of the limestone itself, so that crossing over the ridge to the river at this point almost all the limestone seen was made up of very small and brittle beds, which fractured in irregular shapes and appear to contain a comparatively small amount of good stone.

In the synclinal, however, immediately north of the river and which westward deepens in Wayne township to hold the Oriskany sandstone rocks quarried by the Enterprise Sand Company, the limestone becomes more regularly bedded and seems of better quality than where it was so much twisted to the north.

Bratton's quarry is a small opening at the extreme eastern end of the limestone synclinal opened on the old Vance farm about three miles from McVeytown along the south side of the road leading to Vineyard station. The quarry is small and the beds thin, dipping S. 35° E. 30°; but the beds in the north dip of the synclinal exposed lower down the ridge along the road and the canal are of much better quality and show from 40' to 60' thick. There are no openings, however, in this part of the field.

North of McVeytown, the Lewistown limestone occurs in the valley beyond the first ridge, being exposed for about 2½ miles on the crest of a small interior anticlinal roll.

North of the Ross Ore Bank synclinal the Oriskany ridge is supported upon a strip of the Lewistown limestone, outcropping through the township, but nowhere exposed to view by any developments. Hope furnace on Strode's run at the eastern side of the township, is situated in this limestone valley and some good exposures are seen in the small ridge immediately north of the furnace. Finally another broad belt of these limestone rocks crops everywhere on the north flank of the hill facing the Ferguson valley doubling on itself north of McVeytown, and from that point westward supporting on both sides the Oriskany sandstone ridge of the fourth synclinal.

Glass Sand quarries.

The *Oriskany sandstone and shales* form an important economical part of the geology of Oliver township, owing to the extensive sand quarries opened in this sandstone in the vicinity of McVeytown. They outcrop through the township, everywhere creating ridges and coincident with the Lewistown limestone just described. The sandstone formation maintains its great and unusual thickness in this township, varying between 100' and 150', with an average more closely approaching the latter figure. All the openings have been confined to the first synclinal ridge; and despite the extensive outcropping of the same measures through Granville, Oliver and Wayne townships, *all the operations are confined to this first basin* and largely to its

northern dip. Quarrymen and those experienced in working this sandstone member profess to believe that elsewhere through the county the remaining belts of sandstone do not show the physical character or the same mechanical condition of constitution as the beds along the southern flank of this ridge, all the way from Lewistown to Newton Hamilton. How far true this may be it is not possible to state. This conclusion may have been somewhat produced by prejudice, and from the fact that the two oldest operations were started in this ridge and have continued to furnish a very large quantity of glass sand of excellent quality to the general trade; but it is also true that *nowhere else* does the sand in these ridges seem to be so pure and white in color or so well adapted for economical quarrying by reason of its physical character. Just what constitutes the point of difference between a good and an indifferent stone, supposing of course that both have a parallel chemical constitution, it is hard for one not experienced in the business to realize.

In addition to purity of color, which usually means the absence of all iron salts, the quarryman wants a sand bed with sufficient adherence to require blasting and yet not so hard and crystalline in its nature as to make its quarrying and crushing for the washers expensive. Then too the sand grains themselves must be sharp and well crystallized, that being thought a necessary feature of all good glass sands. Many of the men interested in this important industry were asked to define their opinion of a good glass sand; but beyond the few suggestions already made, no great amount of information was obtained, and in the selection of beds for quarry development they do not seem to seek any additional requirements.

The *Dull and-Bradley sand mine* is situated immediately north of McVeytown on the northwest dip of the Oriskany sandstone here making one-half of the McCoy ore bank synclinal. Originally the sand was quarried here in a large open pit, 80'x80' and from 30' to 40' deep. At present the sand is mined under ground east and west from the bottom of this

pit. All the cars are run out from each main entry to the bottom of a small incline plane and hoisted to the washers. There is ample room in the bottom of the old open pit for switching and arranging the cars, so that despite the necessity to lift them, the whole arrangement of the plan is economical and does its work effectively. All the water of the mine is likewise collected at one point, pumped to the washer, and advantageously utilized there for the cleansing of the crushed sand.

Method of mining glass-sand.

The Oriskany sandstone formation here is about 140' thick ; but as the lower portion is discolored and the upper portion carries some yellow and bluish-gray layers unfit for glass purposes, there is only about 110' in the center of the formation containing the *pure white sand* so much sought for by those interested in glass industries. Through this 110' of rock there are also occasionally found some hard ribs of rock occurring in lenticular masses ; but which are largely crushed at the present time with the softer variety. The dip is steeply northwest 70° to 80°, so that this immense bed of white sand, standing *nearly vertical* in the open pit, presents a very imposing appearance.

On the west side of the mine three gangways, rudely parallel to one another, and each about 20' wide, have been driven into this sand bed. Along these gangways cross-cuts are made every 20' and are likewise driven 20' wide, thus leaving between the main entries and the cross-cuts pillars of sandstone for support, measuring at the base 20' x 25' and extending up to the upper level. Thus the mine is divided by this system like a checker board, each alternate square or pillar being robbed by carrying the wide breasts to the surface and conveying the loosened sand-rock out to the foot of the plane.

The company control about 2,000' of the sand-bed on this dip west of the gap, and had driven about 1500' in that direction during June, 1888. On the east side (at the same period) they had extended one central drift for about 700',

about 15' wide and high, from which the large body of the sand in the future will be mined. The company's property in this direction extends east for about $\frac{7}{8}$ of a mile, and as far as this preliminary test drift has developed this portion of the range there seems to be no diminution in the quality or thickness of the sand. Throughout the mine the sand-rock is very much broken by natural *cleavage planes* which run *in all directions* and prevent anything like uniformity in the bedding of the sand beds.

The output at this mine averages about 75 tons daily all of which is conveyed in carts across the Juniata for shipment on the railroad. The mine cars hold about $\frac{3}{4}$ of a ton each, and so far are hauled by mule power to the foot of the plane and thence to the washer. The crushing and washing process is very simple, and as the sand contains a very small percentage of argillaceous matter, there is but little waste in washing and not much water required. Nevertheless in order to cleanse it as thoroughly as possible the sand is kept wet while being passed through two sets of roller crushers. The sand is first dumped upon a screen 3' x 3', furnished with grate bars $\frac{3}{4}$ inches apart and played on by a small stream of water. All the fine sand passes through these bars to a double wire reel directly beneath the screen, the coarser particles going to the crushers from where it is conveyed to the reel. This latter is a double cylinder, the sand entering the middle and smaller one, there washed while revolving for the purpose of separating the very fine sand from the small lumps which, upon delivery from the cylinder, are shovelled back again to the crushers. But very little power is required to completely reduce the rock to a fine sand, and the operation is in no sense an expensive one. For their output of 75 tons a day the works required 22 men and 4 boys, and the mine 27 miners and 1 boy driver.

Dull and Wilson have opened a small quarry in the same ridge, about a mile west of the Dull and Bradley opening in a small ravine west of McVeytown. Their openings were both idle during the summer of 1888, and most of the

information was kindly given by one of the proprietors. The first opening was a slope entering rather on the south side of the formation; the second opening, further up the stream is a drift, driven north at right angles to the outcrop, at water level, through beds overturned, dipping southeast from 60° to 70° . Neither of these openings was ever very extensively developed; but the sand beds show about the same characteristics as they do further east.

The main gangway was driven for 160' from the drift mouth through a loose gravel containing a good deal of loose slate and sand, beyond which the entry passed through sand for 180' into a gray hard sandstone, here called the foot-wall, and which dips S. 10° E. 60° . Two gangways each 20' wide had been carried westward for about 100' in this sand bed, and between them (it was stated) there is a solid chamber of good white sand, measuring 96' in width which had been hardly developed at all. The sand between the north entry and the "foot-wall," and that between the south entry and the gravel, does not seem to be of as good quality as the central portion of the deposit, so that it may be said that this mine furnishes about the same thickness of good beds as at Dull & Bradley's.

About 400' further east and down the stream an old drift driven north passed through about 150' of sand, likewise dipping southwards here. Somewhere near the center of this sand deposit a cross entry was driven for 250' westward and a short distance eastward. It was from this drift that most of the sand quarried was obtained. The slope entry, still further east, was carried north about 300'; but the operation of this entry has been permanently abandoned.

Marcellus ore mines.

The *Marcellus iron ore* occurring near the base of No. VIII slates has been considerably developed in the synclinals north of McVeytown; but without exception every one of these operations were inactive during 1888 and in the light of the present condition of the iron business and the character of ore which they are capable of furnishing,

it is quite probable that many of them will remain permanently so.

McCoy's ore bank was situated a little east of the stream in the first synclinal ridge north of McVeytown. The Marcellus ore bed was here found 3' to 5' thick. No great quantity of ore was mined at this point, although it is contended that a large quantity of hematite and carbonate exist along this narrow slate valley. When the old Brookline furnace, situated a little further north but in this McVeytown gap, was in operation, this ore might have been advantageously used; but being largely *carbonate* its use at that date was not understood, and all the ores smelted at this old furnace were hauled at great expense across Jack's mountain from the Kishacoquillas valley.

The *Ross ore bank* is situated in a similar geological position in the second basin about 1 mile north of McVeytown, and was by all odds the most extensive and successful ore-mine in the county. Various furnaces as far east as Harrisburg derived a portion at least of their stock from this mine; and when the old Matilda furnace at Mt. Union was remodeled for coke iron, it had expected to get the largest part of its ore supply at this point, where a considerable amount of mining was actually done for that furnace, which still holds a lease upon the property. The gap in which this ore occurs is very deep and picturesque, and as the dip of the measures in the synclinal is very steep, the outcrop attains a height of 350' above the level of the stream.

About 75' above the creek a drift was started in the No. VIII shales and driven across the synclinal towards the north cutting an ore-bed showing brown hematite ore from 3' to 5' thick. This cross-cut passed through beds of black limestone, shale, and *carbonate* ore, spread through 28' of measures, none of the alternating bands being over a foot in thickness. This ore yielded upon analysis 42½ per cent. of iron; sulphur, .260; phosphorus, 135; insoluble residue 3.390.

Ore has been found upon both dips of the synclinal here and along the north side of the basin; but on the south dip

of the ore the Marcellus limestone exists, occasionally forming the foot-wall of the ore-bed, but usually separated from it by from 6' to 10' of buff colored clay. The north outcrop contains ore from 2½' to 8' thick overlaid by from 10' to 15' of black slate to the "overlap vein," which was apparently a tightly folded roll in the ore-bed (having no connection with the main bed of either side of the valley) and which is said to have furnished a very large quantity of excellent brown hematite ore from 25' to 30' thick.

About 145' above the creek the main ore-bed was opened by a gangway driven west for some distance under the highest part of the hill. *Carbonate* ore was obtained in this entry; but the stopes driven up the rise of the bed towards the outcrop nearly all developed the bed altered to *brown hematite*.

The main drift in the recent operations is located about 300' above the creek level and bears northwest for about 400', striking there the south bed dipping 75° towards the northwest. One gangway was driven along this bed 400' long, and 210' beneath the summit of the hill. Breasts had been carried up for about 50' on the bed, about 15' to 18' wide each, leaving pillars between 10' to 12' wide. The ore-bed here is said to be from 10' to 12' thick, which is an unusual development of the Marcellus measures.

From the entrance of this gangway the main drift was carried 300' further across the measures before striking the north vein; and it is to be remarked that in this drift no evidence was seen of the "overlap vein" which evidently basined or feathered out before reaching the depth or level of this gangway. After striking the north bed, which was of varying size, the main gangway was pushed on some 400 or 500 feet further. The same system of mining was adopted here; but the ore itself was almost entirely altered to brown hematite, until near the head of the gangway the carbonate was struck and was stoped upon at that point for a height of about 50' above the entry. The dip here was about 45° to the southeast and it would appear that the existence of the bed both on this and the north dip, whether as carbonate or brown hematite, depends somewhat upon

the depth below the outcrop at which the ore beds may be struck, but also largely upon the natural drainage of the bed itself.

Beneath the plane there were three additional drifts seen. One on the north bed followed the ore for 400 or 500 feet to a point beneath the large open cut driven first on hematite and eventually through the last 200' on a carbonate iron ore bed. The two other drifts were lower down, driven half across the measures, the middle one getting the carbonate ore, but the lower one, near water level, finding *nothing but black slate*. There is another small bed reported to exist between the Marcellus limestone and the top of the Oriskany sandstone, but it has never been developed or well tested. Sufficient has been said, however, to demonstrate the persistency of this Marcellus ore bed wherever it is found to exist at all, and in addition to its being found here on both dips of the synclinal and of workable thickness it can be relied upon to furnish a carbonate ore with from 30 to 35 per cent of iron and about 18 to 20 per cent of siliceous matter; and a brown hematite where this bed is altered, which the Glamorgan Co., at Lewistown used for sometime, with an analysis of $42\frac{1}{2}$ per cent. of iron and about 24 per cent. of insoluble residue. The carbonate ore contains always a considerable percentage of sulphur, but no analysis of the ore mined at the Ross bank has shown over 1 per cent. of sulphur, although this may vary considerably.

Mr. John Whitehead is the present lessee of this property, and, in mining for the Lucy furnace, about 10 tons a day of washed hematite was produced here. Mr. S. Treweek, superintendent at the ore mines, is authority for many of the facts given concerning this mines.

Dull & Bradley's ore bank is situated in the third synclinal north of McVeytown on the property of Robert Clark, and was opened on the south dip of the *Marcellus ore bed*. The opening is located near the summit of the ridge which is largely sandstone and contains little more of No. VIII than the ore bed associated with its Marcellus limestone. The bed was found to be 3' to 5' in thickness

here, dipping 50° towards the south, and was entirely hematite as far as developed, about 75' beneath the surface. This operation is likewise abandoned, and very little can be seen upon the ground to confirm the report of the good quality of the ore mined from here.

The *McCormick ore banks* is a name given to a series of openings, now all abandoned, situated in the center of the synclinal ridge, south of the Kansas valley, and a little east of the Wayne township line. The ridge in which these openings are located is very irregular and the erosion of the *Oriskany sandstone* composing it has strewn the surface of the narrow No. VIII slate valley occupying its central line, so as to largely conceal the character of that formation and its associated ores. A profuse outcrop of *surface hematite* ore, extending along the summit is apt to give color to the belief in a large deposit of iron in this vicinity; but, like many other outcrops associated with the Oriskany rocks, this material is merely a ferruginous sand-rock, which, when broken open, is seen to contain little or no iron except as an outside coating. Similar occurrences might be mentioned in connection with a description of nearly every one of these Lewistown valley townships, and the same is equally true of Juniata and Snyder county. One of the openings south of Jas. Rhodes' house on the south dip of the synclinal has evidently been made on material of this kind slightly richer. It is certainly associated with the Oriskany sandstone, and upon analysis was found to contain only about 31 per cent. of iron and 44 per cent. of insoluble residue. The ore bed itself was only about 1 foot thick. Another higher bed, 1' to 2' thick, occurring in the shales immediately above No. VII, showed practically the same quality of ore.

34. *Wayne township in Mifflin county.*

This is the most western township of the Lewistown valley and of Mifflin county. It contains, roughly, about 40 square miles and, like the other townships of this valley, has the Jack's mountain crest for its north line, about 7½ miles long,

and the Black Log mountain for its southern boundary for about $3\frac{1}{2}$ miles to a point on the Medina crest of Shade mountain, from whence the township and county line bears a little north of west for two miles in a straight line to the Juniata river about 2 miles above Newton Hamilton.

The Juniata practically forms its western line, dividing it from Huntingdon county and after its great bend south of Newton Hamilton, it flows in an easterly direction through the southern half of the township from Newton Hamilton to Ryde station at the Oliver-Bratton line.

Several small streams, the most important of which is the *Beaver Dam run*, drain this township in all directions into the river, *Licking creek* alone draining the narrow synclinal valley between the Blue Ridge and Black Log mountain flowing into Huntingdon county before entering the river.

Newton Hamilton, beautifully situated on the north bank of the river north of where it takes its great bend, is the only important village in the township.

Many of the anticlinal and synclinal flexures which give so great an irregularity to the topography of the townships lying east have either died away entirely or have become so flattened out as to considerably modify the structural features of this township as compared to Oliver and Granville.

For instance, the central Squaw Hollow, or Ross Ore Bank synclinal, holding a very narrow band of the Marcellus slates all through Grandville and Oliver, deepens and widens in this township to such an extent as to permit of the presence of a considerable thickness of the Portage flags in addition to the whole of the Marcellus, Hamilton and the Genessee divisions of No. VIII well exposed in the cuts between Newton Hamilton and the railroad bridge crossing into Huntingdon county.

These Portage rocks are the highest geological series contained in the township, while the Medina red and white sandstone of Black Log, Blue Ridge and Jack mountain are the lowest. These latter form the terraced Black Log mountain wall on the south, and after passing under the *Licking creek synclinal* of lower Clinton rocks they rise

again to form the anticlinal of Licking Creek mountain and Blue ridge. Decending again upon a north dip on the north side of this anticlinal they pass entirely under the Lewistown valley not to reappear again until exposed in the Jack's mountain monoclinial on the north side of the township.

The *Blue Ridge anticlinal* gradually subsides going west towards the Huntingdon county line, first burying the central red Medina rocks IVb, about a mile from the Huntingdon county line, and finally the white Medina IVc, which just enter Huntingdon county at the eastern end of the Germany valley. The northern crest of this mountain is notched in several places, giving it an irregular knobby appearance, but the southern crest is long, straight and unbroken.

Jack's mountain on the north presents a similar unbroken front facing the Lewistown valley, rising to heights of 2300' above tide north of Atkinson's mills and maintaining an elevation of over 2000' west of Jack's Narrows in Huntingdon county, north of Mt. Union. This mountain merges with Stone mountain just before reaching the Juniata river, completely enclosing the Kishacoquillas valley; and the two united running westward as a double anticlinal mountain, triple-crested, west of the Juniata river.

The south dips in the Jack's mountain monoclinial along the Oliver township line are about 50° ; but westward they decrease in strength to only 30° with the effect of throwing southward the *Ore sandstone terrace* which, approaching the Juniata, makes a distinct ridge of its own fully three-fourth mile away from the base of Jack's mountain.

Kansas valley lies between this ore ridge and the fourth Oriskany sandstone synclinal until at the western end of that synclinal 3 miles from the Oliver township line. it becomes merged in *Long Hollow*, extending westward between the Ore sandstone ridge and the Oriskany sandstone ridge to the Juniata. North of Kansas valley the terrace of Jack's mountain is very distinct and regular, the beds of fossil ore which outcrop there can only be traced by the presence of the Ore sandstone, which, however, for the first

5 miles, is often so covered by *débris* from the mountain as to conceal its outcrop, as well as that of its associated ore beds.

At *James Rhodes'* the outcrop of the *sand vein* is profuse; and this is equally true of the mountain slope to the north, where frequently outcrops of altered fossil ore associated with the Iron sandstone member of the lower Clinton rocks invite exploitation. They are, however, in the majority of cases, very treacherous deposits and are mainly either ferruginous sandstones with an excessive percentage of siliceous matter or thin coatings of ore superficially spread over the surface of the sand rocks. Some individual surface specimens of altered fossil ore gathered here have yielded percentages of $46\frac{1}{2}$ per cent. of iron, 0.35 of phosphorus and only 14 per cent. of insoluble residue; but it is extremely doubtful whether any bed of mining thickness could be uncovered here showing the same quality of ore.

An interesting occurrence of detached deposits of "Bog Ore," said to be from 1' to 3' thick is mentioned in Report F, p. 97, located near James Rhodes' house and analyzing about as follows:

Iron,	20.625	per cent.
Sulphur, . . . . .	.034	do.
Phosphorus,	1.326	do.
Manganese,	10.375	do.
Water,	23.270	do.
Insoluble residue,	22.840	do.

This Bog ore is compact, sandy and of a deep brown color; but is merely a hydrated manganiferous lean iron ore without any commercial value.

For a distance of 4 miles east of the Juniata river, the lower Clinton brown and olive shales have been eroded considerably, forming a cove or depression between the Ore sandstone ridge and the mountain. At Phillip Shades', 3 miles northeast of the Juniata, the sand vein bed has been proved of good quality in a shaft and about 18 inches thick.

The *Lucy or old Matilda furnace property*, controls nearly all the ore territory between Shade's and the river. The furnace was idle during the summer of 1885 and consequently no ore was being mined from any part of the prop-

erty. Only the *sand vein* ore-bed has been well developed here about 18 inches thick at the outcrop and 3' thick in the lower levels. The dip is about 30° and the bed has been worked on this slope for nearly 300' furnishing a varying amount of soft fossil ore from breasts 50' to 100' high according to cover and hard fossil ore in the bottom levels. Eastward this bed has been developed for perhaps one-half mile.

The Ore sandstone is about 35' thick and quite massive, immediately beneath which is found the "Mud Vein," 2' thick, but very lean, and separated by only 4' of slate from one of the *Danville beds*, one foot thick, containing in places a high percentage of iron. Another lower Danville bed has been found in some few places; but always very thin, so that mining has been entirely confined to the sand vein which too becomes nearly worthless by reason of its large percentage of siliceous matter after crossing the river into Huntingdon county. This bed through the Lucy furnace property occasionally carries a thin seam of slate or Jack near the bottom; but this is not necessarily characteristic of the bed here. A series of yellow fissile shales underlie the Danville ore bed, and beneath them comes a series of green and red shales and thin sandstones, well exposed near the dam

Kansas valley and Long Hollow are both composed of the upper Salina marls and lime shales and each makes a very fertile strip of farming land between the two ridges.

On the south side of the township the Ore sandstone and fossil ore beds have not been mined at all, although there are portions of this range which show quite as profuse an outcrop as along the terrace of Jack's mountain

On *the property of E. Graham*, a short distance from Shank's gap, a number of shafts were sunk at one time upon the Danville ore-beds; but the sand vein was never proven. The Danville beds have yielded some altered fossil-ore along their outcrop from a bed about 2' thick, overlaid by the Ore sandstone 15' thick.

On *C. Bratton's land*, near the same gap, the same beds have been opened at water level in a ravine where the bed

was said to have measured 3' with interstratified clay seams and to have furnished 50 to 100 tons of hematite or altered fossil ore. Both these localities are close to the Oliver township line.

Near *Galloway Gap* about $2\frac{1}{2}$ miles further west the sand vein was opened 10 inches thick on the property of Geo. Wharton and contained mostly soft ore.

The Ore sandstone and fossil ore beds are again exposed at the extreme south western corner of the township south of the *Ochre mill*, where the river has cut the magnificent section in the Clinton and Salina rocks. The Ore sandstone dips 56° northwest here and is about 15' thick, separated by shales from the Danville ore beds which are here contained in a calcareous and fossiliferous rock 4' thick. The upper bed is 14 inches thick, but very lean, and the two lower beds occur in two calcareous bands 20 inches thick, divided from each other by a thin band of shale and totally worthless as ore.

The *Sugar valley* north of this Ore sandstone terrace is composed of similar rocks found occurring in Kansas valley and long Hollow, and give rise to the same soil. The road up this valley from the Ochre mill is almost entirely through lime shales of the upper *Salina formation*, frequently so made up of good limestone beds as to be mistaken naturally for the next higher formation, No. VI. Indeed some of the beds are so *massive* as to create a subordinate ridge flanking the main Oriskany ridge further north, and dipping at angles of about 55° to the northwest.

The road keeps in these shales for nearly two miles to the new road leading from Harshberger's to the school house on the ridge, which road shows but a very poor exposure of the Lewistown limestone formation and mainly cuts through a mass of sandy slates and shales on the south flank of the ridge underlying the Oriskany sandstone of the crest. This sandstone is 30' to 40' thick and is well exposed in the north leg of the synclinal dipping S. 50° E. 55° - 60° .

This *synclinal* is wholly local and contains a narrow strip of No. VII creating a rugged hill about two miles

long, beyond which in each direction the flexure rises rapidly in the Lewistown and upper Salina rocks. In the valley between this ridge and the river there is a pronounced but equally short *anticlinal*, which carries a narrow wedge of the upper Salina rocks up to within a half mile of the forks of the road at the school house. West beyond this only the Lewistown limestone is exposed and, as the axis subsides quite as rapidly as it rose, these limestones, as well as the very thin band of Oriskany sandstone overlying them, are carried down beneath the Marcellus slates before reaching the Juniata south of Newton Hamilton.

The public road at the school house is about on the crest of this anticlinal. The limestone and the sandstones Nos. VI and VII dip between 70° and 60° to the northwest along the river. In the low gap at Jenkin's house through which the road runs 1 mile east of the school house a good series of the limestone measures is exposed but very thin bedded nearly 100' thick. The Oriskany sandstone measures seem to be totally eroded along the north flank of this anticlinal at least as far as their topographical influence is seen along the river. The Juniata river flows for nearly 2 miles across the steeply upturned edges of the Lewistown limestone formation, a portion of which is seen on either side of the river east and west of Vineyard station, finally issuing on the east bank of the river near the Oliver township line and making the supporting flank of the *Enterprise Mine synclinal* as already explained.

Several small quarries have been opened in this belt, but none of them show very extensive sections of the rock. Passing under the Enterprise mine synclinal these limestones are again brought up on the back of the Chestnut Ridge anticlinal, next north, and continue to be exposed in a high ridge for about $1\frac{1}{2}$ miles west of the Oliver township line. Here they sink beneath the wide rolling *plateau of Oriskany sandstone* which makes such a prominent and remarkable exposition of this formation in the central part of Wayne township.

Vineyard. One *small limestone quarry* has been opened on the Vineyard property, well up the flank of the ridge

about one-half mile northeast from the railroad. It is only important as affording testimony of the structure of this high anticlinal ridge as it shows satisfactory dips of from 40° to 45° towards the southeast on the south flank of the hill.

Glass sand quarry.

The *Enterprise Sand Co.*'s quarry at Vineyard station is opened in the north leg of the synclinal south of this Chestnut Ridge axis, the south or north dipping leg of the synclinal having been eroded at this point. This is one of the newest operations in the district and is excellently equipped for an economical development of the sand bed. The Pennsylvania railroad which practically follows the south bank of the Juniata river all the way from Granville to Ryde station, crosses the river just east of Vineyard station and thereby passes immediately by the washers of the Enterprise Sand Co. greatly to their advantage. In June 1888 this company's operation presented an extremely interesting appearance, and much surprise had been expressed at the absence of all northwest-dipping sand rocks, although apparently opened close to the north outcrop of the Lewistown limestone; but as I have already suggested, all the south leg of the synclinal has been eroded down to the water level, which is the reason why there is but a single crested hill here in which the sand rock dips towards the southeast throughout. Moreover the very steep dips in the south leg of the basin approaching to the vertical, decrease the surface width of the outcrop to one-half of what it would be if the dip in this portion of the synclinal equalled that in the northern half, 40° to 50° . But still further proof of the accuracy of this structure is afforded in the railroad cuts west of Vineyard station where the basin line of the synclinal shows dips of only 10° rising rapidly each way from this central line until finally, in less than a mile and a half from the quarry, the basin has deepened sufficiently to contain a narrow belt of the Marcellus slates, constantly increasing in width going towards Newton Hamilton

The *Enterprise Sand Co.* had originally developed their property by two large open quarries, perhaps a hundred

feet deep, extending from the top of the ridge and separated from each other by a strip of untouched ground into which entries were being extended underground. The stone crops well to the surface, where the southeast dip is not over 20°, but which stiffens towards the bottom of the cuts to one of 40°. A drift has been run northwards from the washer at the railroad for 300' at a lower level than the bottom of either open quarry. A main gangway is driven from the end of the drift in a westward direction a little south of and below the open cuts and which serves through stopes driven up to the bottom of the open cuts to load the material quarried and convey it to the washers. All the blasting was being done in these two open cuts, and the broken stone was thrown down through shoots directly into cars standing in the main gangway. All of the stone exposed in these open quarries has a buff color and rusty appearance, but there does not seem to be any inherent blemish in the rock as after crushing and washing it it appears perfectly white and clear.

The stone sand beds here show a very distinct set of *cleavage planes* which dip towards the northwest at right angles to their stratification, so that one is very apt to be confused by them and to alternate true dip with cleavage. In addition to both dip and cleavage there are immense *joints* or seams called "heading courses" by the quarrymen, which occur along the length of the beds sometimes every 10', sometimes 50' to 100' apart.

The main drift is not driven directly across the strike of the measures, and with sufficient grade to permit the loaded half-ton cars to deliver themselves by gravity from the working faces, to which they are pushed back when emptied almost from the entrance. From the drift the tunnel passes through irregularly bedded and very hard sandstone, having a variable dip, but probably basining before the workable or lower portion of the bed is reached in the rear portion of the workings. This bed is about 125' thick. It is overlaid by a hard rim of cherty sand rock, which really creates the crest of the ridge and is underlaid by a "soapstone" foot-wall to which the gangways are carried.

Thirty-three quarrymen and breakers, 13 outside men and 1 superintendent constitute the force here and the capacity of the works is about 80 tons per day

The washing plant is simple, and yet, perhaps, capable of improvement. The loaded cars, as they come from the mine, were then dumped immediately onto a Chilian mill wheel crusher, although it was proposed to soon equip the works with a Blake stone crusher and a cylindrical screen 6' long and 3' wide. In the summer of 1888, however, the stone was all hand screened. There was a double set of screw-washers, each consisting of a battery of 4 washers, 15' long. The sand, delivered directly from the rollers, was carried through 4 sets of washers, one above the other, before delivery to the drying floor. Each time the sand is washed it seems to become more white. One battery is occasionally used for the "run of mines," stone from which second-class sand alone is obtained; the other battery only washes such material as is crushed from the screened stone. This constitutes first quality sand and brings about 40% higher price than the second-class sand.

It takes about 12 hours for the sand to dry out naturally, but if requested by consumers the sand is steam dried by being fed into an iron cylinder, 15x2½x2½' passing about 30 tons in 10 hours.

Beaver Dam run cuts through this Oriskany ridge about 1½ miles west of the Enterprise quarry, where, despite the fact that the elevation of the ridge has decreased with the expiring of the flexures causing it, three well defined anticlinal rolls are exhibited, which serve to keep the sandstone above water level for nearly a mile north and south.

The first roll just north of the Union Mills dies away after crossing the stream, where it shows north and south dips of only 15°; but the second and third rolls carry the sandstone on their crests in two gentle folds for a mile further west, finally sinking beneath the Marcellus slates, just east of the road leading to Newton Hamilton. At the Union Mills there is a narrow synclinal of these black slates containing in places outcrops of the Marcellus limestone:

but apparently devoid of iron ore. The anticlinal to the south exhibits a beautiful arch of Oriskany sandstone with dips of 10° and 15° north and south ; but this sandstone is very much broken down in this vicinity, everywhere showing beds of loose sand, iron-brown in color, and in places nests of silicious hematite.

At the old *plaster mill* in the gap of Beaver Dam run the sandstones dip north again, the third anticlinal being south of this point between Postlethwaite's and the railroad.

West of Union Mills, which stand upon an outcrop of the Oriskany sandstone, the public road closely marks the division between Nos. VII and VIII, the former being washed bare in many places with a scarcely perceptible northwest dip

Between the railroad and the river, east of Newton Hamilton, the synclinal is occupied by the Marcellus slates; but there is an extremely small thickness of them ; for the bed of the river shows at low water level flat ledges of the Oriskany sandstone very well exposed below the Newton Hamilton dam. No. VII seems to be entirely absent along the south side of this synclinal, or else it has been formerly eroded by the action of the Juniata river. It is likewise very poorly exposed in the gap between Newton Hamilton and the Ochre mill, where the Lewistown limestone No. VI, makes a broad compound arch between the Gifford and Morrison places, with dips of 10° to 15° , beneath which there is a good exposure of the Lewistown and upper Salina shales.

On the west side of the canal below and north of the Widow Ferguson's place the limestone has been *quarried* on a 60° northwest dip, and north of this the Oriskany sandstone shows on the west side of the river, just south of Lane's house in a spur ending at the canal, where it is 60' thick and dips northwest 20° . Overlying this rock on the north flank of the ridge there is a good exposure of the Marcellus limestone, which attains an unusual thickness in this township.

Marcellus limestone quarry.

The *Norton quarry*, opened along the north bank of the river one-half mile east of Newton Hamilton, exhibits, this limestone 40' thick, where it has been quarried to some extent from the bottom of the synclinal basin. It shows a hard gray crystalline and somewhat siliceous limestone, in flat beds from 2' to 4' thick, dipping perhaps 5° southeast and separated by only few inches of shale from the top layer of the Oriskany sandstone, which is exposed in the bottom of the quarry. This opening has been developed at different intervals for the past 25 years, both for lime purposes and for paving blocks for street use in Newton Hamilton.

The same gray Marcellus limestone has been burned at Dysart's between the canal and the railroad further east; at Samuel Postlethwaite's near Union mills, and at John Miller's upper farm on the south side of the river, where a large amount of paving flags has been obtained.

Crossing to the north side of the township the map will show a closely folded Oriskany sandstone synclinal, south of Kansas valley holding within its fold a narrow strip of the Marcellus slates about 2 miles long extending into Oliver township west towards the head of Long Hollow, this synclinal rises rapidly so that the ridge ends in a spur of *Lewistown limestone*, about 1½ miles west of Atkinson's mills. This limestone is exposed in a small *quarry* on J. R. Hannawalt's place south of the Kansas road and near the Oliver township line dipping southeast 50°, but displaying a rather impure shaly rock. This seems to be the character of a large part of the limestone formation at this point, improving in quality somewhat towards Atkinson's mills.

Between this synclinal and the one passing through Atkinson's mills there is an anticlinal of No. VI limestone well exposed on Beaver Dam run with northwest dips of 40° to 50° and southeast dips of 85°, showing a good series of dark blue beds just above Mr. Rhodes' house. This anticlinal belt of limestone is about 200 yards wide and is elevated eastward to receive a triangular-shaped area of the upper Salina lime shales before reaching Oliver township.

The Oriskany sandstone measures are exposed in the north leg of the synclinal at Atkinson's mills just north of Musser's saw mill ; but the sandstone becomes eroded just west of this point just as was the case with the synclinal ridge to the north. At the school house the No. VI limestone is again exposed on a northwest dip of 70° on the south side of this synclinal, where it was once quarried and burned.

The Oriskany sandstone laps around this local anticlinal roll just east of the school house, and turns westward again to make the curving ridge bounding the main slate valley of the township on the north all the way to Mt. Union. The southeast dip along this monoclinical ridge varies between 20° and 30° and the *Oriskany sandstone* becomes somewhat thinner, rarely showing over 100' in thickness. The *Oriskany shales* underlying it, however, seem to take up the thickness lost by the sandstone and all through this ridge are well exposed with a thickness of over 250'.

The Lewistown limestone supporting this shale and outcropping along the north flank of the ridge is in places well exposed too and between Atkinson's mills and the Juniata river contains from 75' to 100' in thickness of good beds. This limestone is opened just below the G. & S. mill at Atkinson's mills, about 25' thick and dipping southeast 40° , and makes a fine display at the extensive *quarries* of the Lucy Furnace Company, located about one-half mile east from the P. R. R., crossing the Juniata below Mt. Union. Nearly 100' of stone is exposed here upon a dip of 30° towards the south, and is said to furnish six different classes of limestone. The central portion of the series, about 40' thick, is found to furnish the best furnace stone ; but while this is the purest bed of the series the beds above and below it contain good stone. During 1888 this quarry was largely operated for furnishing ballast stone for the P. R. R.

These beds are again well exposed along the public road leading from Lucy Furnace to Newton Hamilton, where the ridge is gapped by a small stream flowing into Long Hollow. The Lewistown limestone here really forms the crest of the ridge and its middle massive member, 40' thick, is opened

near the level of the stream upon a 30° southeast dip. A lower division, 20' thick, containing more of gray than blue limestone, is opened a little lower down the stream near the old lime kiln, and the lowest division along the north base of the ridge shows about 40' of siliceous and impure limestone, containing many shale bands. There is an excellent natural opportunity in this gap for the development of a large quarry, which could be extended east and west on both sides of the ravine.

In the main No. VIII slate valley the *Portage flags* are splendidly exposed in the series of railroad cuts west of Newton Hamilton and together with the *Hamilton sandstone and shale* they create a high central ridge extending from the Juniata river east for about three miles to a branch of the Beaver Dam run. From that point east to the Oliver township line this ridge is absent and the valley is composed entirely of the soft Marcellus and Hamilton slates, whose rapid erosion creates a gentle rolling topography. These rocks are well exposed in the road cut immediately west of the Witherow mill on Beaver dam run dipping steeply (60°) to the northwest, and exhibiting a series of black and brown slates with some thin bands of brown sandstone.

The Mount Union Section.

Along the Juniata river, south of Mt. Union, a good section across the valley may be obtained.

The upper Salina lime shales Vc' are first exposed south of that town on dips of only about 15° to 20°, and are succeeded and overlaid by the Lewistown limestone, whose character has just been described at the Lucy Furnace quarries.

The Oriskany sandstone No. VII, crosses the river at the east end of the railroad bridge and does not seem to be over 50' in thickness, while being underlaid by a great thickness of Oriskany shale

The Portage flags show in the bed of a small stream entering the river in Huntingdon county at the north end of

the large island. They are lying perfectly flat and mark the line of the main synclinal basin. The Hamilton and Marcellus slates rise to the surface on the south side of this basin with dips of about 30° , and are succeeded by an anticlinal ridge of Oriskany sandstone—the same mentioned as ending on the canal south of Lane's house—having northwest dip of only 10° , but dipping fully 70° southeast on the south side of the anticlinal.

A tight synclinal of Marcellus slates follows this on the south making the valley of Augwick creek, showing some gray and drab sandy slates at the road bridge dipping fully 85° northwest. A thin band of Oriskany sandstone lies to the south of this valley, creating another ridge and exposing a great thickness of the Stormville shales on a 60° northwest dip. The Lewistown limestone supports this ridge on the south and no better section can be obtained of this formation as well as the Salina groups underlying it, than along the Juniata river south to its great bend at the base of the Blue Ridge. At the extreme bend of the river there is a splendid exposure of the Clinton measures upon the same dip about 500' thick, in which both the Ore sandstone and the Iron sandstone are exposed.

CHAPTER VIII.

Juniata County.

35. Monroe ; 36. Greenwood ; 37. Susquehanna.

These three townships, the most eastern of Juniata county, may be conveniently described together, inasmuch as they are closely related geographically and geologically.

Snyder county. lies immediately east of them with the west branch of Mahantango creek for a mutual line.

Monroe and Susquehanna townships border this on the west with *Greenwood* township filling in the southwest corner, between Monroe and Susquehanna, Delaware township and the Perry county line on the south

All three townships, taken together, have the shape of a rude right-angle triangle, whose base line, about 12 miles long, is the Juniata-Perry county line along Turkey ridge. The vertical side of the triangle, about 7 miles long, extends from Turkey ridge with but one small divergence to the long line of Snyder and Juniata county, crossing Shade mountain from the Lewistown valley to Mahantango creek between Evandale and Richfield.

Mahantango creek forms a sinuous hypotenuse of this triangle about 36 miles long, the enclosed area of the three townships falling between 40 and 50 square miles.

A large part of the drainage in these three townships is eastward into Mahantango creek, and through that stream to the Susquehanna river south of Georgetown ; still an important percentage of the area of Monroe and Greenwood townships is drained southwards through Little Cocolamus creek and its branches, which, after joining the parent stream in the vicinity of Dimmsville in Greenwood township, gaps the Turkey ridge and after flowing directly across the Pfoutz valley in Perry county enters the Juniata river about a

mile below the Tuscarora, and about one-half a mile below Millerstown.

Geologically, except a small triangular area at the extreme northern end of Monroe township occupied by the Salina rocks, and a strip of the Lewistown limestone and Oriskany sandstone measures in Flintstone ridge, and a second small area of the two latter formations occurring on the Georgetown anticlinal axis near the junction of Mahantango creek and the river, the entire area of the three townships is occupied by some one of the divisions of the Devonian formation No. VIII. In this extreme eastern portion of the Tuscarora valley all the subordinate anticlinal and synclinal flexures which create the zigzag series of ridges through the townships lying east of the Juniata river have completely died away approaching Mahantango creek, and with their subsidence all the exposures of the Oriskany sandstone and lower measures have been buried beneath the Devonian rocks, which occupy these townships almost to the exclusion of all other formations.

Structurally this portion of the county may be considered a single and a simple synclinal basin, the line of whose axis enters from Snyder county near the mouth of Quaker run, and curving first toward the northwest it reaches Little Cocalamus creek a little above the Monroe-Greenwood line, where it bends slightly southwards again and passes into Delaware township to a point a little north of East Salem

From the Flintstone ridge on the north to this axial line, all the measures have a south-southeast dip, never exceeding 45° . The dips in the south lip of this main synclinal are even more gentle, being first only from 5° to 10° , and bringing up successively lower members of No. VIII southward to Turkey ridge on dips of from 15° to 20°

Along Mahantango creek this structure is slightly modified by two small anticlinals; first the *Georgetown axis* on the south, which elevates the Oriskany sandstone to daylight for about two miles west of McKee's Half Falls; and, second, a *small axis* about two miles north of the Georgetown anticlinal, which enters the county along the north

line of the Susquehanna township, possibly identical with the *Chapman axis* of Snyder county. Neither of these rolls have any marked effect upon the structure of the district much beyond Susquehanna township, except possibly to decrease the angles in the south lip of the main synclinal of the valley, and account for the fact that this half of the basin is over twice as wide as the north half.

Hamilton ridges.

The most conspicuous member of the Devonian formation No. VIII, in this part of the valley, is the *Hamilton* sandstone and shale, which here contains a considerable thickness of massive sandstone beds and is responsible for the elevated crest of Turkey ridge on the south, and for a similar ridge passing through the northern central portion of Monroe township. It is rendered the more conspicuous by reason of the fact that it occurs geologically between the Marcellus and Genessee formations, both of which are composed of soft slates and shales which erode easily and rapidly and magnify the effect of the hard sandstones of the Hamilton formation between them.

These Hamilton rocks in Mifflin county at the east and the west ends of the Lewistown valley have been described above as very largely shale, containing only some few thin beds of sandstone, which make ridges, but not of any great height. Here, however, the series, nearly 2000' thick, contains in its upper portion a series of fossiliferous gray and yellow sandstones 200' in thickness, which create high ridges wherever they outcrop. Above these sand rocks there are from 800 to 1000 feet of shales, perhaps half of which may be associated with the transition measures between the Hamilton and Genessee divisions. These upper Hamilton shales vary from olive green to brown in color, and may be distinguished from the overlying Genessee slates, which are usually gray to black in color and not at all fossiliferous.

Beneath the Hamilton sandstone, which seems to increase in thickness going west from the Susquehanna river to the Juniata, there is a series of lower Hamilton shales much

more sandy in character, varying from gray to brown in color and perhaps 800' thick. Downward they pass imperceptibly into the upper beds of the Marcellus slate division varying considerably in thickness in different parts of the district, between 300' and 500', with an average of about 400'. At the top of this division there is evidence of some impure limestone, which, along the Susquehanna river near Selinsgrove, is from 30' to 40' thick.

The *Marcellus slate* is usually very black, fissile and pyritous, and is slightly fossiliferous. It is from 100'-200' in thickness and is underlaid by a varying amount of limestone and beds of light gray shale which break into small splintery pieces.

The *Portage rocks*, overlying the Genessee slate in these three townships were nowhere distinguished, and they must be quite shaly in character. The same is true of the Chemung division whose sandstones and shales are so interchangeably stratified as to produce lower ridges than the Hamilton sandstone with crests very much more rounded and eroded by small streams.

All the *Chemung rocks* are very light in color, and may be thus distinguished in place from the darker Genessee slates. This division does not seem to have any great thickness in the Tuscarora valley in eastern Juniata county and only the lower portion of the series is exposed.

The central irregular ridges in Monroe, Greenwood and Susquehanna townships as far west as Little Cocolamus creek are composed of these rocks, everywhere producing a very poor thin soil, which accounts for the languor of farming interests in this portion of the county. Only first class industrious farming, with a liberal use of lime or other fertilizers, will reclaim these ridges, and the soil yields so readily to erosion that only a moderate storm is sufficient to wash out the industry of several days, especially if it has been spent upon the side hills.

Mahantongo creek section.

Perhaps the best exposure of the entire No. VIII formation, which it was found possible to sub-divide with any

accuracy, is seen along the west branch of Mahantango creek from Richfield to McKee's Half Falls.

The Marcellus slate is exposed just south of the gap in Flintstone ridge upon a 40° southeast dip. The Hamilton sandstone succeeds on a dip of 25°, making a high ridge at Shellenberger's Mill at Stony Point. Below the mill the Hamilton upper shales are exposed, brown in color and dipping about 20° to the southeast near the first road passing into Snyder county. Just below the second grist mill there is another exposure of hard gray sandstone probably associated with the Hamilton division, and really creates but one ridge with the more northern outcrop. Going up the ridge road from here south to Peatown, brown and black shales largely predominate with a southeast dip of about 45°; but interstratified with some few sandstone beds. The exposures are few and unsatisfactory.

Along Quaker run, near the first saw mill east of Peatown, a still higher series of gray shales is exposed on a southeast dip of 30°, and along this road for the first time are seen bowlders of *Chemung conglomerate* with white rounded pebbles evidently derived from the crest of the ridge south of the stream. East from this mill the creek cannot be far off the line of the synclinal, for between the school house and the forks of the road the gray and brown shales do not dip over 5° southward.

The conglomerate bowlders become more profuse going down Quaker run from the school house. They are brown and gray in color, often iron stained, but occasionally holding large pieces of white quartz. An exposure of reddish brown slates within one-half mile of Mahantango creek still dipped 20° to the southeast; but at the next cross roads below Jones' house the same reddish slates and thin sandstone dip N. 20° W. 45°.

In Susquehanna township, on the road west of Shaffer's old saw-mill, on Mahantango creek, there is an outcrop of sandstone dipping northwest 20°, and just south of this point the road to Oriental exhibits the presence of a small anticlinal in gray shales and thin sandstone, first dipping about 40° towards the southeast and increasing southwards

to a dip of 60° . These are the Chemung light colored shales and thin sandstones, and show in an exposure here about 100' thick.

North of Oriental the dip is reversed to 10° northwest in dark gray to black Genessee slates, which continue south to the store and show along the creek below the G. M. on a 15° northwest dip.

Mahantango Creek flows east for some distance in a valley eroded out of these shales and the upper Hamilton shales until a little over a mile from the river, at the entrance of a small branch stream from the north, the Hamilton gray sandstone is exposed in the gap in a bed 20' thick, dipping northwest 35° . It makes, as usual, a high sharp crested ridge and in passing through the gap along the main creek the same gray sandstone with some few shale beds is exposed repeatedly, with a total thickness of about 150'. South of this ridge and between it and the Georgetown limestone anticlinal the creek flows through a wide belt of lower Hamilton and Marcellus shales and slates, all showing gentle northwest dips. These rocks are *superbly exposed* just north of Arnold's G. & S. M. upon a dip of N. 15° W. 40° , extending for 150 yards along the creek in an almost uninterrupted outcrop of blue-gray sandstone, thin bedded brown shales and the Marcellus black slate.

The *Oriskany sandstone* making the short ridge running west of Mahantango P. O. everywhere shows a thin bed of *chert* rock producing a sandy gravel soil, containing a great number of flint bowlders. This rock flanks both sides of this ridge, the crest of which is composed of an elevated area of Lewistown limestone nowhere very well exposed.

From the river at Weiser's store and grist mill, west through the Turkey valley and the southern part of Susquehanna township, the exposures are everywhere meagre. At the forks of the road near the river there is a small outcrop of gray sandstone apparently dipping 70° to the southeast, which would indicate a rather tightly folded synclinal of Marcellus and Hamilton measures.

North of the Strawser church, about 4 miles west from the river, the Genessee shales are exposed in the north lip

of the synclinal dipping 20° southeast, making a valley through which Dobson's run flows, flanked north and south by high ridges of Hamilton sandstone. The latter rocks are fairly well exposed at the head of Dobson's run, near the Perry county line and its junction with Susquehanna and Greenwood townships, dipping there about 40° north-west. This ridge therefore is everywhere a monocline, except near the river, where the south leg of the Tuscarora anticline forming the Wild Cat ridge of Perry county laps around the head of Pfoutz's valley to make, with Turkey ridge, a single hill of Hamilton and Chemung rocks dividing Juniata and Perry counties.

The *Turkey valley* in Greenwood township is equally devoid of satisfactory exposures; but in a general way *Crane's run* emptying into Cocolamus creek at the Perry county line in the southwestern corner of the township flows westward through the same Genessee slate valley occupied by *Dobson's run* east of the little summit dividing these two streams. About a mile southeast of the *Seven Stars Hotel* the brown and black Genessee shales, along Crane's run dip but 15° to the northwest, and continue on that dip almost to the hotel, the road running diagonally across the measures. Northwest of the Seven Stars there is a belt of the lower Hamilton shales with a conformable dip, which continues until after passing McDaniel's place where the bottom layers of the Chemung gray and brown sandy slates and thin sandstones dip but 5° to the northwest along Little Cocolamus creek within one-half mile of the Monroe township line.

Above the saw mill, in this township, after passing over a narrow strip of red shales along the township line, brown shale and sandstone, evidently of Chemung age, show with an increased northwest dip of 15° ; but in the next one-fourth mile and near the forks of the creek, this dip is reversed in the same measures to one of 40° southeast and 30° just below the school-house. The main synclinal axis therefore of the Tuscarora valley can be definitely located at the forks of the creek near the Monroe-Greenwood township line. Still further north, along Little Cocolamus creek,

above the schoolhouse and *Bird's run*, the Genessee brown and black slates outcrop conspicuously upon a 40° south-east dip and are succeeded north by good exposures of the gray-blue upper Hamilton sandstone, forming part of the same ridge gapped by Mahantango creek at Stony Point, and showing precisely similar characteristics displayed in the exposure of these rocks at Arnold's mill in the extreme eastern end of Susquehanna township. Two public roads run eastward from this point on Little Cocolamus creek upon either side of the high Hamilton sandstone ridge; the south road in the upper Hamilton shales and the north road alternately in the lower Hamilton shale and the Marcellus black slate, the latter showing everywhere along the south base of the Flintstone ridge.

Additional exposures of the upper Hamilton, Genessee and Chemung rocks might be mentioned as occurring in the southwestern end of Greenwood township along the main Cocolamus creek and *Ducthman's run*. Near the junction of these two streams in the vicinity of Dimmsville there is an excellent exposure of thin bedded sandstone and fissile slate weathering into long rectangular strips extending along the road between the school house and Dimm's mill, upon a uniform dip of 15° north. Shales and black slates predominate along the Mifflin road up Cocolamus creek, largely associated with the lower Hamilton division; but towards the Delaware township line evidently Genessee and all dipping from 12° to 15° northwest

The *timber* all through these sparsely settled and cleared townships is profuse; but of no great size or special value. Nearly 75 per cent. of it is chestnut timber with some little rock oak, the latter showing more plentifully along Turkey ridge, where there is also seen some small hemlock or spruce pine.

The *Flintstone ridge* passing east and west for five miles through upper Monroe township makes quite a distinct and conspicuous feature in the topography of that district occurring as it does between the soft Marcellus slates to the

south of it, and the equally valley-forming shales and marls of the Salina formation to the north. Its crest is Oriskany which in this part of the field is almost everywhere a chert rock 30' or 40' thick, whose broken down bowlders are spread all through the valley on the south side and frequently completely conceal the supporting Lewistown limestone formation on its north flank

Lewistown limestone quarries.

Limestone Quarries.—A small quarry in the limestone formation has recently been opened upon the property of *Reuben Lauver*, situated close to the Monroe-Fayette township line and exposing about 20' of the upper portion of No. VI upon a 25° southeast dip.

A short distance east of Lauver's G. & S. mill in Monroe township near Evandale, the upper Salina olive and gray line shales outcrop along the road dipping southeast, away from the Slenderdale anticlinal, which passes through the northern extremity of this township. These rocks show a marked northwest cleavage, still more conspicuous in the Bloomsburg red shales which outcrop behind or north of the mill.

Two small nameless quarries have been opened in the Lewistown limestone flanking the Flintstone ridge south of Evandale and about a mile east of the Fayette line. Both seem to have been entirely abandoned and developed a rather impure limestone near the bottom of the formation.

West of Richfield and about 150 yards south of the road there are several small independent quarries in this ridge so close together, however, as to practically form one opening for a length of several hundred feet along the ridge. These are known as "Benner's Quarries;" but none of them were working during the summer of 1888. At the most western end of the exposure the limestone beds exhibited a tight fold, with dips of from 35° to 40° N. 45° W. and S. 45° E. The stone is good in certain layers but not conspicuously so, and the entire series exposed will not average over 30' in thickness, mostly very dark blue limestone.

Oriskany flint.

From Richfield to Mahantango creek the Flintstone ridge is considerably broken down and its summits are much lower than further west. In the Mahantango gap in this ridge there is an excellent exposure of the Oriskany sandstone No. VII on the Juniata side of the creek, dipping S. 25° E. 40° and about 30' thick, nearly all of it showing a bluish white quartzite, rough and without fossils. It is totally unlike the true sandstone as exposed through Mifflin county, but essentially the same in composition as the loose flint rock found everywhere through the Flintstone ridge to and beyond the Juniata river and properly explaining its name.

The exposure of this rock on the Snyder county side of the creek is even better; for while the exposure is not continuous, it shows in ledges through about 40' of measures which may be taken as its maximum thickness in this part of the field. Moreover this is one of the few places which display the *contact between Nos. VI and VII*. The top 60' of No. VI here shows a series of intensely dark blue limestone, weathering gray, however, and in rough masses. It is thin-bedded and separated by layers of lime shale and is excessively hard. With an interval of about 60', lower bands of gray and light-blue stone, seemingly of better quality and less siliceous, are opened in a small quarry showing about 20' thick including some shaly members.

Most of the timber still left standing along the Flintstone ridge is white oak, the top of the ridge being especially well timbered in detached places.

38. Fayette township in Juniata county.

This township lies immediately west of Monroe and along the Snyder county line, which cuts a triangular piece out of its extreme northeast corner; otherwise this township would be nearly rectangular in shape. It borders on Juniata county on the north, having the north Oneida crest of Shade mountain for a common line for about 4½ miles. The Snyder county line, passing diagonally across this mount-

ain to Mahantango creek, adds four miles to its north and east boundry, the true eastern line running off from this three miles in length to the little summit between Bird's run and the branch of Cocolamus creek. The south line passes from here across Cocolamus creek to the Flintstone ridge, holding that ridge for a distance of about four miles which is about one-half the length of its southern border line. The Fermanagh line bears nearly at right angles to this, crossing the ends of Lost Creek ridge and over the Slenderdale ridge a little over five miles to the Shade mountain crest. The township is roughly eight miles long by five miles wide; but by the loss of the triangular area in its northeast corner it will not contain over thirty-six square miles.

Lost creek is the most important stream in the township. Rising high up in Shade mountain in the Spiegelmeyer slate valley between the two opposing crests of the anticlinal, it descends with great force and a considerable volume of water in a southwest direction through the township, gapping both ridges along the south flank of Shade mountain; cutting down the Ore sandstone terrace ridge in like manner, and then cuts completely through the Slenderdale ridge, where it exhibits excellent exposures of the Ore sandstone and the underlying lower Clinton rocks. Southwest of this ridge it passes through a fertile valley of the Salina rocks to Oakland mills, where, receiving a number of small tributaries, it acquires strength enough to cut backward through the double-crested Lost creek ridge in Fermanagh township, passing thence westward along its north flank to the Juniata.

A small portion of the eastern end of this township is drained southward through Cocolamus creek which takes its rise in many small springs in this township between Flintstone ridge and the base of Shade mountain.

McAllisterville is the only village of any importance in this township, with a population of several hundred people largely engaged in agricultural pursuits. About a mile east of this village is the summit of the divide between the waters of Lost creek and Cocolamus creek, the valley sloping

gradually but steadily east and west towards Mahantango creek and the Juniata river. By reference to the colored map it will be noted that this dividing summit is immediately north of the double anticlinal roll in Flinstone ridge, which has so duplicated the sandstone and limestone as to present *four outcrops* of these rocks at this point instead of one. It will be further noted that the Slenderdale anticlinal ridge likewise subsides in both directions from a point north of McAllisterville, carrying down on its expiring anticlinal the Ore sandstone about four miles east, within about a mile of the Monroe township line; and in like manner gradually burying the same measures towards the west just across the Fermanagh township line, where the crest of the anticlinal is indented for about $1\frac{1}{2}$ miles by a small synclinal rolls carrying two interior outcrops of the Ore sandstone just into Fayette township, but being present in the lower Clinton shales as far east as the Lost creek gap.

The *geological section* in this township extends from the No. III Hudson river slates in the high anticlinal Spiegelmyer valley of Shade mountain upwards to the Marcellus slate and possibly the lowest bands of the lower Hamilton shale. The map coloring will show the distribution of these and included formations quite as well as any detailed description of them.

The *Hudson river slates* No. III are exposed along the summit of Shade mountain, where they make a valley about five miles long and half a mile wide between the two opposing Oneida sandstone ridges which flank this valley north and south and rise to elevations of 100' or 150' above its level. There are few good exposures of the slate in place, owing both to the natural erosion of these measures, as well as to the large amount of sand *débris* which is being continually washed down the interior flanks of the ridges into the valley, with the effect of concealing the slate. There is but a single road crossing this high mountain barrier from the Lewistown valley at Adamsburg in Snyder county to McAllisterville in Fayette township.

The Spiegelmyer valley rises to an elevation of about 1000' feet above Adamsburg and about 900' above McAllisterville.

Through the Lost Creek gap southwest from here the road passes along the flank of the Oneida conglomerate and sandstone gradually descending into the creek, but rising geologically towards the red Medina sandstone on its descent. Near the contact of Nos. IVa and IVb a small drift has been started just north of the road in some rather dark-colored shales for the purpose, it was stated, of developing *coal*. It is needless to say that the attempt was quickly abandoned when the drift struck a solid bed of yellow sandstone dipping southeast at an angle of 30° ; but the attempt here is only another illustration of the blind work of prospectors, actuated by dishonest motives or by gross ignorance.

Southwest from here the road and creek pass over a belt of the red Medina sandstone and shales, whose outcrop is largely concealed and whose rocks make an elevated plateau but slightly higher than the two ribs of gray and white sandstone enclosing them. The white Medina No. IVc crest is also deeply notched by Lost creek; but besides displaying a great profusion of sharp, angular white sandstone boulders, it shows no good exposure of the Medina rocks in place.

The *Ore sandstone* series has but a single mountain outcrop in this township, forming a terrace ridge on the south flank of Shade mountain, running east and west from Snyder county to the Fermanagh township line. The sandstone itself here is from 10' to 15' thick, and is underlaid by from 15' to 20' of hard, argillaceous shales, under which the Danville ore beds should occur.

West of Lost creek this ore terrace lies much closer to the mountain flank than east of the creek, so that it may be inferred that the dips are greater along that part of the range. None of the ore beds associated with these rocks have been opened along the mountain flank, although in places their presence is indicated by the usual outcrop of hematite or altered fossil ore.

The *Slenderdale* or "Slim Valley," which extends between the mountain Ore Sandstone ridge on the north and the Slenderdale ridge on the south, is everywhere about one-

half mile wide; but as it contains only the lower Salina brown shales, with possibly a little of the upper Salina olive shales, it does not produce any very fertile soil, and has, therefore, never been farmed to any extent. It is of synclinal structure with pretty high dips upon each side of the basin.

The same rocks outcrop all along the south flank of the Slenderdale ridge on dips of between 30° and 40°, where, however, they are overlaid by the upper Salina marls and thin lime-shales which produce a typical farm soil, and which have been given a wider outspread in the southwestern portion of the township by reason of the double crested Lost creek anticlinal. This axis is also responsible for the double zigzag in the Flintstone ridge south of McAllisterville

The *Bloomsburg red shale division* of the lower Salina rocks can be fairly well distinguished all through this township, where, as in Union and Snyder county, it forms the uppermost red shale band of No. V. and presents in its deep red color and the peculiar cleavage of its sandy-shale beds, the same characteristics noticeable in the two counties further east. This Bloomsburg shale enters Juniata county north of Evandale in Monroe township and extends directly west as a low but distinct ridge about midway between the Ore sandstone of Slenderdale ridge and the Lewistown limestone of Flintstone ridge.

West of McAllisterville it becomes rather obscure; but in folding around the eastern end of the Lost creek ridge at Oakland Mills it is seen to maintain its character and by reason of the flat 10° dips on this anticlinal it is spread over a wide belt of territory in the vicinity of the last named village.

Laurel run, a tributary of Lost creek at the western side of the township, cuts through the Slenderdale ridge, which is here considerably broken up and shows no exposures except frequent bowlders of the Ore Sandstone, broken down from the central synclinal as well as from the two main outcrops of the ridge. Crossing the valley south of Slenderdale ridge the Bloomsburg red shales first show at

Kinsers' place on a dip of 60° towards the southeast. This dip is immediately reversed and succeeded by the lower Salina shales, until crossing Lost creek at Burgey's saw mill, the Ore sandstone again shows in Lost creek ridge on a 15° northwest dip. In this portion of the valley therefore the upper Salina lime-shale formation has no representation and are not exposed until Lost creek is reached about a mile east of Kinsers' place.

The Lost creek section through Slenderdale ridge about 2½ miles east of Laurel run is but slightly more satisfactory as far as actual exposures are concerned

J. Tennis has run a small drift into a *fossii ore* bed on the north leg of the anticlinal upon a small tributary of the main creek, which has also notched the northern side of this ridge. The drift is now badly fallen in, entirely obscuring the ore bed, and is located just at water level a little south of the Slim Valley road. The Ore Sandstone is not well exposed here and in addition to being thin, is likewise very shaly, so that the ore-drift may have been located upon one of the Danville ore beds although generally reported to be the Sand Vein.

It was not possible to inspect the ore bed at this point, although it was evidently of good size, and dips about N. 15° W. 40°. The gangue rock thrown out from the opening is highly fossiliferous, brownish white in color and possibly represents the sand-rock underlying the Sand Vein.

In the main gap the Ore sandstone is equally obscure, although many boulders of it, making large blocks, were seen at the bend of the road near Trego's S. M. This dip was obscure; but upon rounding the little ridge further west on the Adamsburg road the underlying argillaceous slates and blue clay rocks dip distinctly N. 20° W. 60°, just east of E. S. Auker's house. Underlying red and brown shales show further south on a 40° southeast dip, and on the south side of the anticlinal, until just north of Wedman's place, the southern outcrop of the Ore sandstone is distinctly marked by a great number of loose blocks of sandstone. Still further south and nearer McAllisterville, there is a good exposure of the upper Salina lime shales

dipping 35° and 30° towards the southeast. These rocks crop out just north of the soldiers' orphan school.

On the second road leading north from the pike east of McAllisterville, the upper Salina measures outcrop on a 40° southeast dip, succeeded northwards at the bend of the road by the underlying Bloomsburg red shales with a slightly decreased dip. North from Kelly's store the Ore sandstone outcrop was not noticed; but it must lie close along the north side of the valley road to judge of the many boulders seen there, as well as the topography.

In the gap at the head of Cocolamus creek *fossil ore* 7 inches thick was once opened on the east side of the stream opposite J. Vanormer's, and also on the ridge further east on Eichman's place. Both openings had entirely fallen in and not even the character of the ore could be seen. The anticlinal here has flattened greatly, the dips not being over 15° or 20° .

In the next gap east and the last notch in Slenderdale ridge, there is again no evidence of the Ore sandstone in place. However, a short distance north of Leister's S. M., the underlying lower Clinton lime shale and olive slate, holding several thin sandstone beds, are excellently exposed on a 40° southeast dip, aggregating about 200' in thickness, including some few barren intervals.

The Ore sandstone must be very thin and shaly at this point and has only been approximately located on the map. Comparatively little information could be obtained all through this valley concerning the character of any of the *fossil ore beds*, but the topographical conditions existing there as well as the character of the rocks associated with the ore measure series, are such as to warrant the belief that if these ore beds exist at all, they would all furnish a large amount of desirable soft fossil ore. The conditions all through this Slenderdale ridge, excepting the absence of railroad facilities, should rather tend to encourage exploitation.

Almost all the road east from Oakland Mills through the valley of upper Salina marls are piked with the *chert rock*

from Flintstone ridge, so that nowhere in the county is traveling rendered more easy or agreeable. Still the geology is often obscured, both by the natural and the artificial position of this rock. In the ridge itself, so great has been the *débris*, its breaking up has produced the Lewistown limestone No. VI is scarcely exposed at all, except where it has been regularly opened in some limestone quarry.

The *Oriskany No. VII* does not seem to exist as sandstone at all except at one locality, and the Lower Helderberg or Lewistown limestone rarely shows over 40' in thickness, producing a good burning stone, but a rather dark lime, not well suited for building purposes.

Lewistown limestone quarries.

The first openings in the limestone formation along the southern border of the township are very small, none of them expose more than 20' or 25' of rock. West of the Mennonite church the limestone dips 55° southeast; at Musser's quarry, a mile further east, the dip is 60° in some good pure beds. At the next quarry, one-half mile further east on the west side of the road, crossing the ridge to East Salem, the dip is only 40°, but varies between that and 55° in isolated exposures for the next two miles. Here, south of McAllisterville, the Flintstone ridge has thrown down such a large amount of chert that the true position and extent of the limestone is concealed and can only be approximately located by its topographical influence with the aid of some few small quarries.

East of the road leading from McAllisterville, due south across the ridge, the first opening in the more southern of the two anticlinal limestone ridges is the *Slagle quarry*, formerly Moore's, where about 20' of limestone in the bottom of the Lewistown formation has been worked for local farm use, dipping N. 30° W. 35°.

East of the road summit there are several other old quarries, none of them large and none of them worked during June, 1888. They belong to Hubbard, Benner and others, all opened upon a S. 30° E. 30° dip on the south side of the

anticlinal. They are but slightly developed and all present a rather ordinary stone and are all near the forks of the road to East Salem on the Gingerich place.

The *Landis quarry*, still further east, is much more extensive; but it too was to a large extent dismantled, and was not in operation. It is open immediately on the arch of the south anticlinal of the Lost Creek ridge with dips of 10° to 15° northwest and 40° southeast. About 40' of very good dark blue limestone has been developed here in an opening 100' long. It is not all first-class stone, much of it apparently being quite siliceous; still it is better than other openings in this same ridge.

A short distance further east the limestone is completely overlaid by the *Oriskany chert*, which creates a knobby ridge extending nearly one-half mile further before it subsides with the anticlinal under the Marcellus black slates.

On the road from the Landis quarry, northward to McAllisterville, the north leg of this anticlinal carries a very faintly defined band of yellow and white chert rock (No. VII) on its north flank, beyond which the road passes into a narrow synclinal valley of Marcellus black slate which extends westward about one-half mile before it becomes entirely enclosed by the junction of the two Oriskany sandstone outcrops. This makes another dome-shaped hill, supported further west by limestone not opened.

West of Kaufman's the No. VII chert band is well exposed at the first bend of the road; also the Marcellus slate No. VIII in a road cut, dipping S. 60° E. 50° , and about 25' thick. Still further north, descending the flank of the ridge, the Lewistown series is exposed in a narrow ravine dipping 50° southeast and from 50' to 70' in thickness.

The narrow valley at the base of this ridge and between it and the main hill south of McAllisterville is an anticlinal of upper Salina rocks, which are here very calcareous and have been opened at the base of the south flank of the main ridge west of Bashour's brick house, dipping northwest 30° - 40° .

The *Samuel Lennart quarry* is the first opening east of McAllisterville, on the north flank of Flintstone ridge. It

is located immediately alongside the public road and has been very badly developed. It shows two layers of fair blue limestone; an upper, 10' thick and lower 15' thick, separated by 4' of shale, the whole series being capped with impure thin-bedded limestone and shale dipping about 15° southeast. There are 3 old kilns here, but the quarry has never been extensively worked. The Lewistown limestone occupies the entire ridge here to the exclusion of higher measures, which do not occupy this ridge until the synclinal has deepened to such an extent one-half mile eastward as to hold the Oriskany sandstone and later the Marcellus slates, which make a narrow valley 1½ miles long to Cocolamus creek.

The *Long, Benner and Reynolds quarry*, situated on the crest of the more northern of the two Lost Creek anticlinals, and about a mile southeast of Lennart's opening exhibits the anticlinal structure of the middle ridge. This opening is just opposite the frame schoolhouse, and shows dips of 15° and 40° north and south. There are four kilns here and a large quarry which is operated periodically for farm use, developing some excellent blue beds, in all about 25' thick, this is the same series of rocks occupying almost a precisely similar geological position at the Landis quarry on the southern anticlinal ridge. The limestone in the middle ridge extends east for about a mile, beyond which it is enclosed in a knob of Oriskany sandstone reaching nearly to Cocolamus creek.

The *Oriskany sandstone* shows an outcrop in the north monoclinical ridge about a mile west of Brown's store on Cocolamus creek dipping 40° southwards along the private lane crossing the ridge. *Sink holes* occur conspicuously along the north flank of this ridge and are largely the means of locating the limestone formation, here covered with chert. Between this point and Brown's store the limestone is sparingly opened in two or three places. Where opened on the *Koons* and *Knaus* places the limestone is impure although burned for local use. The dip is about 70° southwards.

Kobel's quarry is a large excavation on the east side of Cocolamus creek in the gap opposite Brown's store. It was

not worked last summer; but is operated periodically for local farm lime. The dip is S. 25° E. 40°, and the quarry shows about 30' of fair blue stone, rather thin bedded and with an uneven fracture.

Frymoyer's quarry is about 1 mile further east along the ridge and about 200 yards south of the valley road. It has long been abandoned and shows no new features except a more gentle 25° dip and less development than at Kobel's. No stone has been quarried or burned here for a long time. John Brown is the present owner of the property.

The *southeast corner of the township* is occupied by a small area of the Devonian rocks. The Marcellus slates closely hug the base of the Flintstone ridge, as well as the zigzag overlaps of the Lost creek ridge anticlinal and almost completely fill the two synclinal valleys between the limestone and sandstone spurs, south of McAllisterville.

The *lower Hamilton shales* closely follow the Marcellus slates extending perhaps one-half mile west of Cocolamus creek in the second and deeper synclinal; while the Hamilton sandstone occupies a small portion of this corner in the vicinity of the old school house.

One important outcrop of the *Marcellus limestone* occurs about 8' thick just opposite Brown's mill dam on the south flank of the northern Oriskany sandstone ridge. It has a dark blue color and of good quality, overlaid first by gray slate and then black slate, both well exposed dipping S. 25° E. 35°.

39. *Fermanagh township in Juniata county.*

This township lies west of Fayette with the Shade mountain for its northern border line, seven miles long; the Flintstone ridge for its northern line, 4½ miles, and the Juniata river making an irregular western border, about six miles long from "The Narrows" on the north to about one-half mile below Mifflintown. Its area is about twenty-five square miles, and geologically is largely a western prolongation of Fayette township.

Its drainage is all westward into the Juniata, mainly through three streams and their branches:- 1st. *Horning*

run, on the north, rising in the northeastern corner of the township near the old road, crossing the mountain to Wagner, in Mifflin county, and flowing southwestward across the Slim valley and Slenderdale axis to the river about two miles above Mifflintown. 2d. *Lost creek*, the most important of the three streams, as well as the largest, entering the township on the east near Oakland mills; cutting through the more northern of the two lost creek ridge anticlinals, and after cutting twice through the north leg of this axis flows west to the river at the Cuba mill, about $1\frac{1}{2}$ miles above Mifflintown; and, 3d. *Happy Hollow run*, which flows westward along the southern side of the township through the Mifflintown synclinal to the river just below the county seat.

Mifflintown, the county seat of Juniata county, is likewise the largest town of the district, beautifully situated on the east bank of the river and the old Pennsylvania canal, and nearly in the center of the county.

The *geological series* of rocks exposed in Fermanagh township extends from the Hudson river slates No. III at the base in the Spiegelmeyer anticlinal valley upwards to the Oriskany sandstone of Flintstone ridge, which occupies the southern side of the township. Between this ridge and the mountain there is a valley four miles wide of the Clinton and Salina formation, topographically modified, however, by the presence of *Lost creek ridge*, a double-crested anticlinal of Ore sandstone and lower Clinton rocks, passing eastward through the township north of Mifflintown and gradually sinking just at the Fayette township line beneath the wide plain of Salina rocks which spread out as already described near Oakland mills.

The *Slenderdale ridge*, a mile and a half further north, is likewise an anticlinal of the same rocks; but it declines with the flexures causing it from the east, westward, carrying down all four outcrops of the Ore sandstone about a mile west of the Fayette line, but maintaining its elevation in overlying Salina rocks which create a conspicuous ridge south of Horning creek to within one-half mile of the Juniata river.

The expiring *Blue ridge anticlinal* has preserved only one small knob of the Medina white sandstone on its crest east of the river and just north of Grahamville; but the lower Clinton shales and sandstone create high ground for $1\frac{1}{2}$ miles further east. Here the Ore sandstone sinks beneath water level on the crest of the anticlinal and returns on the north side of this ridge for nearly two miles westward in the Juniata "Narrows" synclinal. Two outcrops of the Ore sandstone and Sand Vein fossil ore have been opened in the *tightly folded synclinal* at the old Glamorgan mines.

The township therefore shows an alternate series of ridges and valleys running east and west, and watered by the various streams just mentioned.

The *No. III slates* in this township form the western extremity of the Spiegelmeyer valley, enclosed between the two outcrops of the Oneida sandstone and conglomerate, making the double interior ridge of Shade mountain.

This valley, or that portion of it contained in Fermanagh township, is about 3 miles long and one-half mile wide, narrowing towards the western end, beyond which the Oneida sandstone crests come together to form a high knob. These slates are well seen along the now pretty well abandoned public road crossing Shade mountain south of Wagner. No good outcrops of the slate were seen in crossing the ridge at this point, everywhere presenting a broken down mass of brown and gray somewhat fissile shale, whose decomposition gives rise to a gray clay soil.

Both the *Medina* and *Oneida members of No. IV* are well exposed in the north dip of the anticlinal (in Mifflin county.) The former dips N. 55° E. 5° in a 60' ledge, and the latter about 50° northward, making the inside ridge overlooking the valley and containing near its base a coarsely conglomeratic rock filled with pink and white pebbles.

Neither of these formations show good outcrops on the south flank of the mountain, where, however, the dip must be somewhat steeper, as the two ridges are closer together and carry the Iron sandstone and the Ore sandstone in a high terrace.

The latter rock and its overlying fossil ore were not well seen along the public road; but some old test shafts put down here indicated a vertical if not *overturned dip* in the measures, which decline in strength going westward $1\frac{1}{2}$ miles to the Suloff mines of the Duncannon Iron company.

Fossil ore mines.

Suloff Mine.—This mine, developing the *Sand Vein ore-bed*, is located on the west side of the old Suloff Gap road, about one-half mile north from Henry Suloff's house and $4\frac{1}{2}$ miles northeast from Mifflintown.

The mine has been leased and operated by the Duncannon Iron Company for the past 15 years, and a large quantity of fossil ore taken from it to their furnace in Perry county. The main drift is located between the road and a small stream flowing southwards from Suloff gap, and is driven northwards to the "back vein" or main outcrop.

The ore bed coming westward from Fayette township makes but a single outcrop (as shown on the map) until it reaches this point, where it makes a gentle basin; doubles eastwards and backwards on itself for a short distance; then it folds over an equally gentle anticlinal to return westward for $2\frac{1}{2}$ miles as the north leg of the main synclinal in the Juniata "Narrows;" consequently the three outcrops of ore which have been tested and developed at the Suloff mines are not three distinct beds of ore, as the miners sometimes declare, but are simply a triple-folded outcrop of the same Sand Vein ore bed. This structure is shown on the map.

The mouth of the main drift is located just south of the central outcrop, called here the "Middle Vein," forming the south lip of the synclinal and the north leg of the anticlinal, and passes northwards about 50 yards east of the west end of the synclinal, where the Ore sandstone and fossil ore are brought to daylight.

East of the tunnel the basin deepens and spreads the two outcrops a little further apart. The north leg of the synclinal, or the "Back Vein," as it is locally known, had been drifted upon in May, 1888, eastwards for about 1000

yards, the first 800 yards on a steep southeast dip and the last 200 yards on a steeply *overturned* northwest dip. The ventilation had become so bad at the face that the company were at that time sinking an air-shaft at this point from the surface to the mine level, which has since been completed.

The south leg of the synclinal had been developed only about 100 yards east of the main tunnel, where the bed was found to pitch rapidly beneath water level, while flattening its dip from about 45° northwest at the tunnel to a nearly horizontal dip as the anticlinal was approached eastward. Between the two opposing synclinal outcrops in the main drift, a heavy bed of "*over clay*" (decomposed slate) was found to occupy the basin, and the Ore sandstone underlying the ore bed was found about 20' thick.

The form of the anticlinal roll south of the narrow synclinal is well seen a short distance in from the mouth of the tunnel, where siliceous slates and shales form about three-quarters of the arch, the balance lying south of the drift mouth. The south outcrop of ore was not cut in this drift from the fact that this ore bed lies south of the drift mouth; but the bed has been struck in several shallow shafts a little southeast of the drift, showing about 2' of excellent ore on a 10° southeast dip.

The new tunnel which has been started southeast of the original opening, and perhaps 30' lower in elevation, will certainly strike the ore bed on its *south* dip; but there is some doubt as to its striking the *north* leg of the anticlinal, from the fact that the succeeding synclinal is very shallow and may basin entirely above the level of the tunnel.

The bed in the rear outcrop, most largely mined, varies somewhat in thickness, according to the swelling or thinning (from 3 inches to 10 inches) of a central ore bench carrying some "*soapstone slate*," dividing a top ore bench 4 inches to 6 inches thick from the lower bench of about equal thickness, both furnishing soft fossil ore. The whole bed is capped with about 4 inches of slate, or "*pin*," and throughout the mine furnishes on an average 20 to 22 inches of ore. In the rooms the ore alone is removed, the stopes extending upwards for from 60' to 100' in length. In the

entries about 4' of slate additionally have to be removed for a traveling way.

The ore is all hauled in wagons to Patterson station on the Pennsylvania railroad, opposite Mifflintown, costing, during the season of 1888, 75 cents a ton for haulage. With the cost of mining and royalty added, the ore cannot cost much less than \$2.50 on the cars at this point. The Duncannon Iron Co. has used about 150 tons a month in their furnace during the last 16 years, where its yield has been found to be about 33 per cent. of metallic iron.

On *the J. Suloff property*, about one-half mile further west, the "back vein" was, at one time, leased and mined by Messrs. Williams and Willis. This drift has been idle for some time and it was reported that it had been extended northwards for some 200 yards beyond or back of the ore bed towards the mountain, with the hope of getting to an outcrop of the "mountain vein." Whether the intention was to develop the Danville fossil ore bed, which occurs slightly lower down in the Clinton measures and nearer the mountain, and has been worked at the Glamorgan mines on the west; or, whether a knowledge of the duplication of the ore outcrops at the Duncannon mines, led to the supposition that a drift at this point should necessarily develop two beds, there are no means of knowing. The latter object does not seem possible to attain if the structure has been properly made out; and the other hope of striking the Danville fossil ore is wholly dependent upon its extension as ore this far east of the Glamorgan mine. But even if this hope was realized, and the bed found to exist in good condition, its dip at this point would be rather severe, and as it is only about 9 inches thick at the Glamorgan mines it would be extremely doubtful whether it could be very advantageously worked under the different structural circumstances.

The *Glamorgan* or *Graham mines* which operated both outcrops in the synclinal are located about midway between J. Suloff's and the river. The amount of ore mined from

them has been considerable, and was last shipped by the canal from Grahamville to the Glamorgan furnace at Lewistown. Large quantities of ore were piled along the canal during 1888 for some distance above Grahamville awaiting shipment; but the furnace being out of blast there was no opportunity for getting rid of this surplus nor of personally inspecting the mines, all of which were idle.

Mr. Austin Farrell, at present superintendent of the Ivanhoe Furnace Company of Virginia, was the last superintendent at these mines, and as it was impossible to make any satisfactory personal examination of them Mr. Farrell has kindly submitted the following facts by letter: "The ore occurs in a synclinal basin and was generally spoken of as the *North* and *South* veins, the South vein dipping northwards at angles of from 5° to 40°, and the North vein southwards at about 50°. In many places the South vein lay so flat as to prevent its being worked cheaply and it was therefore abandoned. Both the Sand Vein fossil ore bed and the (Danville) 'Ginger vein' were worked, the former about 20 inches thick and the latter 9 inches thick separated by 38' of sand rock (Ore sandstone and shales). The *Ginger Vein* was so called from its color and had for its hanging wall a hard sand rock. In all there were 7 openings here, in the Sand Vein bed, Nos. 1, 3, 4, 6 and 7, and two, Nos. 2 and 5 in the Ginger Vein. Both veins in all cases were reached by cross-cuts through the slate, which were made feasible by the broken topographical conditions of the ground at the mines. One cross-cut, No. 4, was about 900' long, starting in the lower Clinton shales south of the southern outcrop of both veins and reaching to the north outcrop of the Sand Vein, which it struck just in the basin. This was the only recent opening in the Sand Vein ore bed, as the ore had been worked out from the other drifts which were located at higher levels and nearer the outcrop. From this long 900' cross-cut, gangways were extended east and west as usual upon the ore bed. The Sand Vein yielded about 40 per cent. of iron, and the Ginger or Danville bed about 45 per cent; and when these beds were last actively worked they yielded monthly to

Glamorgan furnace about 1500 tons of Sand Vein fossil and from 800 to 1000 tons from the Ginger Vein. The average height of the stopes was about 50'. The basin between the two outcrops of fossil ore is filled with the lower Salina shales and slates."

Some little development has also been made in past times on the extreme south outcrop of the *Sand Vein* on the south side of the Blue Ridge anticlinal. The Ore sandstone makes quite a prominent terrace ridge here for something over a mile east of Grahamville, forming a sure guide to the location of the overlying fossil ore.

Along *Big run*, a branch of Lost creek, which makes a wide gap in Slenderdale ridge, the Ore sandstone measures are exposed and apparently make a double anticlinal; a southern one, burying the Ore sandstone soon after crossing the creek, but the northern and stronger one still keeping these measures above water level for one-half mile west of the creek. Along the road the southern anticlinal creates a *beautiful arch* in the Ore sandstone 60' above creek level. The sandstone is about 25' thick but occurs in thin beds with dips of 5° southeast and 20° northwest.

Some abandoned ore openings were seen in the synclinal north of this axis, most of which were very small and never seem to have been very successful.

Towards the north end of the gap and about 50' above the level of the stream, an old drift had evidently developed the Sand Vein on its south dip in the north anticlinal. It has been long abandoned and the timbers were so rotted that it was impossible to examine the opening, but it evidently furnished some good soft fossil ore. It was opened by Simon Mumma and it is claimed that the bed was about 2' thick, but carried some "Jack" mixed with it. It is also said to show a sandstone floor with a gentle southeast dip. The same ore was struck higher on the ridge on a steep north dip, the bed furnishing about 12 inches of ore.

The Ore sandstone to the north of it outcrops at the bend of the road on a 40° southeast dip, underlaid by reddish

brown shales on a 60° dip. No exposure of the sandstone in the north side of this anticlinal was noted.

Westward to the river the Slenderdale ridge is made up of the Clinton rocks occurring above the Ore sandstone measures; but they seem to be quite sandy and generally much more massive than elsewhere in this district. It may be too that the Ore sandstone extends further west than as shown on the map; but there are no gaps in this ridge until *Horning run* swings around its western extremity only a short distance from the river and the opportunities therefore for noting its presence were not very favorable. They likewise contain several thin beds of limestone, and in the gap of *Horning run* these olive and lime-shales make the crest of a perfectly preserved anticlinal with dips of 60° southeast and 10° northwest.

Further south down the run the upper Salina lime shales show upon a southeast dip of 40° with some reddish shale, possibly the Bloomsburg measures, between these two outcrops dipping southeast 50°. The synclinal passes about through the mill and holds a very small amount of the lower members of the Lewistown limestone, rather impure and shaly in places, but containing some good beds.

To the east this basin rises steadily, showing everywhere a narrow fold with dips of about 40° southeast and 70° northwest, and passing into Fayette township it deepens again to receive the first limestone ridge south of McAllisterville. This is best known as the *Licking Creek synclinal*.

Crossing Slenderdale ridge from Suloff's gap only the olive and brown Clinton slates are seen until along the south base of the ridge, the Bloomsburg red shales show near Crum's place on a 30° southeast dip and can be traced as a narrow band hugging the foot of Slenderdale ridge into Fayette township.

On the south side of the Licking Creek valley there is another corresponding band of the same red rocks showing especially well between Thomas' place and the schoolhouse and dipping steeply northwest. It is between these two outcrops that the upper Salina lime shale occurs, making, as usual, an excellent farming soil belt through the township from one-half to 1½ miles wide.

Immediately north of Mifflintown, along the canal and pike, the same upper Salina lime shales outcrop with southeast dips of 30° to 40° succeeded northward near the first road leading east by a considerable outcrop of the Bloomsburg red shales and thin bedded sandstones, creating an excellent exposure extending along the pike for nearly 100 yards to the first lockhouse. Some Clinton olive and lean lime shales succeed, going north, and beyond the next ravine the *Ore sandstone* is *finely exposed* on the south flank of the Lost Creek ridge anticlinal about 20' thick and dipping southeast 20° . It is quite massive and shows the same gray hard sandstone weathering brown, and which dresses so readily as to have been used in many parts of the district for *building* purposes, despite the fact that the iron it contains generally causes it to weather a dark brown color, and somewhat irregularly so. The effect of this weathering is to many very pleasing.

Its outcrop here creates a little terrace ridge on the flank of the main hill formed of lower Clinton measures, so that the Sand Vein ore bed would necessarily have to be sought for along the ravine, and would be largely devoid of soft fossil ore. Higher up the ravine some ore might be found, as the dip is slight and the hill increases in elevation going eastward. The Danville beds are concealed here, though they have been apparently sought for in the side of the sandridge higher up.

The *Ore sandstone* in the north leg of the anticlinal is concealed, and though the Bloomsburg red shale at the *Cuba mill* dips 60° northwest, indicating a single simple anticlinal axis, the exposures on the west side of the river along the railroad show the lower Clinton shales to be considerably twisted and folded between the two outcrops of stone.

Along the road leading east from the river on the south side of Lost creek ridge the stream practically divides the Bloomsburg red shale from the underlying upper Clinton shale.

The *Ore sandstone* first touches the road about a mile

from the river at the first cross-road, still exhibiting a gentle 20° southeast dip. The Sand Vein ore bed has been slightly stripped along its outcrop here.

The sandstone shows again a little north of Stoner's place as loose rock and crossing the summit an interior synclinal axis carries two outcrops of the Ore sandstone near Gross' place with converging dips of about 15°. This basin rises rapidly westward, so that the Ore sandstone is carried out to daylight before reaching the river. Eastward it runs through the center of the ridge to the Fayette line, where the double axis is seen with gentle dips of from 10° to 15° in each one of the anticlinals.

Making such a flat arch between Stoner's and Gross', the ore should be readily reached upon either side, if found at all, in good condition; but no openings were seen on this road and the underlying sandstone is so frequently exposed on the flanks of the ridge that the ore itself must be eroded through much of this south ridge. The Danville beds have not been proved here either, and it is not likely that they exist with mining thickness.

It is reported that ore has been dug to the depth of several feet along the outcrop on the summits of both the parallel ridges which here constitute the Lost creek ridge; but no regular mining has been carried on.

The next road crossing south over Lost creek ridge from the Licking creek synclinal shows a good outcrop of the *Bloomsburg red shales*, 100' thick, at S. Thomas' at the forks of the road, dipping 70° northwest and succeeded southward by a band of Upper Clinton gray lime shale to the Ore sandstone which makes a narrow low ridge on a 50° northwest dip. This ridge is very low at this point, so that it could not afford ore-breasts of great length. This is true also east and west of the road even though the hill rises to much greater elevation.

A few yards south of this outcrop the underlying Clinton brown and red shales outcrop at W. Allison's house, dipping southeast 50° in the south leg of the first anticlinal just before Lost creek is reached; but immediately after crossing

the creek the Ore sandstone is again obscurely exposed in both sides of the narrow interior synclinal, the dips of which must be quite steep. Boulders of this rock continue for a long distance up the flank of the hill, and just before reaching the summit at Bell's house, red shale and sandstone show on a 10° N. W. dip giving evidence of the broad flat structures of the main anticlinal axis.

Mr. Bell claims to have struck the Sand Vein ore bed in a well near his house, 53' deep, furnishing 18 inches of hard fossil ore. He does not recall striking any massive ledge of sandstone beneath the ore bed, but reports the existence of several thin beds of sandstone divided by bands of slate underlying the ore. It is just possible that the Danville bed is the one found here, for the measures between the outcrops of the Ore sandstone on either side of the hill correspond closely in appearance to the lower Clinton shales. There is no appearance of the Ore sandstone until going south of his house, where a profusion of boulders mark its outcrop.

The south flank of the ridge is composed of the Bloomsburg red shales dipping about 30° S. E. beyond which the upper Salina marls and a narrow synclinal tongue of the Lewistown limestone, extending 2 miles east of the river, are crossed over to the base of the Flintstone ridge. Only the bottom layers of the No. VI limestone are exposed along Happy Hollow run, forming a very gentle basin with N. and S. dips of between 10° and 20° .

At the east end of the Lost creek ridge, south of *Jericho Mill*, the Ore sandstone shows on the dying spurs of each anticlinal with dips of 15° on the north axis and 10° on the south. The brownish-red soil of the rock when decomposed is very conspicuous at the nose of each ridge and along the south flank, where frequently large flat beds of the Ore sandstone are exposed in massive plates on a 10° S. E. dip, over which the road runs west to the first dwelling.

The *Flintstone ridge* in this township and Walker township on the south is of synclinal structure, the south line of Fermanagh township running for about $1\frac{1}{2}$ miles along

the Oriskany sandstone of the north lip of the synclinal and for an equal distance west on the supporting Lewistown limestone.

The *Oriskany sandstone* makes a broad flat double-crested hill for about 2 miles west of the eastern township line, but beyond that point the synclinal rises rapidly and the Lewistown limestone forms the hill to the exclusion of the sandstone for the next $1\frac{1}{2}$ miles. Beyond that, 1 mile to the river, the limestone has been eroded and the synclinal hill gently sinks, holding only the upper Salina limestones.

Lewistown limestone quarries.

The *Banks quarry* is the first opening in this township, located about one-fourth mile west of the Fayette line. This opening is about 100' long and though not active when seen in June, 1888 it had been worked during March of that year and some 3000 bushels of lime burned. The dip is not over 35° S. E. and the quarry affords about 30' of good blue limestone in rather thin beds and showing nests of calcite.

D. Beshour's quarry is the next opening about three-eighths of a mile west. It is a smaller quarry but capable of furnishing much good stone. The dip is 40° S. E. here and the limestone somewhat lighter in color.

Two fields west from here there is a small nameless quarry about 100' south of the road opened in the same strata, and west of the road crossing the Flintstone ridge a small thickness of the good beds of No. VI have been sparingly opened at *Gingerich's quarry* just beyond the point of the Oriskany ridge.

Still further west the north flank of the ridge shows some few exposures dipping 70° to the southeast as the basin shallows, but no quarries have been opened here and the stone has become very hard and cherty. Along the road leading into Mifflintown there is a sharp anticlinal ridge extending for about 2 miles east of the river with dips of 40° N. W. and 70° S. E. in the upper Salina shales, which accounts for the presence of the narrow limestone synclinal extending for about an equal distance east of the river along the north side of Happy Hollow run.

40. Delaware township in Juniata county.

This township extends from the crest of the Tuscarora anticlinal ridge on the south to Fayette township on the north. Greenwood bounds it on the east and Walker on the west. Its shape is somewhat irregular, by reason of the offset in the Perry county line passing from the spur the Tuscarora mountain at the Juniata gap northward for $1\frac{1}{2}$ miles to the crest of Turkey ridge, along which it runs for a mile to the Greenwood township line. The east line is straight and a common one with Greenwood and Monroe, about 4 miles in length from Turkey ridge on the south to the Birds run summit on the north. The west line has one break extending $3\frac{1}{2}$ miles from the crest of the Tuscarora mountain across the Juniata river valley to the Oriskany sandstone ridge of the north leg of the main Tuscarora synclinal; and with a slight angle extending 2 miles further from that ridge to the summit of Flintstone ridge on the Fayette township line. The area approximates 30 square miles.

Cocolamus and *Delaware creeks* drain the entire township, with the exception of its lower portion, which is drained directly by the Juniata river. *Thompstontown* and *East Salem* are the principal villages.

The *rock section* exposed extends from the red and white Medina sandstone in Tuscarora mountain to the Hamilton rocks of No. VIII in the Tuscarora and East Salem synclinals between the zigzag outcrops of the Oriskany sandstone and Lewistown limestone in the ridges flanking these two principal slate valleys.

The *Medina white sandstone No. IVc*, which makes the Tuscarora anticlinal, is nowhere well exposed. Even at the magnificent gap made by the Juniata river its rock is so broken down as to conceal all evidence of the beds in place; but the arch must be rather flat at the river with dips of not over 45° . Westward they stiffen somewhat as the ridge rises in elevation, and at the same time, $1\frac{1}{2}$ miles east of the Walker line, the anticlinal splits to receive a narrow tongue of the red Medina No. IVb.

The *Ore sandstone* and the *lower Clinton measures*, forming a terrace and a single outcrop on the north flank of the mountain, are likewise largely concealed west of the railroad. On both sides of the river, however, the flattening dip of the measures has thrown the *Ore sandstone* outcrop nearly one-half mile north of the mountain, where it makes a distinct ridge of its own, rising to elevations of 150' above the river on the east side, dipping 25° N. W.

The old Juniata furnace, now dismantled, was situated south of this ridge and a little further down the river, and was built upon outcrops of reddish-brown (iron) sandstone and brown shales underlying the *Ore sandstone* measures, dipping N. 20°.

Passing northwards through the gap in the ridge the *Ore sandstone* again shows at the first creek crossing, succeeded northwards by a band of the *Bloomsburg red shales* on a dip of N. 10° W. 40°. The upper *Salina lime shales* overlie these to the main valley road outcropping with increased dips of 50°. All the valley between this main road and the river is occupied by these upper *Salina marls and lime shales*, which, as usual, make it extremely fertile and attractive farming soil.

Another belt of these rocks, about three-fourths of a mile wide, is brought up upon the crest of the *Academia* anticlinal entering from Walker township near the center of Delaware. As this broad axis enters this township to finally die away altogether its crest is indented by a narrow synclinal along Delaware run which holds the *Lewistown* and *Oriskany* formations.

Lewistown limestone quarries.

Mr. Samuel Evans has opened a very good limestone quarry in the *Lewistown* formation about one-fourth of a mile west of Delaware run and just east of the road crossing over the ridge. The quarry has not been very economically opened and is situated in the south leg of the south axis exposing 25' or 30' of very dark blue limestone on a 50° S. E. dip.

D. B. Dimm has opened another quarry immediately op-

posite this across the valley in the north leg of the north anticlinal, where the dip is 30° northward in corresponding limestone measures. Both quarries are worked merely for farm use. The massive portion of the Lewistown limestone formation does not appear to be so thick nor to contain as good beds as it does in Mifflin county, but the lower portion of the formation, as well as the top members of the upper Salina group, are much more calcareous and often contain beds of sufficient thickness to warrant their being economically worked. These same characteristics prevail through the synclinal occurring between these two outside ridges along Delaware run.

Smith and Keyser's quarry, situated on the west side of Delaware run about a mile south from East Salem, shows about 30' of the same dark blue limestone, with a peculiar *conchoidal* fracture and dipping only 10° N. W. in the south leg of the synclinal. The good limestone is overlaid with 15' of shaley impure limestone which extends to within a few feet of the surface. There are two kilns here burning limestone for farm use, which obtains a ready sale through the slate valleys to the east of this point.

The Oriskany sandstone in these ridges seems to be entirely *chert*, making two flat hills extending for nearly a mile east of Delaware run, the southern one being slightly the longer and higher. The same cherty character of rock occurs in the main Flintstone ridge, lying north of the East Salem slate valley; while the southern ridge, flanking the Tuscarora valley on the south and virtually extending Turkey ridge westward through Thompsontown to the river below Mexico, is covered with the same chert wherever the ridge has not been entirely eroded. In this southern ridge the limestone is nowhere quarried, making a very uncertain and interrupted outcrop and nowhere very massive.

North of Thompsontown, along Delaware run, this ridge is completely eroded and the occurrence of chert and limestone can only be inferred from the character of the soil and the records of well diggings in the village.

The *Marcellus slates* outcrop a little further north, and

are succeeded in about one-half a mile by an outcrop of the *lower Hamilton shale and sandstone*, making a tightly compressed synclinal, with dips of from 60° – 80° . It shows a somewhat unevenly bedded grayish-white sandstone 30' thick, important as being the only suitable sandstone occurring in this vicinity for *paving* and *building*, for which purposes it has been largely used at Thompsontown. The outcrop is somewhat twisted, especially in the south dips, showing well in the brown slates overlying the sandrock. The structure north to the base of the Oriskany sandstone ridge at the school house is probably complicated by several sharp but local rolls; for a gray sandstone ledge very like the one just described is seen at many places to and beyond the old stone grist mill.

The Marcellus black slate is well exposed just below the school house dipping S. E. 20° in the north leg of the Tuscarora synclinal. Its low dip carries it forward nearly to the school house where a band of the *Marcellus limestone* shows overlying the chert. It is greenish-blue in color; slaty, feriferous and about 15' thick.

North of the Academia anticlinal in the East Salem basin, the road and the hills on either side of it north of the brick church are composed, first of the Marcellus slate, quickly succeeded by the lower Hamilton shales and a considerable thickness of the Hamilton gray sandstone, weathering brown and dipping 40° N. W. At East Salem the Genessee slates with the upper Hamilton shales outcrop on 35° N. W. dips and extend east and west through a branch valley of Delaware run into Walker township.

These rocks form the synclinal, the axis of which is but a short distance north of East Salem. Between the basin and Flintstone ridge the same measures are repeated only on reversed (southeast) dips. The Hamilton sandstone creates a sharp ridge just north of the forks of the road at Mrs. Fry's dipping 30° S. E. and between this ridge and the Flintstone ridge the Marcellus shales outcrop.

Along *Cocolamus creek* the same section of rocks (somewhat amplified by reason of the increasing depths of the Tuscarora and East Salem basins) is exposed between Turkey

ridge and the Fayette township line. Turkey ridge itself in this township is made up of the Oriskany sandstone, north of which the Marcellus and Hamilton measures come in on north dips with a narrow valley of the lower Genessee slates along *Dutchman's run*.

Here is the Tuscarora synclinal basin, north of which the road between Dimmsville and Goodville is largely in the massive gray Hamilton sandstone on the south flank of the Goodville ridge, dipping 10° S. E. The Hamilton is exceptionally massive at this point and creates a high ridge running eastward into Greenwood township. North of this ridge, which is double crested here with a high basin of the upper Hamilton shales between the two anticlinals, the *Genessee slates* are well exposed along the Mifflin road near the church and cemetery dipping about 15° N. W.

Ascending Cocolamus creek the brown slate and sandstone show a few yards north of the main road dipping 20° N. W., succeeded in the next 100 yards by broken fissile Genessee slate on a 35° N. W. dip. North of here there is an almost continuous rock exposure for the next 200 yards growing more and more sandy, but largely composed of shale. A barren interval of one-half a mile brings in an exposure of these same rocks—the upper Genessee and lower Chemung rocks perhaps—just south of the brick school house on a S. E. dip of 40° .

At the *Fayette line* there is a *superb exposure* of the Hamilton gray sandstone 60'–80' thick, dipping S. 20° E. 40° . Some beds are quite massive but are intercalated between beds of shale, which weather considerably and serve to break down the sandstone. The whole section along Cocolamus creek and south to Turkey ridge resembles closely that of Little Cocolamus creek in Greenwood and Monroe townships. The Devonian rocks, occupying one-half to two-thirds of Delaware township, are only slightly more farmed and cultivated than those of the more eastern townships and mainly because the sandstone members of the formation have been pretty generally eroded, leaving the bulk of the area to be occupied by the softer shales and slates.

41. *Walker township in Juniata county.*

This township occupies a somewhat irregular area between Tuscarora mountain and Flintstone ridge, south and north, and Delaware township and the Juniata river on the east and west.

Its north line is a common one with Fermanagh and Fayette, 7 miles along Flintstone ridge; its east line, common with Delaware township, $7\frac{1}{2}$ miles long, crossing the Tuscarora valley and the Juniata river from Flintstone ridge to Tuscarora mountain. Its south line is only 3 miles long on the crest of Tuscarora mountain, owing to the convergence of its east and west boundaries; while the west line is formed by the Juniata river from a point about one-half mile below Mifflintown to Tuscarora station on the Pennsylvania railroad just where the Juniata is turned eastward by the flank of the Tuscarora mountain the line running straight from the point, a mile in length and nearly north and south to the crest. It will thus be seen to have an average length of about 6 miles and an average width of about 5 miles, enclosing an area of approximately 30 square miles.

The *Juniata river* flows through it for about 8 miles and drains the entire township by means of small brooks entering it from the north and south.

Mexico and *Van Wert* are the only settlements within its border lines, both of them being small villages; the first situated on the north bank of the river at the mouth of *Doe run*, and the latter towards the northeastern section of the township upon the right hand fork of the same stream.

The *main structural features* of the township are the same as those of Delaware, consisting primarily of the Tuscarora and East Salem synclinals, both of which hold the Devonian, Oriskany and Lewistown limestone formations and are separated from each other by the Academia anticlinal, just bringing up the Ore sandstone at the river and sinking eastward towards Delaware township, where it contains only the upper portion of the upper Salina rocks Vc'.

The *Tuscarora mountain* on the south is an anticlinal of red and white Medina sandstone, IVb and IVc, the town-

ship and county line keeping along the south Medina crest where the rocks dip southward into Perry county. There are no water or wind gaps through the mountain here, although the north Medina crest is cut down in six or eight places by small streams rising in the interior red Medina valley, giving the mountain a rugged and *knobby* appearance when viewed from the valley to the north.

The Juniata river everywhere washes its northern flank, which is here very steep and carries the Iron sandstone and the Ore sandstone members of the Clinton formation as high *terraces*, suggestive of the steep dip of these strata. It is highly improbable that either of these ore-bearing series will be found productive of commercial ore, although no very great amount of time or money has been spent upon their exploitation.

The only other point in the county where the Ore sandstone outcrops above water level is upon the river, about a mile north of Port Royal, where the slowly sinking Academia anticlinal exposes a circular outcrop of the Ore sandstone with S. E. dips of 10° and northeast dips of 20° , seen along the river road between Port Royal and Mifflintown.

On the south side of the township, the Salina valley, between the Juniata river and the main limestone ridge, shows a width of over a mile, due to the occurrence of a small anticlinal traversing this district from east to west about midway in the valley and spreading the upper Salina lime shales over a wide area to the manifest advantage of the farming interests located there.

The Juniata river flows through the corresponding synclinal between this axis and the Tuscarora mountain generally over a bed of the top lime shale layers of the Salina formations. These same rocks are exposed along the Academia anticlinal between the two limestone ridges which converge eastward to narrow the valley between them.

The *Bloomsburg red shales* or Lower Salina occupy the crest of this axis from the school house on Doe run east to the Delaware township line, lying a little on the south side of the valley. West of the school house the increasing strength of the anticlinal divides this single belt of the

Bloomsburg shales into two and elevates between the stream and the river a smoothly rounded ridge or plateau of the Upper Clinton brown and olive shales.

At the school house the red shales dip 20° N. N. E., succeeded immediately north of the cross roads by the marls of the *upper Salina group* on a similar dip, and they in turn, by an excellent outcrop of the *lime shales* of this formation here so calcareous as to contain some *good limestone* beds creating a decided ridge and outcropping a little north of the road running to Mifflintown over Flintstone ridge.

These limestone beds have been opened within a mile of the Fermanagh line and quite extensively *quarried* for farm use near Gingerich's on a 15° N. dip. Between this outlying ridge and the main limestone in the Flintstone ridge there is a wide belt of limestone land caused by the low 10° dip of the rocks. They are exposed as soft olive and gray lime shales with some thin red beds all along the road east to Van Wert, south of which village the Bloomsburg red shales again show on the crown of the axis with dips of 40° N. W. and 30° S. E., maintaining that position into Delaware township.

Between these red shales and the limestone ridge on the south side of the anticlinal there is a belt of the upper *Salina lime shales* corresponding to the one occupying the valley north of Van Wert; but the rocks show steeper dips here, consequently narrowing the width of the valley holding them.

Beyond the right branch of Doe creek at J. Lukens' place there is an excellent exposure of these lime shales, dipping S. 15° E. 30°; but the chert of the Oriskany ridge to the south of this point has completely concealed the Lewistown limestone No. VI, whose presence can only be judged of by the numerous *sink holes* occurring along the north flank of this ridge.

Lewistown limestone quarries.

West of the brick church, however, the *Lewistown limestone* is well exposed nearly 80' thick in two small quarries, the bottom of the formation being rather impure and shaly;

the top good and pure limestone, 40' thick in small beds ; the whole dipping S. E. Another small quarry opened in the same rocks is situated just west of where Doe creek gaps this ridge, about 1½ miles east of the Juniata river.

North of Van Wert on the north side of this valley No. VI has been opened on the south flank of the ridge in a small quarry showing some good dark-blue limestone beds, rather poorly opened on a 45° N. W. dip. Much of the top of the limestone formation is likewise concealed here by the Oriskany sandstone, which shows in the road cut a considerable bed of chert rock, which has been quarried for road ballast.

The limestone ridge bounding the Tuscarora valley on the south has been slightly opened also. The limestone crosses the river from Turbett township about 250 yards below the Mexico bridge and was formerly quarried and burned along side the canal on a dip of N. 25° W. 47°. Perhaps 20' or 25' of thin blue beds are exposed here in excellent shape for economical development ; but presenting no very massive or superior limestone. The outcrop reaches the Thompsonstown road at D. Siever's house on a dip of about 60° N. W., and from there east to Delaware township keeps along the north side of the road, making a very low ridge.

Benner's quarry, situated about 1½ miles from Mexico and 100 yards north of the pike, shows an exposure of inferior stone in thin beds filled with clay seams, about 60' thick on a dip of N. 30° W. 50. Some little lime is burned here during the winter for farm fertilizing ; but the stone is much better fitted for road ballast, for which purpose it is largely used.

Hamilton's quarry is the next opening 1½ miles further east, and between the two quarries the limestone ridge is almost obliterated. This quarry is opened in nearly the same measures ; but the beds seem to be of rather better quality, and more free from clay. All the good burning lime is taken from the central portion of the series about 60' thick, in which none of the beds are over 3' in thickness. The top and bottom divisions of the formation are slaty, and the Oriskany sandstone is largely eroded and absent here.

East and west of the Evangelical church the Marcellus slates outcrop (VIII b) within 100 yards of the road, to the entire exclusion of the limestone and sandstone ridge.

The narrow valley in which Mexico is located is composed of the Marcellus slates and the lower Hamilton shales, very little evidence of the Hamilton sandstone existing far beyond the Delaware township line.

Just north of Mexico, and immediately back of the brick schoolhouse, these slates are largely quarried from time to time for road use at *J. M. Thompson's quarry*. The opening is largely in the lower Hamilton shales, brown and buff colored, with some thin bands of sandstone, which, near the base of the exposure, aggregates 12' or 15' in thickness and has been used in Mexico for building and bridge purposes. The dip is 30° S. E.

The East Salem synclinal on the south side of Flintstone ridge is almost wholly occupied by the Marcellus black slate.

42, 43. Milford and Beale Townships.

These two townships can be conveniently described together, as they make a roughly rectangular area, comprising about 50 square miles, lying west of the Juniata river and north of Tuscarora creek. The north line of Milford township, as well as the Juniata-Mifflin county line, runs west along the south (Medina) crest of the Blue ridge for about 8½ miles, having a slight offset one-half mile long at the eastern end of the mountain passing to the Juniata river in the "Narrows."

The western line of both townships is a straight one about 5 miles long, extending from the Blue ridge at Minehart's gap southeast to the Tuscarora creek near the center of the Tuscarora slate valley. The Tuscarora creek forms the southern boundary everywhere, except at the great Horse-Shoe bend, south of Academia, where the line runs along the north Limestone ridge for nearly a mile.

Milford township has an irregular offset comprising the Licking creek valley area between Blue ridge and the West Shade mountain. The latter mountain forms the line be-

tween Milford and Beale for nearly 7 miles to the summit of the high anticlinal spur of Medina white sandstone, which sinks beneath the Clinton rocks in the Lost creek or *Forge ridge*, about $3\frac{1}{2}$ miles west of the Juniata river. From that point the line bears south for one-half mile to a public road, which everywhere divides the two townships southwards to the Tuscarora creek at the base of Limestone ridge, about 4 miles west of Port Royal.

The *drainage* of this combined area all passes into the Juniata river by means of Tuscarora creek and its numerous tributaries descending southward across the valley and through the Academia ridge from the Shade mountain district. *Licking creek* is its chief tributary, rising in the narrow valley between Licking creek and Black Log mountain in Mifflin county, and flowing eastward into Juniata county south from Minehart's gap. Thence it passes eastward for nearly 10 miles through Licking creek valley; but instead of pursuing its direct course for 2 miles further to the Juniata, it is there turned abruptly southwards, passing through the Lost creek ridge, across the Mifflintown valley at Farmdale, and makes a deep gap over a mile long through the *Academia ridge* before entering Tuscarora creek, a mile west of the Juniata river. The sudden deflection in the course of this stream north of the Shade mountain or Lost creek anticlinal is all the more curious from the fact that it had a narrow limestone valley to conduct it directly to the Juniata, instead of following which it forced its way through two high anticlinal ridges before finding its way to the Tuscarora creek.

Patterson, Port Royal, Johnstown, Allenville and *Academia* are all flourishing villages in these two townships. The two former, situated on the west bank of the Juniata river, in Milford township, derive greater advantages from their location on the main line of the P. R. R.; while of the three latter, situated in Beale township, Academia is the most important and the most beautifully located at the base of a high ridge overlooking the Tuscarora valley.

The *principal structural features* consist of the Blue ridge anticlinal on the north; the Black Log—Shade mountain—Lost creek ridge anticlinal in the center, and the Academia ridge anticlinal on the south. Between the two former is the Licking creek valley synclinal of lower Helderberg, Salina and Clinton rocks; and between the two latter anticlinals is the Miffintown synclinal valley largely composed of lower Helderberg and upper Salina rocks, with the lower Salina and Clinton measures on the flanks of the bounding ridges. The Tuscarora synclinal axis lies largely south of the creek and Beale township, so that the rocks on the south side of the Academia ridge all dip southward into this basin and are largely Salina and lower Helderberg strata.

Both Blue ridge and Shade mountain show outcrops of the red and white Medina No. IV sandstone, but the township and county line along Blue ridge lies wholly upon the south (white Medina sandstone) ridge until along the Juniata river this rock gradually sinks over the dying anticlinal with dips of 60° N. W. and about 50° S. E.

The *Shade mountain axis* on the south side of Licking creek valley keeps the red Medina (No. IVb) rocks on its crest for about 4 miles east of the Tuscarora township line, where the anticlinal sinks and permits the two white Medina crests to come together and form one anticlinal ridge about 3 miles in length, showing dips upon the road north of Johnstown of 25° S. E. and 40° N. W.

East of the Medina sandstone knob the ridge is *triple-crested*, outcrops of the Ore sandstone forming separate ridges on the north and south flanks of the anticlinal with the Iron sandstone and lower Clinton shales making the central backbone and anticlinal.

The north Ore sandstone ridge has received locally the name of the "*Forge ridge*;" while the southern outcrop making a similar ridge is known as the "*South ridge*." Both, together with the central backbone, create the Lost Creek ridge anticlinal.

Where the Shade mountain Medina sandstone is elevated, the Ore sandstone ridges become merged with it as terraces

on each mountain flank. The Forge ridge division extends for about 5 miles up Licking creek and becomes united along the synclinal line with the same strata, outcropping on a southeast dip and making a terrace along the south side of the Blue ridge. The South ridge outcrop of the Ore sandstone creates a single terrace along the south side of Shade mountain, dipping southeast under the Mifflintown synclinal and appears again as the north division of the triple-crested Academia ridge.

The *Ore sandstone* in this ridge makes two parallel lines about a mile apart which coalesce over the crest of the Academia anticlinal just east of the Juniata river and north of Port Royal. This ridge is gapped by Licking creek and by a small stream west of Academia and several other branch streams create considerable notches either in the north or south flanks. The central portion of the ridge is composed of the lower Clinton rocks and Iron sandstone, which create broad rounded summits upon either flank of which the Ore sandstone, from 20' to 25' thick, creates narrow broken crests of white, gray and brown sandstone.

Fossil ore mines.

Along the flank of Blue ridge, west of the Juniata, the Sand Vein fossil ore bed has formerly been worked at several points.

At *Milford siding*, on the Penn. R. R., the Ore sandstone creates quite a distinct but low ridge and the ore bed, opened on a south dip of about 30°, had very little stoping ground and was largely hard ore. The bed was about 20" thick here and laid almost directly upon the Ore sandstone.

About 1½ miles west of the river and nearly due north of the Lutheran church, on Licking creek, the Sand Vein has been worked at several places on Samuel Aughey's farm. Peter Hiestand, of Newport, first opened the ore here and it was last worked by Wm. Nankewell, of Patterson, in 1886. The Ore sandstone still makes a distinct ridge at this point and the slope is so gentle southwards that no great length of breast could be obtained in working the ore. The various drifts are now pretty well fallen shut, and the

ore varies from 18'' to 2' in thickness with some "Jack" near the bottom and dipping S. 15° E. 40°. One drift had been carried through the Ore sandstone about 20' thick, in search of the Danville beds, but they were found to be worthless, spread through about 2' of calcareous slates.

R. Nankewell has again opened the Sand Vein about three-fourths of a mile west of Aughey's; but no mining had been carried on there since June, 1887, when the last shipments were made to the Logan I. & S. Company. It was claimed that the ore improved in quality considerably coming westward from Aughey's, but there was no evidence of the truth of this statement in the appearance of the ore itself. Both localities should furnish an ore containing from 40 to 42 per cent. of metallic iron and from 18 to 25 per cent. of siliceous matter. One drift at Nankewell's was carried in northwards from the road at his house for a distance of about 10 yards, and a gangway carried westward from there on the ore bed for 250 yards additional. A second opening further west is carried into the bed upon a slight northwest pitch in order to avoid the excessive length of a drift which would have been necessitated by the gentle slope of the terrace. Mr. Nankewell reports the bed as dipping 45° S. E. and with the following average section :

Roof, clay slate.		
Ore breaking in square blocks,	12''-14''	} 2'±
"Jack,"	7''-10''	
Ore, soft and good,	2''	
Foot wall, sand rock.		

Several thousand tons of ore have been mined and shipped from this point, the last mining being conducted entirely upon the upper thick bench. The bed is a mixture of soft and hard ore, the soft variety rarely extending much below 30' from the outcrop.

The *Geiss mines* are located between these two properties under similar circumstances, where, however, all the soft ore has been worked out and the mines abandoned.

The outcrop of the Ore sandstone and fossil ore can be traced with more or less success for 5 miles west of Nanke-

well's, but the great expense of conveying any ore mined in this portion of the valley, together with the limited length of the soft ore breasts which could be obtained, have combined to prevent or delay the development of that portion of the Licking creek valley. The same circumstances prevail along Shade mountain on the north dip of the Ore sandstone, the country being exceedingly wild and rugged and presenting but few opportunities for advantageously developing the ore, even if found to exist in quantity and of attractive quality.

The trough of the Licking creek valley synclinal is deepest at the Juniata river, where it shows a small thickness of the bottom layers of No. VII (?), which continue to occupy a narrow strip westward to the center of the valley for nearly 3 miles, beyond which they are eroded by the rise of the basin which is occupied by the upper Salina and lower Salina rocks westward to the Ore sandstone outcrop already described. The limestone rocks in this narrow basin are nowhere very massive; still there are several thin beds which, in the aggregate, present sufficient inducement for quarrying them in the absence of the thicker and better beds in the main division of the Lewistown limestone formation.

West of the Licking creek church these thin limestone beds are especially well displayed with contorted northwest dips, averaging about 75° , interbedded with some greenish-gray lime shales. The whole series makes detached hills in the trough of the basin for perhaps one-half mile west of the church. The underlying upper Salina lime shales, occupying wide strips on either side of this narrow lime belt, furnish generally a gray and good soil; but there are several bands of red shale in the formation notably well seen near Pardner's brick house, east of the church, on a 40° N. W. dip, which may fairly represent the *Bloomsburg shales* in this part of the region.

West of the B. S. S. the red and greenish-gray transition beds between the upper and lower Salina are exposed with nearly vertical northwest dips; and at a point opposite the

S. M., the Bloomsburg red shales are seen on the north side of the basin within 50 yards of the road. They continue west to Bossinger's mill before joining the south outcrop along the flank of Shade mountain.

South of the church, through the gap in Forge ridge, the Bloomsburg red shales show at the forks of the road, nearly 100' thick, and dipping 40° N.W. The Ore sandstone outcrops not far south of this point on a 50° N. W. dip, and some ore from the Sand Vein was once mined from the Aughey farm, long abandoned on account of its siliceous character.

The crest of the anticlinal along the road following Licking creek is covered by the upper Clinton brown fissile shales, occurring geologically between the Ore sandstone above and the Iron sandstone below. In the gap they show dips of 20° N. and S., showing the broad and regular structure of the anticlinal. On the road running west through the ridge only a few hundred yards west of Licking creek, the Iron sandstone is brought to view on the crown of the arch with 10° dips each way, and is excellently exposed in plates from 3' to 5' thick, ascending the Shade mountain spur.

In the gap south of the anticlinal from Kerlin's to the Germania mills the south dips of the Clinton shales remain gentle at angles from 20°-30°, until the Ore sandstone of the South ridge is seen crossing Licking creek just below the mills upon a 30° S. dip and about 20' thick. No ore has been found here; but west along this outcrop on both sides of the road dividing Milford and Beale townships, some excavations have been made in the Sand Vein ore bed, all of which show the lean rather slaty ore.

The Ore sandstone makes a distinct ridge along this township road and is excellently exposed from 20'-30' thick on a dip of S. 35° E. 40°-50°.

East of *Bratton's place*, the Sand Vein was once opened and mined by Thomas Quinn on property of Miss Stinson. Only the crop ore apparently was taken and the stock pile still at the opening showed a hard siliceous fossil ore which could hardly command a sale at all at the present time.

The Sand Rock foot wall, having a deep brown red color, was still well exposed on the open cut, dipping S. 23° E. 40°.

About one-half a mile further east along the ridge, and 100' above the road an old drift was started by Levi Dundore on land of Bratton & Shitz. No ore of any moment was taken out before the operation was abandoned.

Still further east along the ridge and northwest of J. P. Shitz's house, the Sand Vein was again opened and operated upon for a short time. The dump showed a mixture of fair ore and a great deal of lean siliceous ore, so that it may be safely assumed that this whole ore range is more than usually siliceous.

The *Ore sandstone* is again well exposed on the road going over to Licking creek, and indeed it would be difficult to find this well recognized rock more continuously exposed than it is through the South Ridge between Johnstown and Licking creek gap. Unfortunately the gaps are few, so that a detailed section of this is hard to obtain; and in the Licking creek gap it is but partially and poorly exposed. The whole south slope of the ridge, however, is scored bare, exposing this sandstone for a considerable elevation and showing its *massive character*. It varies in color through all shades of gray and brown according to the weathering it has undergone and the amount of iron it contains.

In *Beale township*, north of Johnstown, openings were made on land of J. Pennypacker, now entirely abandoned. The hard thin-banded fissile and red and brown slate underneath the Ore sandstone dips S. 30° E. 45°, to which dip the sandstone and overlying ore closely conform. An old analysis made from this ore when actively mined yielded about 45 per cent. of iron, 25 per cent. of insoluble residue, with .168 per cent of phosphorus, which is quite as good as the general character of the ore along the south side of Shade mountain in these two townships. Several other minor openings were made both in this bed and in the *Block fossil* ore beds, occurring higher on the mountain, but the openings, without any exception, were entirely filled in and never seem to have yielded any quantity of ore at any particular point. The Block fossil ore was especially lean and siliceous,

its percentage being put at about 30 per cent of iron and 35 per cent of insoluble residue, besides being high in phosphorus.

The section along the Juniata river shows very nearly the same characteristics as along Licking creek. The Ore sandstone is not well exposed on either side of the Lost creek ridge anticlinal, but the underlying Clinton shales show north dips of 15° and south dips of 30° with various minor local rolls, due to the flattening of the axis at this point.

The first railroad cut above Mifflintown shows the Bloomsburg red shales near the brick yard on a southeast dip of 35° , and a good exposure of these and the underlying rocks can be seen along the track going north. The overlying upper Salina rocks are slightly twisted in Patterson with north and south dips of 12 and 35 respectively, but soon settle to the southeast dip into the main Mifflintown synclinal, occupied by a strip of the lower Lewistown limestone measure, tapering as it extends westward for about eight miles to Allenville, in Beale township.

South of Mifflintown there is an almost uninterrupted and very interesting *exposure* of the *Salina* rocks of nearly 1500' along the railroad, commencing at a point about 300 yards south of Patterson station at an exposure of lime shales, olive-gray sandstone and red and gray shale on a 35° N. W. dip. The exposure consists of a thick mass of variegated lime shale and slates, containing here and there thin bands of gray sandstone from 5'-15' thick, and bands of red shale, from 10'-20' thick, the whole thrown into a series of graceful anticlinal and synclinal folds. Some of these *folds* are *tightly compressed*, the rocks rising nearly vertically from each side of the basin; others are broad and wavy, producing wide arches and carrying a thickness of 50' or 60' for some distance along the railroad in a succession of sinuous curves.

The estimated thickness of rocks here exposed is about 400' but the same beds are so frequently duplicated as to deceive an observer not conversant with this fact. Viewed

from the eastern side of the river the effect is peculiarly striking, as the variation of color in the several beds assists the eye in following the graceful and gentle curves. The locality is one of the best in the county for viewing these rocks, and it is further indicative of the force exerted upon these soft measures and the effect produced by the sudden elevation of the Ore sandstone further south on the back of the Academia anticlinal.

It may be remarked here also that the red bands in the upper Salina formation have become very intimately interbedded with the gray lime shale layers, making it somewhat difficult to distinguish the *Bloomsburg red shale* division here and in the territory west towards Huntingdon county. On the north side of the Mifflintown synclinal the Bloomsburg division is more readily recognizable, as it makes a distinct dark red band running east and west between the base of the South ridge and the narrow blue limestone valley, passing through Farmdale, Johnstown to Allenville.

The road west from Patterson to the Baptist church on Licking creek is nearly always on these red shales, which, just outside the borough, show some greenish slate beds on a 35° S. E. dip, and well seen as beds of red shale in a road cut east of Cunningham's brick house on a 30° S. E. dip. Some fair limestone beds are quarried from the middle of the basin on the Cunningham farm upon dips of about 40° S. E. The axis of the basin runs along the road between the two Birchfield farms, showing very flat dips and a rich soil.

Johnstown is situated in the center of this basin, which, along the township road between Milford and Beale, shows a rather close fold with south dips of 60° and north dips of 50°, flattening to about 10° in the center. The upper Salina lime shale belt, No. Vc', on either side of the basin is about 200 yards wide. On this township road, north of the basin, the first red bands come in just above G. W. Snyder's house occupying the position of the Bloomsburg division, but containing several lime bands, all dipping 45° S. E.

Between Farmdale and Port Royal, along Licking creek

the upper Salina measures south of the limestone valley are again exposed with somewhat irregular dips as along the river, but with a general northwest dip of about 40° , away from the Academia anticlinal to the south.

The *Bloomsburg red shales*, here again somewhat mottled and indistinct, come in just before reaching the first side road, and with the intercalated lime shale beds cannot be less than 150' thick, nor more than 250' vertically above the Sand Vein fossil ore bed, opened in the field on the east side of the creek and the road.

The *Ore sandstone* crops out just at the dam above Hahn's mill and is again well exposed in the ridge on the west side of the creek, dipping N. 45° W. 40° . Some little work of exploration has here been done on the Burchfield property, on both the Sand Vein bed above the Ore sandstone and the Danville ("Ginger" or "Mud Vein") bed, beneath the sand rock. A drift has been driven on the latter bed about 100' above water level. No information could be ascertained concerning the quality or thickness of the bed and the drift was too badly fallen in to permit of any personal examination, but if of any economical value at all, there would be a most excellent opportunity for mining with the security of long stopes and probably much soft fossil ore.

Good exposures of the underlying Clinton shales occur at Hahn's mill, a little further down the creek, south of which the dips flatten greatly and finally make a broad anticlinal arch. The exact position of the axis is obscured here by erosion, but passes about one-half a mile below the mill.

The *Iron sandstone* is not exposed on the arch and is probably not elevated at any point east of the creek. There are no other exposures until approaching the McCullough Mill dam, where gray and red slates underlying the Ore sandstone dip about 30° S. E. The Ore sandstone next appears at the turn of the road near the upper end of the Port Royal dam, dipping S. 42° E. 30° , about 12' thick and somewhat shaly. Ferriferous shales occur above and below it, but without visible ore.

The Bloomsburg shales follow further down the creek and

then the upper Salina marls, with No. VI, finally outcropping just at the mill dam and near Tuscarora creek on a S. 40° E. 50° dip.

The *Oriskany measures* seem to have been entirely eroded by Tuscarora creek here and for some distance west, which is true in a measure of the Lewistown limestone also.

An excellent section of the Ore sandstone group can be obtained on the road leading west from Port Royal where the base of the ridge is washed bare by Tuscarora creek about 2 miles from the river. The dip is S. 23 E. 35 and the section shows :

Port Royal section.

Sand Vein fossil ore bed ; not exposed.		
Ore sandstone, in thin beds ; shaly,	12'	0''
Blue shales, with hard SS. ridge,	20'	0''
Ore ? ferruginous l. s., fine grained,		2''
Slate, blue,		6''
Ore ? ferruginous l. s., fossiliferous,		4''
Slate,		2''
Sandstone,		4''
Slate,		1''
Sandstone,		2''
Slate,		1''
Ore, hard fossil in blocks ; lean, calcareous,		2''
Sandstone and slate,		4''
Ore, lean and siliceous,		8''
Slate and sandstone,	1'	0''
Ore, hard fossil ; calcareous,		5''
Blue slate,	15'	0''
Ore, in square blocks ; " Mud Vein ?"		½''
Brown shale and sandstone,	50'	0''
Variegated slates ; blue, green and gray,	40'	0
Red slates.		

The *Danville beds* are here worthless, but the section is an interesting one. The Ore sandstone does not cross the creek, being seen again in a small run further west, making the bed of the old mill dam at the next cross roads.

Just west of this point the Tuscarora creek bends southward and flows across a plain of Salina rocks, nearly a mile wide to and into the Limestone ridge at J. Groninger's, passing in and out of this same ridge west to the Beale township line. The ridge is low and broken here, but shows about 60' of good limestone in a bluff at the Beale township

line, dipping S. 35° E. 60°. The *Oriskany sandstone*, here largely chert, making the crest and south flank of the Limestone ridge, is largely eroded along the creek between Port Royal and the point south of Academia, although well exposed at individual points.

Near the Beale line, a little north from Tuscarora creek, there is a fine exposure of the upper Salina Vc' measures at John Robinson's house, dipping 50° S. E. and exposing between the two main roads an excellent series of lime shales, gray and blue in color, and very clacareous. These lime shales seem to have a greater thickness, solidity, and a greater number of good limestone beds in this part of the region than elsewhere, rendering it exceedingly difficult to limit the horizon of the still more massive Lewistown limestone measures. The red bands begin to come in between lime shale layers east and west along the main road above Robinson's house; but the body of the Bloomsburg red shale evidently lies along the flank of the ridge north of the road.

Along the township road, between Beale and Milford, the Ore sandstone in the south leg of the Academia anticlinal shows about 10' thick, crossing just back of U. Sasner's house, dipping 30° S. E., but without visible fossil ore. Both this ravine and the one north of Robinson's should be good places to prospect for the Sand Vein ore beds; for the ridge is unusually high and solid, except where it is cut down by these ravines, and offers good stoping ground and other advantageous circumstances for development by drifts along the strike of the bed for any ore that may be found there.

The *Iron sandstone* outcrops further north along the township road, making the bed of the road and ravine for some distance as they ascend the ridge on a southeast dip of from 10° to 15°. It shows a dark reddish-brown sandstone, weathering into an iron-brown sandy soil, like trap in color, and breaks in rectangular flat blocks. This rock makes the crest of the anticlinal along the ravine; but on either side of the road the hill rises to higher elevations and

is composed of the lower Clinton shales. These latter rocks are well exposed along the road through the center of the ridge, meeting Licking creek at Hahn's mill. They show a mass of red and brown slates and thin sandstone beds, which, in places, have been slightly cultivated and yield a fair soil.

The *Ore sandstone* in the north leg of the Academia anticlinal along the township road is not well exposed; but it makes a low terrace ridge just north of Woodward's B. S. S. through which the road passes and descends the north flank into the Mifflintown synclinal limestone basin.

On the road leading south from this valley across the ridge to Academia, about one-half mile west of Johnstown, the Lewistown limestone in the basin has a slight representation flanked on either side by wider outcrops of the upper Salina lime shale.

The Ore sandstone forming the north leg of the Academia anticlinal, passes through C. Beale's place at the forks of the road, showing a northwest dip of 60° , but not very massive. It is underlaid going south with a great mass of the brownish red and grey shales of the Clinton measures on northwest dips of 40° , declining to 20° at the crest of the axis at D. Kaufman's.

In the south leg of the anticlinal the Ore sandstone outcrops just back or north of the Academia church, dipping southeast 40° . There is an excellent exposure of the overlying Bloomsburg red shales in Academia, making a long sloping terrace on the flank of the ore ridge, upon which the village is built.

Between Academia and Tuscarora creek the upper Salina lime shales come in upon conformable dips, slightly rolled, but averaging about 50° S. E.

Along the road east to Pomeroy's store these *Salina* rocks are again seen to contain many good *limestone* beds, so *massive* indeed as to form a ridge quite as high as the main limestone ridge further south beyond Patterson's mills. Between the store and the mill these measures show some northwest dips; but at the bridge they show a normal southeast dip of 60° , which dip continues up the creek to the dam in good massive limestone layers.

The *Oriskany sandstone No. VII* seems to be almost entirely *absent* here, the Lewistown measures being almost immediately succeeded and overlaid by the Marcellus slates in Spruce Hill township.

In the next gap about two miles west of Academia, between Allenville and the Tuscarora creek, an almost identical section is exposed.

The *Lewistown limestone* and *Oriskany sandstone* make a prominent ridge here, curving gently towards the northwest so as to admit quite an area of the Marcellus slates along the south side of the township between the ridge and Tuscarora creek. In the elevated valley between the limestone ridge and the ore ridge, the Bloomsburg red shales are well exposed at Jacobs' Mill on a 40° S. E. dip and about 300 yards up the stream the Ore sandstone shows on the road just below the mill dam, about 15' thick, and dipping S. 36° E. 30°. Some little soft fossil ore has been thrown out at this point, and as the ridge rises amply from the creek this point would offer advantages for mining, if the ore bed was of sufficient thickness and good quality. Neither of these facts could be ascertained, but the ore seen at the opening was very fair.

The reddish-brown and olive slates which underlie the Ore sandstone show here about 200' thick, and as usual make a very conspicuous outcrop on account of the thin, but frequent ribs of a block sandstone which accompanies the slate and shales and weathers but slightly.

The anticlinal passes in the vicinity of W. Leach's house with nearly flat dips; and going north to Boone's house the brown and olive slates are repeated with beds of sandstone from 4'-6' thick at the forks of the road on a northwest dip of 45°. Slate and shale, generally reddish and brown in color, occur almost without interruption northward on dips increasing to 60°, presenting a section of rocks from 300'-350' in thickness up to the Ore sandstone in the north leg of the anticlinal, which shows just south of Bratton's house with a similar dip.

The fossil ore measures are all concealed; but there was

some slight indication of the presence of the Danville beds here. North of Bratton's the Bloomsburg red shales occur in a narrow band near the forks of the creek and between this point and Allenville in the trough of the basin there is a narrow band of the Lewistown limestone which does not extend west to this point.

North of Allenville the country is wild and unbroken. The Ore sandstone, however, makes a distinct ridge at some distance from the flank of Shade mountain, so that the dips through here west to Tuscarora township are eminently gentle.

The Academia anticlinal declines also in that direction just as the Shade mountain, or Black Log anticlinal, begins to take new strength and forces its Medina sandstone walls sufficiently apart to receive the Oneida sandstone, as well as the slates and limestone of the Black Log valley.

The opposing outcrops of the Ore sandstone in the Academia anticlinal, a mile apart south of Johnstown and Allenville, converge westward and are little more than one-half mile apart on the Tuscarora township line.

44, 45. Turbett and Spruce Hill townships.

These two townships can be advantageously described together, as they complete the great rectangle between Blue ridge and Tuscarora mountain and the Juniata river and Tuscarora township line.

Tuscarora creek everywhere forms their irregular northern line in common with Milford and Beale townships, except for the short link south of Academia, where the Limestone ridge forms the Beale-Spruce Hill line.

Tuscarora mountain carries the southern border line of both townships, dividing them from Perry county, its long straight crest coursing for about 11 miles in a nearly east and west direction, almost equally divided between each township.

The *Juniata river*, between Port Royal and Tuscarora Water Station, is the east line of Turbett township, which is further separated from Walker township by a north and south line a mile long, between the Water Station and the crest of the mountain.

The Spruce Hill-Tuscarora township line is a straight one, $3\frac{1}{2}$ miles long between Tuscarora creek and Tuscarora mountain; while the mutual line between Spruce Hill and Turbett townships is a somewhat irregular one, running between the creek and the mountain in a general north and south direction from a point $3\frac{1}{2}$ miles west of Port Royal, south between the two forks of the mountain road leading over into Perry county.

Spruce Hill is slightly the larger of the two townships, whose combined area may be estimated at about 40 square miles.

The *drainage* of both townships is all northward from the mountain into Tuscarora creek, except a small portion of eastern Turbett township which drains eastward directly into the Juniata river. All these streams are insignificant except Tuscarora creek, which flows in all directions of the compass, and makes a remarkable *horseshoe bend*, nearly 3 miles long east of Pleasant View, cutting through at two places in each of the limestone ridges bounding the Tuscarora slate valley, and on the south cutting nearly one-half mile into the Salina rocks of Spruce Hill township. In this great bend the creek on either side is never more than a mile distant and in places it approaches itself to within half that distance. (Compare the great bend of the Juniata below Mount Union in Mifflin county.)

The *geological rock section* extends from the red Medina sandstone and slate No. IVb in the Tuscarora mountain upward to the Marcellus slate and lower Hamilton shale in the basin of the synclinal along the Tuscarora township line. The No. IV rocks in Tuscarora mountain are nowhere well exposed in place, as with the single exception of a small gap in the north white Medina crest along the Spruce Hill-Turbett line, the mountain is entirely unbroken.

But one road crosses it into Perry county between the Juniata river on the east and its western extremity in Tuscarora township south of Bealetown, and this road passes completely over the summit. Just before reaching the last bend of the road north of the summit a poor exposure* of the red Medina rock dips nearly due N. (25°), creating the

anticlinal which has nowhere been strong enough to bring up the Oneida sandstone measures.

A *superb view* of the entire Tuscarora valley, as well as the anticlinal mountains forming its northern border lines, can be obtained from the north terrace of the Tuscarora mountain on this road; and though the laborious trip up its steep flank is rendered geologically unsatisfactory by the poor rock exposures, this view will well repay tourist or scientist who wishes to get an idea of the topography and structure of the Juniata district.

The *Ore sandstone* and *Iron sandstone* show but a single outcrop in these two townships, extending east and west as a high unbroken terrace along the north flank of the Tuscarora mountain. Very little, if any, development has ever been attempted, and what little has been done has been mainly near the Juniata river, where the Sand Vein fossil ore bed is reported to be from 8" to 12" thick. Various efforts have been made from time to time, in a perfunctory manner, to locate the Sand Vein or Danville ore beds further west along the mountain range; but the terrace ridge is so completely covered with *boulders* of all sizes of white Medina sandstone fallen from the mountain further south, that the task is an exceptionally difficult one, especially so in the face of the uncertain character of the ore and the disadvantages of getting it to market if found.

A most conspicuous feature of the district lying along the base of the Tuscarora mountain is a narrow synclinal basin of limestone, known as the "Sink Hole valley" from the fact that many of the mountain streams upon reaching it sink and pass underground to the river.

This little valley extends west from the river for about $5\frac{1}{2}$ miles, or about to the mountain road to Perry county near which several large *sink-holes* serve to locate its position. Few, if any, limestone outcrops are actually seen, but a great number of sink-holes of all sizes and shapes serve to locate the limestone which is itself practically concealed everywhere.

In Spruce Hill township the synclinal still exists between

the public road and the mountain, but the limestones are everywhere eroded ; the sink-holes are absent and the basin is occupied by the upper Salina lime shales which prevent underground drainage and compel the mountain runs to pass over them to the Tuscarora creek.

The *upper Salina rocks* flank the Sink-Hole valley on either side in Turbett township and are best exposed on the north side away from the mountain drift, where they form a wide belt with dips of from 50° – 70° , S. E. The succeeding anticlinal to the north between the Sink-Hole and Tuscarora valley synclinal is largely composed of the Bloomsburg red shales or the lower Salina rocks, showing more conspicuously in Turbett than in Spruce Hill township.

In the former township on the road from the Tuscarora water station to Port Royal, via Hertzler's store, the upper Salina rocks are seen east of the brick school house, dipping 50° N. W. and 70° S. E., making a subordinate roll south of the main axis. To the north of the school, the Salina shales outcrop with variegated beds, but with comparatively little lime, to the road leading down to *Blue Spring hollow*. Here, at Jacobs' place, some red beds occur, but are almost immediately succeeded by the upper Salina lime shales on northwest dips of 40° , flanking the South Limestone ridge.

The *Lewistown limestone* making this ridge spreads out on either side of the road forks at the head of the gap, followed by a band of No. VII chert, $100' \pm$ wide, and finally the Marcellus black slate on a 50° N. W. dip. A fine *spring*, giving the name to the ravine, emerges from the first (Hamilton ?) sandstone layer in No. VIII which dips about 30° N. W.

There is an excellent exposure of the No. VIII rocks through this gap, the synclinal holding some grey and drab shales with 20° dips, and the *Marcellus limestone* several feet thick near the bottom of the series north of the school. A thin sandstone, some $12'$ thick, occurs in conjunction with with it, as at Lewistown, immediately above the lowest black slate. Its sand is sharp and largely discolored by iron.

The occurrence of No. VIII Marcellus slate in contact with No. VI limestone at Kepner's one-half mile west of Port Royal, would seem to indicate that the Oriskany sandstone *No. VII* was in places *never deposited* at all, while elsewhere, within a radius of a few miles, it divides those two formations with a considerable bed of loose flint or chert. Further west, towards Groninger's, the No. VII chert ridge rises with some little show of Oriskany sandstone boulders along the road, but the ridge made by this rock is here very insignificant.

There is an excellent exposure of the Lewistown limestone on Tuscarora creek above Groninger's, and an old quarry has developed a grey *crystalline limestone* several feet in thickness. This rock is said to polish well and makes a very excellent fertilizing lime. It carries nodules of calc-spar and also thin flakes of iron pyrites. The Oriskany sandstone is poorly represented and shows the same cherty characteristics mentioned further east.

The *Marcellus black shales* overlies the sandstone with a nearly vertical dip, charged with iron pyrite and exposed from 50' to 100' thick, carrying towards the top, bands of blue and gray argillaceous limestone, occurring between bands of slate in several layers from 8''-10'' thick. The exposures are nearly continuous and are largely in Spruce Hill township and the north lip of the Tuscarora synclinal.

At the bridge over Tuscarora creek, about one-half a mile east from the Spruce Hill township line, the Lewistown limestone outcrops on a dip of S. E. 60°, and taking the road leading south up the first ravine, good outcrops of shale and limestone show along the stream on a 70° S. E. dip.

The *Oriskany sandstone* does not seem to exist at all, or if it does, merely as a slate and shaly sandstone, although large quantities of chert and flint cover the hill tops. The Marcellus black slate and gray slaty sandstone come in quickly on this steep dip in ascending the ravine.

Outcrops of siliceous hematite show in spots along the summit of the ridge; but it is very little indication of any good ore being present, as most of the pieces seen were simply a ferruginous sandstone. The South Limestone

ridge shows a more profuse outcrop of chert along this road, but no beds of sandstone.

Limestone quarries.

On the cross road from Groninger's to Blue Spring Hollow, No. VII is seen after passing the cemetery and No. VI on the south flank of the South Limestone ridge opened in two small *quarries* just where the road makes a sharp right angled bend, dipping N. W. 50°.

The upper part of the No. VI limestone was opened a couple of fields west of Goodman's house and rather shaly. The middle member of No. VI is opened lower down the flank of the ridge on the road at Dr. Graham's quarry, dipping N. 28° W. 45°. While the beds are thin here, there are some near the center of an 80' exposure which seems attractive and are about 20' thick. Perhaps 50' of shaly limestone underlies this quarry exposure, associated with the upper Salina rocks which outcrop along the base of the ridge between the Port Royal road and the small stream to the south on a 60° N. W. dip.

East along the limestone ridge from *Graham's quarry*, a large opening has been made in the south flank.

This is J. Suloff's quarry, where the dip is N. 30° W. 40°-45°. Some excellent stone is quarried here and burned for fertilizing and plastering purposes, at 8 cents a bushel for "run of mine," and 15 cents for first quality white-wash lime. The public road nearly marks the top of the upper Salina measures here, and the No. VI limestone extends up to and makes the crest. The lower beds exposed in the quarry about 40' thick, have a bluish-grey color, weathering white and rough, and are not quarried for burning. The upper stone, of which about 20' is exposed has similar characteristics, the best beds coming from the central portion, 15'-20' thick, quite massive, with a deep blue color and sub-crystalline structure. Nearly all of the burned lime is made from these beds.

J Koons has a quarry further east, or a series of quarries, none of which seem to have developed as good a stone as

Suloff's, nearly all that exposed being shaly and thin bedded.

In *Spruce Hill township* the Tuscarora synclinal passes nearly midway between the two limestone and chert ridges, flanking it north and south, and as the basin gradually deepens going west these two ridges begin to diverge from each other in the vicinity of Pleasant View, until along the Tuscarora township line the slate valley is $1\frac{1}{2}$ miles wide and shows a much more gentle synclinal than in the narrow trough between Pleasant View and the Juniata river.

The *Ore sandstone* in this township makes a high terrace on the flank of Tuscarora mountain until within 2 miles of the Tuscarora line, where the terrace ridge seems to end rather abruptly and becomes merged in the main mountain.

The *Bloomsburg red shales* make a thin band north of the terrace ridge near its base, and are likewise exposed on the crest of the small subordinate axis lying between the South Limestone ridge and the Sink Hole valley synclinal, to within one-half mile of the western township line of Spruce Hill, where they sink out of sight with the axis beneath a wide plain of the upper Salina rocks in Tuscarora township. These red shales are well seen entering from Turbett township near the cemetery and extending to Mrs. Wharton's house, where the anticlinal shows dips of 50° N. and 45° S.

The *village of Spruce Hill* is situated on the upper Salina rocks, which, as already stated, form a broad synclinal basin in this township along the line of the Sink Hole synclinal. There is an exposure of these lime shales southwest of Spruce Hill P. O. at the old mill near Guilford's dipping S. S. 35° , and another further west near Graham's Mill dipping 45° N. W. showing some red shale.

Limestone quarries.

The *Lewistown limestone* enters this township on the east just north of the B. S. S., and has been slightly quarried near the junction of the first road to Spruce Hill, upon a 50° N. W. dip. *North of J. Ard's*, where Tuscarora creek

cuts through this ridge, the limestones are again slightly quarried upon a similar dip, showing about 20' of fair stone.

On the road leading south from Pleasant View past the school house and grist mill, there is a well marked synclinal roll to the south of the main axis in Marcellus slate, just south of the school house. The dips are about 40° each way, and are considerably twisted and broken along the road further south. This structure is reflected in the Oriskany ridge to the east, only there it amounts to a flattening of the Stormville shales along the road between the main ridge and the Tuscarora valley and a broadening of the Oriskany measures into a small knob southeast of Pleasant View.

South of the slate synclinal, going up stream through the gap in the ridge, No. VII shows as flint and chert in a thin band succeeded by No. VI limestone opened opposite the Patterson or Fitzgerald house on the west side of the road; at *Yoder quarry*, where a series of thin limestone beds, aggregating 50' to 60' in thickness, outcrop on a regular northwest dip of 50°. This quarry is on a part of the old Hock property. Better beds show in an adjoining quarry further south and nearer the mill upon a somewhat decreased dip and about 30' thick.

The section further south into the Sink Hole valley synclinal shows some few peculiarities. The upper Salina lime shales first show at Patterson's place, succeeded by gray, green and blue slates upon a 10° dip. At Yoder's barn the dip stiffens to 30 N. W. in red shale, the same measures dipping 30° S. E. near his house and mark the expiration of the red shale anticlinal noted at Mrs. Wharton's in the eastern end of the township.

The back valley road is just in the Sink Hole synclinal and from here west to the Dunkard church in Tuscarora township, the ore ridge on the south side of the basin becomes more and more prominent as the little Sink Hole valley basin shoals up in that direction.

At the most western gap through the south limestone ridge in this township, about one-half mile east of the

Tuscarora line, the No. VI limestone shows at the school-house dipping north only 25° , indicating the broadening of the main synclinal basin to the north. Inside the gap, just beyond the forks of the road to McCoysville and Pleasant View, the Marcellus black slate shows in a small dome-shaped hill caused by the prolongation westward of the small synclinal fold already described south of Pleasant View; and a little east of the forks these slates dip 80° N. W. and 20° S. E. The central portion of the valley south of Tuscarora creek is occupied by a high ridge of Hamilton shales and sandstone, which first begins to take shape west of Pleasant View.

At the ford north of Pleasant View and along the Beale township line the Lewistown limestone is well exposed in the North Limestone ridge in massive layers, dipping S. 36° E. 55° , showing some good beds of smooth dark gray limestone. The same rock is exposed lower down the creek.

46. Tuscarora township in Juniata county.

This township lying immediately west of Beale and Spruce Hill and between Black Log mountain on the north and the Tuscarora mountain on the south, has a roughly trapezoidal shape only that the two parallel sides on the north and south sides of the township are made irregular by offsets in the township lines.

Thus the north township is formed by two lines making an obtuse angle with each other; the first a little over 2 miles long, extending from the south Medina crest of the Blue ridge across the Licking creek valley to the summit of the anticlinal knob of Oneida sandstone in Black Log mountain; the second line runs for $2\frac{1}{2}$ miles along the north crest of the Black Log mountain to join the western township line. The latter is $8\frac{1}{2}$ miles in length, running southwest straight across the Tuscarora valley from Black Log mountain to the summit of Tuscarora mountain. The east line, 9 miles long, is likewise straight, bearing a little southeast from Minehart's gap in the Blue ridge to the summit of Tuscarora mountain, while the south line, in common with Perry county, runs 3 miles west along the Medina

backbone of that mountain to the high spur south of Bealetown; thence $1\frac{1}{2}$ miles southwest across the Liberty valley to the Medina crest of the southern division of the mountain and with it $4\frac{1}{2}$ miles west to the Lack township corner. The area of the township will not fall far short of 50 square miles.

McCoysville and *Reed's Gap* are both flourishing little villages on the north side of the synclial and upon opposite sides of the North limestone ridge, while *Bealetown* (Honey Grove) and *Waterford* are two additional villages in the southern portion of the township, both lying south of the Southern limestone ridge on small tributaries of Tuscarora creek.

This stream is again the most important avenue of drainage in the township, receiving accessions from all parts of the township by streams of considerable size. Entering from Lack township it cuts through the South Limestone ridge north of Waterford and washes its south base for the next two miles where it again cuts back into the slate valley to wind its course eastwards and northwards across the valley near to the center of the township.

Here it receives its most important tributary, *Willow Run*, a three-pronged stream watering the main central slate valley, as well as receiving a tributary from the Shade mountain through Reed's Gap, and with the parent stream makes a considerable creek flowing eastward for 2 miles to the Spruce Hill township line.

Within one-half a mile of that line it receives the *McCoysville branch* from the north, which, after cutting through the Academia anticlinal ridge crosses the plain of upper Salina shales and cuts through the North Limestone ridge just east of McCoysville.

The *geological column of rocks* exposed in this township extends from the Hudson river No. III slates, in the eastern end of the Black Log valley, upwards to the Hamilton and Genessee No. VIII sandstone, shales and slates, contained in the main basin of the township.

The *structure* is diversified and extremely interesting. On

the north the Black Log valley, or Shade mountain axis, carries a triangular area of No. III slate on its crest for about 2 miles east of the Lack township line, beyond which the valley is enclosed by a single high ridge of Oneida sandstone extending $1\frac{1}{2}$ miles beyond the slate and enclosed, in its turn, by the red Medina No. IVb rocks which create an elevated plateau within a double ridge of the Medina IVc sandstone bounded north by a small triangular wedge of the Clinton rocks in the Licking Creek valley.

The *Academia anticlinal* extends for nearly 4 miles into this township from Beale and is well marked for that distance carrying a double outcrop of the Ore sandstone on either flank to within a couple of hundred yards of the Reed's Gap road.

Its subsidence at this point brings the Medina sandstone of Shade mountain and the Oriskany sandstone of the North Limestone ridge within $1\frac{1}{2}$ miles of each other along the Lack township line, while the same rock and ridges are 3 miles apart along the Beale township line. An elevated and gentle synclinal basin occupies the territory between the Shade mountain and Academia anticlinal, flanked on either side by the Ore sandstone ridges and filled up with the Salina measures. This is a virtual continuation of the Mifflintown synclinal and cannot be detected at Reed's Gap.

The main *Tuscarora synclinal* enters the township in the high Hamilton ridge just south of Tuscarora creek, crossing the road leading south from McCoysville on the south side of the creek with south and north dips of 25° and 10° respectively. From here it may be traced directly west through the high ridge to the Presbyterian church at McCollough's S. M. ; and from that point it continues south of Willow Run to the Lack township line.

On the south side of the township the outcrop of the Oriskany sandstone and Lewistown limestone is interrupted just north of Bealetown by a small fold over the western end of the small anticlinal which has already been traced through Turbett and Spruce Hill townships, and which expires upon reaching Tuscarora creek, a mile west of Bealetown.

The *Sink Hole valley synclinal*, after shoaling up near the Dunkard church and the Spruce Hill line, rapidly deepens coming west and receives at Bealetown a narrow tongue of the Lewistown limestone nearly 2 miles long; but it cannot be traced further west in the slates north of this ridge.

Finally the *Tuscarora mountain anticlinal*, which occupies the long straight crest of the mountain from the Juniata Gap, carries down the Medina sandstone in the gap south of Bealetown, where its crest is arched by a double outcrop of the Ore sandstone, which returns on the south side of the mountain to be duplicated in the Liberty valley synclinal passing into Perry county. The continuation of the mountain on the south side of Liberty valley is therefore of monoclinical structure and shows only an outcrop of the Medina sandstone IVc, the red Medina and Oneida lying south in Perry county.

Reed's gap in Shade mountain, is very wild and rough. The Medina white sandstone No. IVc, shows just above the tannery on a dip of S. 60° E. 75°, and is completely cut through by a swift flowing stream, whose branches rise behind this mountain wall in the red Medina valley between the Oneida and Medina crests. The Ore sandstone outcrops along the upper end of the dam, but it is poorly exposed here, as well as elsewhere along its mountain outcrop and the overlying Sand Vein fossil ore bed is nowhere open in this township.

The road between Allenville and Reed's gap enters this township upon an outcrop of the Bloomsburg red shale, dipping north into the Mifflintown synclinal.

At *McKinley's mill and school house* there is a fine gap in both the ridges forming opposite legs of the Academia anticlinal, which are here less than one-half a mile apart. An old drift near the Shade valley road seems to have been driven into the Danville ore bed, beneath the Ore sandstone, but nothing could be learned of the results attained here.

To the south through the gap the anticlinal is well exposed in the lower Clinton brown shales, which first show a northwest dip of 80° succeeded south by dips of only 20° each way on the crest of the anticlinal. Olive and red slates

show at this point nearly 400' thick until just north of Creighton's house the Ore sandstone is again exposed on a south dip of 30°, above which the Sand Vein is said to have been found 26" thick. The loose ore seen here was of very fair quality, and as the hill rises to 250' or 300' above the valley, there would be an excellent opportunity for developing the ore bed at this point. A band of the Bloomsburg red shale occurs south of the ridge on a dip of S. 35° E. 50°, succeeded by variegated slates for the next 100 yards along the road.

Going west from McKinley's the road to Reed's gap runs for over a mile between the two opposing outcrops of the Ore sandstone, gradually ascending the south ridge through outcrops of brown fissile shales and at the summit showing another excellent exposure of the *Ore sandstone*, 15' to 20' thick, dipping S. 48° E. 65°. Boulders of this rock cover both flanks of the ridge, showing a tough grey and brown sandstone, with a block structure frequently discolored by iron. Apparently no ore of any value is associated with the outcrop at this point, being pretty generally eroded, and in the next mile the ridge and anticlinal die away altogether to be succeeded by a band of the Bloomsburg red shale. The direct road between Reed's gap and McCoysville is everywhere in the upper Salina lime shale, which dips between 50° and 60° to the southeast and which seems to have thinned considerably. Reed's gap store is situated on these rocks.

Going south from the store along the creek, the Lewistown limestone No. VI shows near the base of the first ridge and has been somewhat quarried on the east side of the creek on a southeast dip of 45°. It may be from 40' to 60' thick and is immediately followed and overlaid by the Oriskany sandstone, which though thin (35'±) are compared with the same strata in Mifflin county is nevertheless rendered just as conspicuous by its sharp white sandrock and chert giving rise to a harsh arenaceous soil.

Both the Marcellus black slate and the lower Hamilton grey and brown shales show outcrops immediately inside the gap with dips of S. 30° E. 30°, the latter excellently ex-

posed at the first road near J. Kirk's house. Two high parallel ridges, very narrow and with steep flanks, succeed going south without good exposure, but evidently composed of the Hamilton sandstone. The second one is higher and broader of the two, and shows some thin bedded gray sandstone and shale between Andrews' mill and the creek crossing on a dip of 20° S. E.

Repeated exposures occur going down Willow run, at first sandy and gradually becoming more and more slaty.

Taking the right hand road over the hill to Waterford a *splendid exposure* of gray and black Genessee slates and thin sandstone shows in the stream at the forks of the road near Milliken's, 25' thick and dipping S. 35° E. 15° to 20° . Gray shales follow on top of these going up the ridge, showing very little sandstone.

This ridge probably contains some Chemung rocks in the synclinal, and from its summit both the bounding Oriskany hills on either side of the Tuscarora valley can be readily overlooked. Descending its south flank the gray slates again appear on a 10° N. W. dip, on the south side of the synclinal, and in the ravine still further south some shales and sandstone outcrop on a 25° N. W. dip. A belt of hard angular gray sandstone, smooth-grained and very tough, show near the red frame school house dipping 45° N. W., probably associated with the Hamilton measures.

In the gap north of Waterford, the Marcellus slates outcrop on a 40° N. W. dip, succeeded south by the Oriskany sandstone, which has here become a mere mass of shale and shaly sandstone 40' thick creating a very low ridge. The Lewistown limestone underlies these rocks upon a dip of N. 35° W. 35° , and makes a supporting flank of the ridge, well exposed also in the creek at the north end of the bridge. It is about 60' thick and exhibits some good limestone beds.

A little over a mile northeast from Waterford the Tuscarora creek cuts through the limestone and sandstone ridge at Smelker's house, beyond which the limestone ridge becomes doubled, by reason of the synclinal and anticlinal north of Bealetown. The North ridge ends on Tuscarora

creek, where its base is flanked by a roll of Oriskany sandstone. No. VII all along the south side of the Tuscarora synclinal is largely chert and flint and very seldom shows any sandstone beds.

At *Bealetown*, near the brick school house, thin beds of limestone dip 25° N. W., and the ridge to the north is composed entirely of the same rocks, the Oriskany sandstone of this narrow synclinal only extending about one-half a mile east of Tuscarora creek.

Allen's limestone quarry is situated well up the south flank of the second limestone ridge, and on the north side of the small anticlinal of upper Salina rocks separating the two limestone ridges. It shows about 60' of stone on a dip of N. 30 W. 35. It is not very evenly bedded as yet, though it has barely been uncovered.

It has a sub-crystalline structure, grayish-blue in color and the bottom layers rather siliceous. Near the top of the exposure the beds are very fossiliferous; but the central beds furnish a good quality of lime, which is burned periodically for local farm use. Altogether it is the best exposure of the Lewistown measures in this portion of the valley.

Higher beds crop out on the road near Mrs. McCullom's just after crossing a small branch stream, dipping 40° N. 35° W. Here about 50' of greenish lime slate intervenes between the good limestone beds and the first flint layers of No. VII.

For over 2 miles east the road runs through a valley dividing Nos. VII and VIII gradually rising to a summit and exposing the Marcellus limestone from 10' to 15' thick in many places between McCullom's and Grey's place at the McCoysville road. This limestone has a greenish-gray cast and weathers buff; but it nowhere seems to be associated with any iron ore. North of Grey's place and along the McCoysville road, the great Tuscarora synclinal has shallowed up considerably, and doubtfully contains any repre-

sentatives of the Chemung rocks. The synclinal seems to contain only the upper Hamilton shales and slates and on the north side of the basin, along Tuscarora creek, large slabs of Hamilton sandstone outcrop on a southeast dip of 40° . The lower Hamilton shales and the Marcellus black slate are exposed north of A. Noss' house making a bluff along the road on a 25° S. E. dip.

McCoysville is located largely on the Oriskany sandstone measures. The Lewistown limestone at the village is quite massive and has been quarried just below the brick church on a dip of S. 40° E. 45° . The entire series however is somewhat shaly and aggregates about 100' in thickness.

About one-half a mile east of *McCoysville* the same beds opened at the village are slightly quarried on the south side of the road on a 40° S. E. dip, but most of the work has been confined to one good bed, from 4'-6' thick, which, though about the best seen, yields an inferior lime when burned, with a dark gray color, totally unfit for plastering purposes. The cemetery to the east of this point is located on a knob of upper Salina lime shales.

The *south side of the township* between the Limestone ridge and the Perry county line is entirely occupied by the Salina and Clinton rocks with the Medina sandstone in the Tuscarora mountain. South of Bealetown the upper Salina rocks are first exposed on dips of about 50° N. W., showing best at the mill dam, where too the Bloomsburg red shales are sparingly exposed on the north flank of the Ore ridge.

Probably 300' or 350' of brown and olive shales overlie the *Ore sandstone* south of the old stone grist mill, and the Ore sandstone itself makes a distinct ridge on either side of the creek, showing a brown quartzose rock about 25' thick on a dip of N. 20° W. 30° . It does not seem to overlie the white Medina sandstone exposed in the anticlinal of Tuscarora mountain further south by more than 200' which would indicate a considerable thinning of the Clinton rocks in this portion of the field.

The first good exposure of the Medina sandstone shows a

dip of 15° N. W., the south leg of the anticlinal dipping 20° S. E. into the Liberty valley synclinal. Only a portion of the formation shows here aggregating possibly 60' in the knob on the west side of the gap, but eastward the mountain rises rapidly and the dips on either side stiffen at the same time.

The *Sand Vein fossil-ore* bed has never been opened on either of the three outcrops exposed along the flank of Tuscarora mountain, and there is no evidence of the existence of the Danville beds at all. The south outcrop, running west towards Waterford, must show a very gentle dip, for the Ore ridge lies nearly a mile north of the base of Tuscarora mountain with a wide valley of the lower Clinton rocks between. This ridge presents a series of interrupted knobs rising to elevations of 150' or 200' above the valley, in every way favorable for mining operations and likely to contain a large quantity of good soft fossil.

Further west in Lack township the Sand Vein bed has been found 18" thick and there is no good reason for doubting its presence in equally good condition through the mountain outcrop in Tuscarora township.

The Liberty valley synclinal extending west through this township is everywhere marked by a narrow band of gray lime soil, flanked on either side by wider bands of the Bloomsburg red shale. The axis passes about one-fourth of a mile south of Waterford and seems to be somewhat characterized by a number of small sink-holes, the valley itself being entirely dry during the larger part of the year.

47. Lack township in Juniata county.

This township lies at the extreme west end of the Tuscarora valley in Juniata county, bounded on the south and west by Perry and Huntingdon counties and in shape nearly square, with a length east and west of about 7 miles and a breadth north and south averaging 8 miles. Its area therefore approximates 56 square miles. Its east and west and north and south lines are approximately parallel, but the two latter do not make right angles with the former.

Black Log mountain (Oneida sandstone) on the north side of Black Log valley makes the northern township line for about $5\frac{1}{2}$ miles, west of which point the Juniata-Mifflin county line crosses to the Medina sandstone crest and continues 2 miles further to the Huntingdon county line.

The *Tuscarora mountain* of white Medina sandstone makes the southern border line of the township for a distance of about 7 miles, with one break in the straight line of the crest, about three miles west of the gap leading to Horse valley in Perry county. The eastern line of the township is a common one with Tuscarora, $8\frac{1}{2}$ miles long from the Black Log mountain on the north across Tuscarora valley to the crest of the Tuscarora mountain on the south. The western line, a common one with Huntingdon county, is of about equal length, $8\frac{1}{2}$ miles, between the same mountains.

Tuscarora creek is the main stream of the township, draining with its several branches all the Tuscarora valley, as well as the Salina valley, lying along the base of the Tuscarora mountain. It enters from Huntingdon county near the southwest corner of the township and flows east-northeast generally along the south base of the South Limestone ridge to within a short distance of the Tuscarora line, where it cuts through the ridge, making a loop in the slate valley to the north before entering Tuscarora township.

Willow run, its principal tributary, rises along the Shade mountain north of Peru Mills, two of its branches making gaps there in the North Limestone ridge before entering the slate valley further south.

Black Log valley, on the contrary, is drained westward through Black creek, which, taking its rise in the northwest corner of Tuscarora township, flows generally through the center of the Black Log valley over Hudson river slates No. III and Trenton limestone No. II into Huntingdon county, where, after pursuing its course for about 10 miles, it turns northward and breaks through the Black Log mountain at the Orbisonia gap.

Peru Mills and *Waterloo* are the only villages in Lack township, neither of them large or of much importance. This township is sparsely settled.

The *geological section* of rocks is more extensive than elsewhere in Juniata county, from the fact that the Black Log axis elevates the top or Trenton layers of the Siluro-Cambrian limestones for about $2\frac{1}{2}$ miles east of the Huntingdon county line along Black creek. The central portion of the township contains representatives of the Chemung rocks in the Tuscarora synclinal, so that the entire series between No. II and the top of No. VIII are here exposed.

The *structure* of this portion of the district has become greatly simplified by the expiration of the subordinate axis, which modify the topography and geology of the county in the vicinity of the Juniata river.

The Black Log valley anticlinal, on the north, the Tuscarora mountain monoclinal on the south, and the broad Tuscarora synclinal in the center are the only well marked flexures. As has been already stated, the first axis carries, for $2\frac{1}{2}$ miles east of Huntingdon county line, a narrow wedge-shaped area of limestone on its crest, beyond which the entire valley of Black creek and the inside flanks of the two bounding mountain walls—Black Log and Shade mountains—are occupied by the Hudson River slates No. III.

The Black Log mountain of Oneida sandstone IV a, is a comparatively low ridge, forming a terrace on the south flank of the Medina crest, which is largely in Mifflin county. It is, however, coarsely conglomeritic, exhibiting along its strike a series of pulpit rocks, or dome-shaped outcrops, whose rocks dip northwest 40° – 50° . The slates on its south flank are decidedly brown in color and are very readily eroded, thus presenting but few good outcrops.

Along the main valley road these rocks show all the way west to beyond the valley church, where they dip 60° S. E. A short distance beyond this point, on *C. Gluck's farm*, a small *limestone quarry* has been opened on the south side of the creek, showing a few feet of limestone, dipping 35° S. E. into Snade mountain. This is No. II limestone which occupies so large an area in the Kishacoquillas valley and is the only place in Juniata county where it is exposed. West along the creek it is pretty generally covered with a

slate wash, so that its extent can only be surmised from the topographical condition and a few disconnected outcrops.

On the south side of the valley the Oneida sandstone terrace of Shade mountain rises to slightly greater elevation than along Black Log mountain, but it is still merely a terrace upon the main Medina crest which greatly overlooks its summit. This whole mountain is extremely rough and is entirely unbroken throughout the township, except in one by two small notches in its outer crest near the Tuscarora line.

The *Ore sandstone terrace* on the south flank of Shade mountain rises about half-way up the mountain; but its out crops of sandstone and fossil ore are so completely concealed by *débris* from the mountain that practically little, if anything is known of their character here. Further west in Huntingdon county this outcrop has been considerably exploited of late and good reports are given both of the thickness and quality of the Sand Vein fossil ore bed. In this township, however, there would be but limited facility by means of natural gaps to mine this ore, and all development would have to be carried on by means of long drifts or cross-cuts through the overlying slates, with the probability of finding a good deal of hard fossil ore in the bed.

Between this Ore ridge and the Limestone ridge there is the usual valley of Salina slates and shales, but in this township this valley is largely wooded and considerably broken up with small hills rendering, its cultivation more difficult than usual.

On *the south side of the township* the features just described are generally repeated. The Tuscarora mountain shows a high crest of white Medina sandstone dipping northward towards the Tuscarora valley. In the gap south of Waterford leading to Horse valley, a vast number of Medina sandstone boulders are seen, but no good outcrops of the rock in place. The Ore ridge here lies a mile north of the mountain, wholly distinct and separated from it by a small synclinal crimple in red shale south of the Union tannery.

The *Ore sandstone* here is 20' thick and crosses the road

just above the Hackenberry place with a dip of N. 60° W. 30°. Several years ago a small shaft was put down on the *James Wallace* place about 1½ miles west of the gap and several wagon loads of ore were raised. The shaft was only 10' deep and is now entirely filled up. The Sand Vein ore was the one found here.

Mr. Spanogle has done some slight work on the same bed just back of Hackenberry's house, by means of a drift at creek level. This opening was likewise fallen shut, but some good soft fossil ore was seen loose at the mouth of the opening and the bed mined here is reported to have been 18" thick.

West towards Waterloo, the outcrop of the fossil ore bed can be traced with more or less persistency gradually approaching the mountain as the little synclinal basin south of Waterford expires. The Ore ridge is very knobby here and frequently cut by small ravines, in one of which, south of Titzel's place, some little ore has been found.

The *Limestone Ridge*, to the north of the Waterford and Waterloo pike is considerably eroded by Tuscarora creek. Indeed, from the Waterford gap, for over 3 miles west to the school house the ridge is almost entirely eroded; but north of the school house the creek runs through the upper Salina shales and permits the limestone and sandstone ridge to take form again.

There is another short strip of ridge land east of Clark's S. M. From the school house west, except where it is cut out at Neeley's and Gallagher's by small streams, the ridge is fairly persistent to Waterloo, and everywhere presents the Oriskany No. VII as a flint deposit on its north flank, with the Lewistown limestone No. VI, really making the crest and south flanks on an average dip of about 50° N. W.

The upper Salina rocks present very few outcrops and the Bloomsburg? red shale shows a thin interrupted streak of red land running just south of, and parallel with, the pike.

Going up George's creek, about 1½ miles east of Waterloo, both Nos. VI and VII are cut out. A grey sandstone some-

what calcareous, first shows in the bed of the creek on a 40° N. W. dip succeeded by exposures on both sides of the cross roads, above and below Beale's S. M., of grey slates and sandstone, the latter breaking in blocks, but the former largely predominating, on dips of 35° and 30° N. 25° W.

The *Marcellus black slates* and limestone are wanting. The Hamilton measures show near the forks of the creek at J. Grey's on a 20° N. W. dip and underlie an upper Hamilton shale and Chemung ridge which rises with well rounded summits to the north of this point, right in the center of the Tuscarora synclinal.

On the north flank of this ridge going towards Peru, reddish-brown sandstone shows near Reeder's lane, dipping S. E. 25°.

A short distance east of the Cross Keys store and church, along the road to Peru mills, a small outcrop of the Marcellus limestone shows in the road cut, with the Oriskany sandstone and Lewistown limestone underlying it in the hill to the north. This Marcellus limestone has a greenish cast and weathers into a very dark soil. It breaks into long narrow blocks and occurs in thin hard ribs. The dip was obscure, but evidently stiffly southeast.

In the gap of the ridge, just east of here, the outcrop of No. VI limestone is considerably increased by a small anticlinal flexure, showing dips of 20° N. W. and 50° S. E., the latter decreasing in the Oriskany sandstone.

A *small quarry* here has been mainly opened in the upper slaty members of No. VI, the massive limestone member being just at water level on the crest of the anticlinal, but outcropping again further up the ravine on its regular southeast dip where it could be much more advantageously opened.

At *Peru Mills* the anticlinal has worked into the Oriskany sandstone, which is here quite massive and apparently fully 50' thick. Northwest dips of 40° and southeast dips of 20° were seen in sandstone at this point, and at the top of the formation there occurs a small layer of pebbly sand rock about 3' thick, to which Mr. Dewees, in Report F, has as-

signed the name of *Peru sandstone*. It is not fossiliferous, and in Huntingdon county contains pockets of iron ore.

The *Lewistown limestone belt* on the north side of the ridge is still quite wide, but shows only southeast dips of 25° and 30° . Its top layers are cherty and lean, but better stone has been quarried near the center of the series, where, however, the best beds seem to lie still in the bottom of the opening.

A second quarry, still further up the ravine, shows about the same features and neither opening ever seemed to have been very actively or economically worked. Both were idle when visited and were probably only worked periodically for the supply of local lime.

A little of the Marcellus limestone shows at Peru and the Marcellus black slate shows in the first bend of the road east of the mills and continues to border the road eastward to Tuscarora township. In the gap north of the school house a little over a mile east of Peru mills, the local anti-clinal axis has expired completely, the dips being uniformly southeast about 30° .

The upper portion of the limestone formation is still quite slaty and the more solid members weather with rough surfaces and show a strong northwest cleavage of 60° . Limestone has been quarried a little east of this gap at *M. Dougherty's*; and upon the crest of the ridge a mile west of the Tuscarora line, some little siliceous iron ore was derived from the Oriskany sandstone formation.

A section south from this point across the Tuscarora valley is almost entirely devoid of exposures, but the same rocks occur there as have been already described further west between Waterloo and Peru mills.

Lack township, agriculturally, is largely given up to wheat and some little corn, but the greater portion of its area is still well timbered. The chestnut oak which once grew so thick along the interior slate ridges has been largely cut out for its bark, and a thick but small second growth Chestnut has taken its place.

A large portion of the Tuscarora valley could be made to support a farming population by a more general use of lime or other fertilizers, which is equally true of all the eastern portion of the county, where the same Devonian measures spread over large areas in five townships; but the lack of railroad communication has retarded the growth of both sections whose lands cannot be made to yield the same results as the richer Salina soils on either side without laborious and careful farming.

Along the Juniata the sandy Oriskany ridges have of late been planted with peach trees, and a number of flourishing orchards, as well as a good demand for the fruit, seems to justify the impression that this hitherto useless soil is well adapted to the cultivation of peaches.

Tobacco has likewise of late been planted in a number of places bordering the river and its success seems to be likewise assured. But in the cold gray slate soils at either extremity of the county the farms as a rule are becoming poorer and poorer, and but few of the larger farmers are able to compete at all with the product of the large wheat fields of the west. It is true, therefore, that these regions have both artificial and natural disadvantages; but they both have good beds of limestone within comparatively close reach, which might be much more largely used than it is to the advantage of the farming interests.

The *Tuscarora and Shade mountains* originally contained about 50 per cent. of chestnut oak and ordinary chestnut timber. Nearly all the chestnut oak has been cut out. The other 50 per cent. is made up of red and black oak, scrub pine, a little white oak, poplar, birch and beech.

The best white oak came from the limestone ridges and the flats at the base of the mountains, but it is now pretty well cleaned out. The central slate ridges support a scrub pine, some little white oak and chestnut oak, and as the latter was the only timber of value and has been fairly well cleared out no land in this part of the valley is considered to contain good timber tracts. The chestnut along the south flank of the Shade mountain is very much better than

the same timber on the north flank of Tuscarora mountain, on account of the southern exposure.

The whole county, with the exception of some few isolated tracts, has been pretty well stripped of its valuable timber, and being in no sense a manufacturing district, it must of necessity look to its farms, its limestone and its best ore beds for its future industries and source of commercial wealth.



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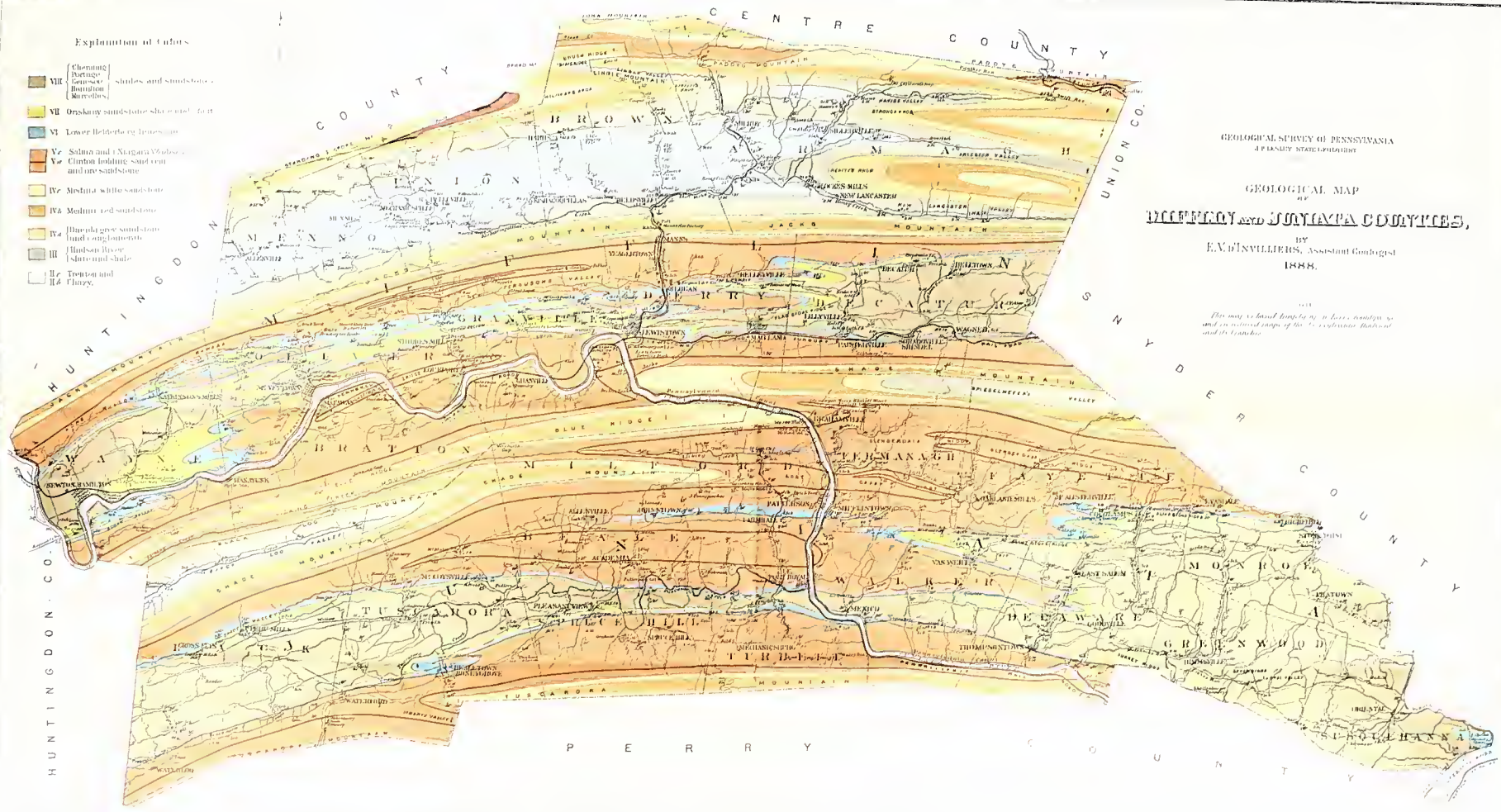






Explanation of Colors

- VIII Chenango, Seneca, Hamilton, and Onondaga shales and sandstone
- VII Onondaga sandstone shales and iron
- VI Lower Belvidere limestone
- V Schuylkill and Niagara sandstone
- IV Clinton bedding sand iron and gray sandstone
- III Medina white sandstone
- IIa Middle red sandstone
- IVa Through gray sandstone and conglomerate
- III Hamilton River slate and shale
- IIb Trenton and Flory



GEOLOGICAL SURVEY OF PENNSYLVANIA
A PLANNED STATE INSTITUTION

GEOLOGICAL MAP
OF
CENTRE, UNION AND PERRY COUNTIES,
BY
E. D. SNIVILLERS, Assistant Geologist
1888.

This map is based principally on the notes, reports, and on actual maps of the "Geological Survey" and its branches.

