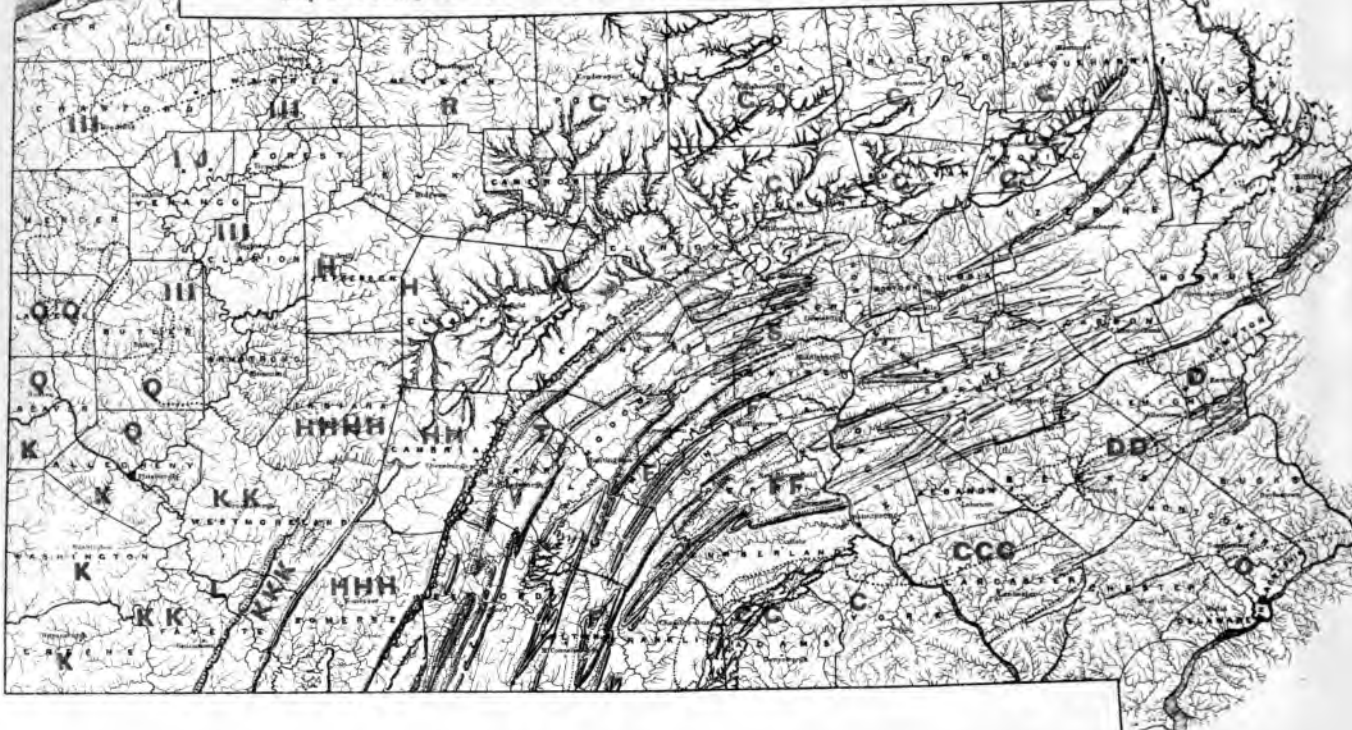
Map of Pennsylvania, Shewing the Areas Surveyed in 1874, 1875, 1876 & 1877.



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA:

REPORT OF PROGRESS

DD 1875-'6.

THE BROWN HEMATITE DEPOSITS

OF THE

SILURO-CAMBRIAN LIMESTONES

OF

LEHIGH COUNTY,

LYING BETWEEN

SHIMERSVILLE, MILLERSTOWN, SCHNECKSVILLE, BALLIETSVILLE,

AND THE

LEHIGH RIVER,

BY

FREDERICK PRIME, JR.,
ASSISTANT GEOLOGIST,

WITH 5 MAP-SHEETS AND 5 PLATES.

HARRISBURG:
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FOR THE SECOND GEOLOGICAL SURVEY.
1878.

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PREFACE.

LAFAYETTE COLLEGE, EASTON, PA.,
June 1, 1878.

Prof. J. P. LESLEY,
State Geologist of Pennsylvania:

DEAR SIR: Herewith I transmit to you a report on that part of the limestone of Lehigh county, which was surveyed in 1875.

In the survey of the region I was assisted by Messrs. Ellis Clark, Jr., and Ellis C. Kent, as Aids, who showed much energy in their work.

Mr. John H. Dager assisted me in drafting during Mr. Clark's illness. Messrs. Frederick P. Garrettson, C. F. Lewis, and David Hunt acted as volunteer aids, and did good work.

It may be proper to state here that a few years ago some Germans drove an adit in the limestone on Squire Saeger's farm near Ironton in search of silver-ore. As there were not the slightest evidences of its existence at this locality, or elsewhere in the Siluro-Cambrian limestones of the Great Valley, east of the Schuylkill river, it has always been a mooted point whether these men actually were themselves deceived or were adventurers. Of course no silver-ore was found.

Among the most recent discoveries in Northampton County may be mentioned that of Laurentian limestone, about three miles north of Bethlehem on Joseph Dech's farm, near to which is a gneiss in which the mica is very largely replaced by graphite.

Chazy fossils have been discovered near Bath, the forms belonging either to *Euomphalus* or *Maclurea.*

I am under obligations to R. H. Sayre, Esq., Chief Engineer of the Lehigh Valley Railroad; Joshua Hunt, Esq., President of the Catasauqua and Fogelsville Railroad; Gen. Robert McAllister, President, and Mr. William Andrews, Supt. of the Ironton Railroad; D. O. Saylor, Esq., President of the Coplay Cement Co., Joseph Hunt, Esq., Ass't Superintendent of the Crane Iron Co., and others for valuable aid in the prosecution of the work.

Yours very respectfully,

FREDERICK PRIME, Jr.

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* This numbering of the chapters is in continuation of the Report on Lehigh County for 1874.

ERRATUM.

By an oversight in the report for 1874, the analysis of brown hematite iron ore from the Thomas Iron Co.'s Mine, No. 52, was erroneously credited to Hensinger & Saul's Mine, No. 54.

LIST OF ILLUSTRATIONS.

REPORT OF PROGRESS

IN THE

LEHIGH IRON ORE DISTRICT,

1875.

Chapter XII.

The Maps.

Of the five sheets which accompany this report, four compose a contour map of the limestone portion of Lehigh county, from its western boundary to a line a little east of the Lehigh river.

This map is published on a scale of 1600 feet to 1 inch, which scale it is hoped will be sufficiently large for practical purposes, being the largest on which it was practicable to issue the sheets, and one fourth of the scale used in field work.

The curved lines are contour lines, having a vertical distance apart of 10 feet. The numbers attached at intervals indicate the height above the level of the ocean. In order to ascertain this the levels of the East Pennsylvania and Lehigh Valley railroads were taken as standards, from which the lines of the surveys were run.

In running the lines and determining the contours a Heller & Brightly mining transit was employed, and stadia measurements taken on all the most important points. While for a few unimportant interior lines an old transit and pacing were used, care being taken to make all such conform to the stadia measurements.

The topography was drawn in the field in the note books by eye, and although no absolute correctness, except at the points where lines were run, can of course be claimed for work thus done, still the contours are relatively and approximately true.

In using the levels of the two railroads there was found a discrepancy of three feet at East Penn Junction; and as the East Pennsylvania railroad had been first used, all the levels of the Lehigh Valley railroad were changed 3 feet to correspond with it.

The arrows indicate *dips;* the points of the arrows showing the direction in which the rocks *dip*, the cross-heads the direction in which the rocks *strike* or *trend*, and the numbers show the *amount* of dip.

The colors indicate different geological formations, thus:
The Archæan (Laurentian) rocks are indicated by a red color.
The Potsdam Sandstone by yellow.
The Siluro-Cambrian or Magnesian Limestones by blue.
The Hudson River and Utica slates by a neutral tint.
The Ore mines by an ochre-brown.

The railroads are indicated by continuous thick black lines; and ordinary roads by parallel lines.

The numbers attached to the mines correspond to the key-list in the southeast corner of the map. These have been for the most part attached to them in the order in which they were visited, and although some irregularity has thus ensued, it is thought that no serious difficulty will be found by those using the sheets.

On the extreme west of the map are a few mines with numbers attached to which no reference is made in the key-list, as they are situated in Berks County, and will be referred to and described when the map of that portion of the State—now nearly completed—is issued.

It is hoped that this map will be useful, not only to ordinary persons in showing the surface topography of the district mapped, but also to engineers as serving in lieu of preliminary lines.

The single sheet which also accompanies this report shows the mines at Ironton on a scale of 200 feet to 1 inch. The contour lines are also 10 feet vertically apart. The mine dumps, which have been omitted on the map of the entire limestone district of Lehigh county, are here given, together with the slate nose which separates two of the mines from the others. The key-list of colors on the sheet will explain the different kinds of beds observed and noted.

Chapter XIII.

The Topography.

A glance at the accompanying map will at once show that the southern portion is strongly accidented, the centre is comparatively level, while the northern portion is again accidented, though to a less degree than the southern part.

These three distinctive topographical features correspond to three distinct geological formations.

The southern portion—colored red on the sheets—consists of Laurentian rocks, composed of gneiss and allied rocks, which weather rapidly when exposed, so as to leave steep slopes and often almost precipitous bluffs. The ravines, while steep, are generally of a medium breadth, at times much contracted.

In the middle—colored blue—occur the Siluro-Cambrian limestones, which have been eroded far more uniformly and even more rapidly than the preceding, and hence have given rise to a valley, which is comparatively level, though at times rolling. The limestone valleys in this Great Valley, as it is called, are broad and fertile, having a gradual fall, and the small hills slope gradually, except where the beds have been tilted nearly vertically.

The trend of the gneisses is southwest and northeast, being at right angles to the force which elevated them, and which came from the southeast; thus forming the South Mountain Range. The limestone which lies north of and which once entirely overlaid this range, has also been much folded and upturned by the same cause. The dips which occur in it are generally southeast and northwest in direction, the few exceptions to this rule being due to local folds in the limestone rocks. Simple as the limestone valley looks on its surface, it is in reality very complicated, and the study of its structure has been rendered much more difficult by the comparative scarcity of outcrops. These are often a mile or more apart, and therefore its structure, as briefly stated in the following pages, has been much less perfectly ascertained, than would otherwise have been the case, owing to the difficulty mentioned.

The same remarks apply to the slate district examined, for while outcrops are more numerous, the dips observed are often rendered very doubtful by the intensity of the cleavage and the rapid weathering of the rocks ; owing to which the hills soon become covered with a layer of soil, and the valleys with the *debris* washed down into them. To this same rapid weathering, as well as to the synclinal structure of the hills, are due their rounded shape, as also the narrow and contracted anticlinal ravines between them, often so narrow that there is not a sufficient space for a wagon-road alongside of the stream which flows through them.

The slate ridge south of Fogelsville, and Huckleberry Ridge, are two slate hills, which, having to a certain extent escaped erosion, have remained overlying the limestones, as evidences that the latter were formerly entirely covered by the slates.

The Lehigh river, which is the principal stream, breaks through the Kittatinny Mountain at the Lehigh Gap, and thence has a general south-southeast direction until it reaches Allentown. Coming in contact here with the quartzite flanking the South Mountain, and being unable to force its way through this, it turns northeast and continues its course in the limestone until it empties into the Delaware, at Easton.

The minor streams, which all empty into the Lehigh, have had their courses determined in part by the folds of the rocks, but more commonly by the erosion which they have accomplished in the limestones.

Chapter XIV.

The Laurentian Rocks in Lehigh County.

The Laurentian Rocks of Lehigh county have only been studied incidentally during the past year where they occur between Shimersville and Emaus, and also north of the latter town where they occur locally.

On the direct road from Shimersville to Emaus there are but few rock outcrops. Two shafts have been sunk in search of magnetic iron-ore near the road, about three-quarters of a mile from Shimersville. When visited they had caved in and there was nothing to be seen.

About one-eighth of a mile beyond, at Jordan's Mine, No. 99, shafts had been sunk to the south of, and about five hundred feet from the road; these had also fallen shut, but on the dump of one of them—which was about 10 feet deep—there was a small quantity of magnetic iron-ore in large lumps, some of which seemed very rich in iron, but there did not appear to be much of it. Close to this shaft were two others, about 20 feet deep, both of which had caved in, but from the ore on their dumps it seems that this forms thin strings in the gneiss. The latter is very micaceous.

Nearly a mile north of Shimersville zinc-ore is stated to occur on Nathan Kunkel's farm; it was searched for closely, but no evidence of it could be found on the surface in the way of pieces or bowlders of ore.

Half a mile E. N. E. of Kunkel's there is a low gneiss hill, the rock of which is very feldspathic. The Emaus–Shimersville road passes in a ravine between this hill and another one due east of it. In this latter the gneiss where observed is also very feldspathic, and the rock in both hills is full of various cleavages.

About 600 feet east of Shelly's brown hematite mine there occurs in the cut of the Perkiomen railroad (now being graded) a black micaceous gneiss, containing a great deal of hornblende, and the dip obtained at this point confirms that of the most eastern of the two hills just mentioned.

Gneiss occurs a short distance to the east in the railroad cut close to Daney's brown hematite mine; the rock is composed of white potash mica and a much decomposed white feldspar. This gave the gneiss a very handsome appearance, but the ready weathering of the feldspar renders the rock unfit for building purposes.

Two miles northwest of Emaus the Little Lehigh Creek cuts its course in a ravine, about 100 feet deep, close to Jerusalem Church. At the southern portion of the exposure Laurentian rocks occur in contact with the Siluro-Cambrian limestones, but to the north where the stream repasses into limestone Potsdam sandstone is visible overlying the Laurentian rocks and underlying the limestone.

The Laurentian rocks consist of gneiss or mica schist; the dip where observed is 5°, S.20°E, but close to this occurs a fold in the gneiss which dips on one side 26°, S.33°E. and on the other 20°, N.33° W. The presence also of numerous cleavage planes, which dip 16° to 20°, N. 45° E. tends to obliterate the true bedding and renders it impossible to obtain the true dips at other points of this confined exposure.

Gneiss is next met with in the hill south of the Lehigh at Allentown, where the river makes a bend from a southerly to an easterly course. As but a small portion of this hill is shown in the map accompanying this report, it has been thought best to postpone any notice of it until the report of Northampton county is issued.

A hill of gneiss occurs east of Allentown and north of the Lehigh river just opposite to the one just mentioned, and it expires beneath the limestone some distance west of Bethlehem. The gneiss outcrops are best exposed on the southern side of the hill, as the Laurentian rocks on the northern side disappear beneath the Potsdam sandstone and Magnesian limestone with few exposures. One of the best points to study the gneiss is in the now abandoned railroad cut. Wherever the gneiss could be seen it was hornblendic in character, with the hornblende in places changed to a yellow epidote, and occasionally containing a little calcite. Owing to the ready crumbling of the rock, it it is in several places decomposed to a sand. In this condition it is used for building purposes, notably in the sand-pits on the road south of the Lehigh Iron Works at East Penn Junction; it is however but little suited to this purpose, as it contains but little, if any, quartz, and is composed almost exclusively of decomposed feldspar and hornblende. This tendency to turn into sand prevents it from showing many outcrops, and gives rise to numerous bowlders which conceal the rock in place. Its general position and structure can be best seen from the map, it being premised, however, that some of the dips are uncertain and may be only cleavage, as the rock is a very massive one and gives few indications of bedding.

The presence of Laurentian rocks with Potsdam sandstone at the exposure north of Emaus, on the Lehigh east of Allentown and north of the river, at Quaker Hill north of Bethlehem, and at Chestnut Hill north of Easton, tends to prove that the total thickness of the Siluro-Cambrian limestones is small and that the great thickness of those rocks observed in Central Pennsylvania and further south in the Great Valley, has been replaced by a maximum thickness of probably not more than 2,000 or 2,500 feet.

CHAPTER XV.

The Potsdam Sandstone (No. 1) in Lehigh County.

On page 7 of the report for 1874, it is stated that Potsdam sandstone is nowhere seen on the northern flank of the main range of Archæan rocks within the district surveyed. This was an error, as it was well known at the time, that a small patch of Potsdam sandstone* occurs about half a mile south of Millerstown as a low ledge dipping N. 7° to

* Mentioned in Final Report First Geological Survey of Pa., Vol. I, p. 196.

9° W., and having a dip of 9° to 16°. In addition to this, another small patch occurs about half a mile southwest of this point, high up on the mountain flank, which dips S. 85°W.30°. As remarked on the same page of the 1874 report, the whole summit of Lock Ridge is covered on its northern flank by the Potsdam sandstone, containing a great abundance of *Scolithus linearis*. From the locality south of Millerstown, the sandstone seems to be altogether wanting, until a point due east of the Emaus furnace and of mines Nos. 105 and 106 is reached, where it occurs in a roll, forming a terrace just above the limestone, and in consequence of the fold, has an apparent dip of 21° to 32°, S. 42° E.; from here on it is continuous to a point a little beyond mine No. 193, where it disappears, being buried beneath clay and limestone. In this entire distance it has a tolerably constant northwest dip, varying in amount from 43° to 58°, and conforming in strike to the mountain flank.

Potsdam sandstone is mentioned on p. 6 as occurring on the north side of the gneiss outcrop near Jerusalem Church, on the Little Lehigh creek. Its predominant dip is northwest. The character of the rock is totally different from that met with elsewhere, being softer, more shaly, very thinly bedded, containing apparently more damourite than at other localities, and in places much decomposed. The outcrops are few, but sufficient to show it as occurring on the northern flank of the gneiss, while it seems to be totally wanting on the south. It is closely overlaid by the limestone, which is conformable with it. In this two shafts have been sunk in search of brown hematite ore. One of them had fallen in; the other gave the following section, commencing at the surface:

Gravel, clay, and ore, about,	8′
Damourite slate,	8″
Brown clay,	10″
Decomposed rock, about,	12″
Loose Potsdam sandstone,	12″
Solid Potsdam sandstone in the bottom.	

The ore found was insufficient in quantity to pay for mining.

It may be remarked here that the Potsdam sandstone at this point as well as along the main range of the South Mountain occasionally contains a thin film of martite or red hematite; which is practically of no importance.

The Potsdam sandstone again re-appears in the quarry on the mountain side just above the furnaces of the Lehigh Iron Co. at East Penn Junction, where it has been quarried to a depth of 21 feet, which must be very nearly its total thickness, as syenitic rocks occur within 10 feet of it, the contact being covered up. Here also the rock has a general northwest dip of 26° to 37°. A little beyond to the east it has been cut away for a short distance by the Lehigh river, but soon re-appears again. The finest exposure of it thus far observed is at Henry Seller's quarry about 1¼ miles east of East Penn Junction just south of and above the Lehigh Valley railroad. Here the lowest beds of the sandstone are distinctly exposed and differ much in character from the upper ones. The latter are a hard, compact quartzite, while the former are a distinct puddingstone, composed of pebbles the size of a man's head to the size of a hen's egg or smaller. Often, too, these layers contain fragments of red feldspar (orthoclase) which are perfectly fresh and of a dark-red color, imparting a reddish appearance to the entire rock, a portion of the color being due, however, to the peroxidation of the ferrous oxide originally present in the rock. Well preserved specimens of *Scolithus* are also found in Henry Seller's quarry near the Lehigh and east of East Penn Junction.

At all the other points mentioned the rock has the characteristic appearance mentioned in the report for 1874, although occasionally, as at the outcrop of 58° nearly due south of mine No. 107, it is conglomeratic in character, while at this mine a few specimens of *Scolithus* were observed in the quartzite.

A little west of the quarry just mentioned and close to the Lehigh Valley railroad track, the junction of the Potsdam sandstone and Laurentian rocks can be well seen. The dips of the two rocks seem to be conformable, but this may be wrong, as the exposure is small and the gneiss apparently has a slight roll. The gneissic rock is here distinctly bedded.

A layer of rock, directly beneath the Potsdam, and only 2 inches thick, was analyzed by Mr. F. A. Genth, jr., with the following result:

Silica,	52.09
Ferric oxide,	11.61
Alumina,	19.80
Manganous oxide,	0.07
Lime,	0.33
Magnesia,	3.15
Ferrous oxide,	2.64
Potash, (with a trace of soda,)	7.89
Loss on ignition,	3.11
	100.69

Thus showing the rock to be essentially damourite, containing a little magnetic oxide of iron.

Directly under this is a gneissoid rock containing mica, and a partially altered hornblende, under which lies a hornblendic rock decomposed to a serpentine-like mineral.

It is possible that these gneissic rocks which seem to lie conformably with the sandstone, and which are true gneisses, are in reality Lower Potsdam, and a further study of these points, in connection with the South Mountain rocks is necessary in order to decide this question.

Crossing the Lehigh river Potsdam sandstone of the same character as that just described occurs on the west and north flanks of the gneiss hill east of Allentown, having a varying direction of dip conforming to the outlines of the hill. The discrepancy in the dips, as shown on the map, is more apparent than real, being due to the sandstone folding around the flank of the hill, and to local flexures of the rock.

CHAPTER XVI.

The Magnesian (Siluro Cambrian) Limestone Formation (No. II) in Lehigh County.

When the report for 1874 was written, so little of the limestone formation of Lehigh county had been examined that it was impossible at that time to do more than call attention to it in a very general way, and a general discussion of it was then impracticable. For the sake of clearness, I will repeat from that report, that under the name of *Magnesian limestone*, or as designated by the Pennsylvania Geological Survey, Formation *No. II*, is comprised the *Calciferous sandrock*, the *Chazy*, *Birdseye* and *Black River* limestones of the New York geologists*. Lithologically it seems to be impossible to make any distinction between the limestones which must belong to different geological horizons; for limestones from the top of the series, close to the Trenton limestone, look quite as much like those from just above the Potsdam sandstone (No. I) as do specimens taken from two beds in the same quarry not 10 feet vertically apart. No traces, either lithological or palæontological, have been found by which the Calciferous sandrock, (said by Rogers to occur near Easton,) can be recognized or differentiated from the other formations.

There are however certain marks which would seem to characterize the lower limestones to a certain extent, but they are not infallible. The most characteristic distinction is the presence of large quantities of chert in the lower limestones, which form nodular and lenticular masses of greater or less size in these rocks and which are not apparent in the upper beds. The chert frequently contains cav-

*The Birds-eye and Black River limestones should perhaps be grouped with the Trenton, as probably overlying the break represented in the west by the St. Peters sandstone.

ities, often rhombohedral in form, and stated by Prof. Safford* to be due to crystals of dolomite since dissolved out. In many places also the limestone is oölitic, but attempts made to use limestones of this character as indications of a geological horizon have proved a failure owing to the frequency and irregularity of their occurrence, it being found that a bed of limestone which is oölitic may entirely lose this character in the course of a few feet along its line of strike. Still this oölitic texture is often a very striking feature in a limestone exposure; the rounded grains are generally a little larger than a sturgeon's roe and vary in quantity, so that while at times a bed is so thickly studded that barely enough space is left for the paste which holds them together, in other places the globules occur scattered sporadically through the mass of otherwise homogeneous crystalline limestone. The oölitic texture of limestone has been commonly explained by the occurrence of some minute nucleus—usually a grain of sand—around which concentric layers of carbonate of lime have been deposited, but this explanation is not always very satisfactory.

It frequently happens also that the limestone occurs as a breccia-bed between two layers of a homogeneous character. The fact of this occurrence has been used by some persons as an argument in favor of the idea that these brecciated beds having been formed out of the *débris* of the older formations. This explanation which seems plausible at first sight, must on a closer examination of the brecciated limestones occurring in Lehigh and Northampton counties be rejected. Any one observing the brecciated beds of the Magnesian limestone of these counties will at once perceive that these layers occur almost without exception—none have been noticed in the course of the Survey—between strata which are apparently homogeneous, and also that the angular fragments composing the rock as well as the paste cementing them are *exclusively* carbonate of lime or else dolomite. Besides which the brecciated beds occur in all horizons from the base of the limestone formation to its top. All of these facts tend to prove that beds which were origi-

* See Safford's Geology of Tennessee, P. 215.

nally as compact as those immediately over and underlying them have been *fractured in place subsequent to their first formation*, and the fractured fragments afterwards cemented together by the percolation of waters carrying calcite or dolomite in solution; these substances being obtained, very probably, from a partial solution of the fractured fragments. The fracturing of the beds was due to the flexures and foldings which they have undergone since their deposition, and to the fact that being less pliable and elastic than those by which they were enclosed, they were compelled to break in order to yield to the enormous pressure to which they were subjected.

This explanation does away at once with the otherwise necessary hypothesis of the preëxistence of older rocks from which these breccias were formed.

As typical localities, may be cited Mary Kohler's quarry, about three-quarters of a mile west of Whitehall Station on the Lehigh Valley railroad; and on the Jordan, just north of Helfrich's Spring.

The character of the limestone is found to vary much as to texture, color, hardness, structure, and composition. Some beds are compact, others crystalline. Blue and dove are the most common colors, but at times the limestone is seen to be almost white, at others nearly black; while the blue varieties are of all shades. Some beds of the rock are very hard, this being most common in the dark-blue ones, while others are soft, weather to a sandy rock on exposure in quarries and outcrops, and can readily be disintegrated to the depth of $\frac{1}{8}$ to $\frac{1}{4}$ inch when rubbed between the fingers. The harder rocks have resisted, to a much greater extent than the others, the disintegrating and dissolving action of the weather and subterranean streams, consequently they often form ridges more or less prominent, and have directed the course of the surface rivers and creeks.

This is very well exemplified in the steep monoclinal bluff of hard limestone, which bounds the Jordan about one quarter of a mile N.W. of the Thomas Iron Company's Mine, No. 149.

Being hard, these rocks are well adapted for curbing and crossing stones, and extensive quarries for this purpose have been opened close to and north of the Jordan, three quarters of a mile east of Orefield. The excellent stone here quarried needs only to be better known to be widely used for the purposes mentioned.

The softer beds, on the contrary, have often yielded to the solving action of water, by which means many of the sinking streams, so common in the limestone, are formed, which, disappearing, continue their course in a subterranean channel, and either join larger rivers through underground mouths, or, meeting with some resistance, re-appear at some far distant point. The result of the dissolution of these beds is often to let down such superincumbent ones as have a stability insufficient to resist the loss of support, thus producing the frequent sink-holes and depressions in the limestone country, so common everywhere, as well as numerous foldings and crimpings of the beds. It follows, then, as a natural sequence that dips are often obtained apparently contradictory in direction, but which are only local, and do not in any way change the general trend and inclination of the strata.

With respect to structure, the farmers distinguish two kinds of limestone, called by them rock and slaty limestone. The former comprises those which occur in massive beds; the latter, those which are slaty or shaly. The rock limestone is considered by the farmers to make a better manure than the slaty variety; and they are probably correct, as the slaty structure is in part due to the presence of greater quantities of silicate of alumina, which is valueless as a manure. It sometimes happens that the limestone, composed of pure calcite or dolomite with, a few per cent. of silica as impurity, occurs very thinly bedded and much resembles slate in appearance, often giving out a ringing sound when struck. At other localities the limestone is very shaly and easily decomposed and rather clayey in appearance due to the presence of large quantities of alumina.

The limestone sometimes possesses a very peculiar appearance, more closely resembling clam shells planted as closely together as possible with their convex sides uppermost. Although this structure has been carefully examined, no nucleus could be found accounting for such a formation.

As regards composition the limestone may be considered as composed of varying proportions of carbonates of lime and magnesia together with greater or less quantities of silica and alumina. The proportions of these different substances vary considerably. Prof. W. T. Roepper of Bethlehem and Mr. William Firmstone, Superintendent of the Glendon Iron Co., both inform me, that as the result of numerous analyses, they have become convinced that the carbonate of magnesia is, on the whole, greatest in the beds nearest the bottom of the series and closest to the South Mountain and that it decreases as they recede from these and approach the slates (No. III). It is certain that the beds which belong either to the top of the Magnesian Limestone (No. II) or to the Trenton Limestone are so much richer in alumina that they are well adapted to the manufacture of cement.

For the sake of comparison analyses of the ordinary Magnesian Limestone are subjoined; for additional ones the reader is referred to Report of Progress, Lehigh District, for 1874, pp. 10, 11 and 12.

	I.	II.	III.	IV.	V.	VI.
Insoluble residue, ...	8.980	10.750	8.400	11.070	10.980	7.850
Ferrous Carbonate, . . .	1.035	1.450	.538	1.398	1.305	1.188
Bisulphide of iron, . . .	.030	.611	.268	.105	.320	.238
Alumina, ...	.070	.140	.065	.860	.300	
Carbonate of lime, . . .	49.316	51.558	86.036	70.750	56.220	83.632
Carbonate of magnesia,	40.463	35.216	4.594	15.256	31.201	5.462
Phosphorus, ...	.006	.018	.016	.019	.005	.026
Carbonaceous matter, . .	.250	.210	.420	.120	.120	.835
Water, ...	.089	. . . . . .	. . . . . .	. . . . . .	. . . . .	. . . . . .
	100.239	99.953	100.337	99.578	100.451	99.231

I. Brecciated limestone from Mary Kohler's quarry, $\frac{3}{4}$ mile west of Whitehall station, Lehigh Valley railroad.

II. Hard limestone from Ephraim Wenner's quarry, leased by the Crane Iron Co., at the Jordan Bridge of the Catasauqua and Fogelsville railroad.

III. Soft limestone, same locality as II.

IV. Limestone from Edward Guth's quarry, near Guth's station, C. and F. R. R.

V. Thomas Iron Co's quarry, at Guth's station.

All of these specimens were analyzed by Mr. A. S. McCreath.

VI. Ironton railroad Co's quarry, one mile E. S. E. of Ironton; analyzed by Mr. D. McCreath. Thin films of fluor spar were occasionally seen in this quarry.

The following analyses were kindly furnished me by Joseph Hunt, Esq., Asst. Supt. of the Crane Iron Co. The analyses were made in February, 1876, by Mr. J. B. Britton:

	A	B	C	D	E	F	G	H	I
Silica, ...	7.080	4.120	4.670	7.340	6.090	27.730	14.590	33.180	8.230
Ferric oxide and alumina, ...	1.540	1.730	2.050	3.710	3.230	2.760	4.530	5.760	1.210
Carbonate of lime, . .	85.200	76.790	78.230	61.530	70.100	65.910	71.960	58.300	89.460
Carbonate of magnesia	5.890	17.030	14.540	26.840	20.080	3.140	8.340	2.290	.630
Phosphorus, ...	.022	.016	.005	.008	.013	.019	.025	.027	.008
Undetermined matter,	.268	.314	.505	.572	.487	.441	.555	.443	.462
	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

All these samples were taken from different beds in Troxell's quarry, worked by the Crane Iron Co. at the Jordan Bridge of the Catasauqua and Fogelsville railroad. Of these A, the lowest bed, has a dip of about 50° and is farthest away from the railroad, while I, the topmost one, is nearest the railroad and has a steeper, almost vertical dip. Beds F to I, inclusive, are not worked.

These beds were still farther analyzed by Mr. James Gayley, chemist to the Crane Iron Co. For this purpose A was sub-divided into 5 layers, B into 6, C into 2, D into 4, and E. into 1:

	A					B					
	1	2	3	4	5	1	2	3	4	5	6
Silica,	9.120	3.840	4.230	6.190	7.260	16.250	8.160	9.980	13.550	10.160	9.940
Carbonate of lime,	77.120	80.350	81.920	81.590	79.450	76.020	86.260	83.870	72.070	76.920	73.950
Carbonate of magnesia,	.890	1.060	1.640	7.820	3.840	1.310	.400	4.080	3.280	2.430	3.000
Ferric oxide and alumina,	12.230	13.930	11.640	4.310	9.070	6.070	4.500	2.000	10.590	9.840	12.820
Phosphorus,	.023	.065	.040	.040	.028	.005	.014	.012	.021	.012	.002
	99.383	99.245	99.470	99.450	99.648	99.655	99.334	99.892	99.511	99.362	99.712

	C		D				E
	1	2	1	2	3	4	1
Silica,	9.360	17.060	15.970	28.380	10.340	29.950	8.160
Carbonate of lime,	66.450	54.110	75.760	60.870	84.250	50.070	87.430
Carbonate of magnesia,	15.260	14.110	4.260	1.760	2.340	1.280	.460
Ferric oxide and alumina,	8.300	14.100	3.360	8.490	2.520	18.860	3.520
Phosphorus,	.009	.017	.036	.027	.046	.009	.017
	99.379	99.397	99.386	99.527	99.496	100.169	99.587

The Crane Iron Co. also had the different limestone-beds in Frederick Eberhard's quarry, in the Valley of the Jordan, near the Catasauqua and Fogelsville railroad, analyzed by Mr. James Gayley, their chemist, with the following result:

	A	B	C	D	E	F	G	H
Silica,	15.860	4.210	5.980	2.860	7.840	5.590	5.780	11.580
Carbonate of lime,	57.410	59.250	58.870	59.590	57.160	59.690	64.150	54.670
Carbonate of magnesia,	9.380	21.640	25.490	31.030	25.990	32.690	23.170	27.100
Ferric oxide and alumina,	16.850	14.320	9.160	5.910	9.040	1.660	6.530	6.410
Phosphorus,	.017	trace.	.012	.002	.008	.011	.005	.013
	99.517	99.420	99.492	99.392	99.533	99.641	99.635	99.773

	I	J	K	L	M	N	1	2
Silica,	4.360	3.540	3.750	2.990	3.050	2.200	6.390	5.530
Carbonate of lime,	59.720	63.770	60.860	68.100	54.390	55.390	53.540	51.650
Carbonate of magnesia,	21.090	23.430	26.540	21.070	36.280	35.050	38.350	41.000
Ferric oxide and alumina,	14.420	8.530	8.220	7.450	6.570	6.680	1.210	2.320
Phosphorus,	.007	.015	.017	.026	.019	.007	.030	.009
	99.597	99.285	99.387	99.636	100.289	99.327	99.520	100.509

The beds in this quarry are lower than those at Troxell's; A is the bottom of the quarry, N the top bed; 1 and 2 are loose lots picked up from the loose stones in the quarry in order to ascertain the average.

The Geological Survey is also indebted to Joseph Hunt, Esquire, for the following additional analyses:

	WENNER'S QUARRY.					HUNT AND EBERHARD'S QUARRY.					
	1.	2.	3.	4.	5.	1.	2.	3.	4.	5.	6.
Silica,	17.500	13.900	6.100	12.812	3.620	14.678	10.120	3.200	15.600	10.168	6.180
Carbonate of lime,	47.830	78.450	62.760	49.434	88.080	48.398	51.552	80.855	49.092	49.982	54.966
Carbonate of magnesia,	34.590	7.190	31.180	35.510	6.350	34.776	37.258	....	33.912	....	....
Forric oxide and alumina,	....	....	....	2.700	2.100	1.540	....	....	....	..	....
Phosphorus,	.019	.011	.009	.016	.004	.017	.016	.007	.020	.017	.016

Wenner's quarry lies between the Jordan railroad-bridge and Guth's station. Hunt and Eberhard's quarry is near Guth's station. The analyses were made by the chemist of the Pennsylvania Steel Company.

Fluor spar has thus far been only found in the quarry of the Ironton railroad company, forming thin films in the limestone.

An element changing the composition of the limestone is hydromica or damourite, which in addition to forming large bodies of slate, mentioned elsewhere, also occurs intercalated as thin beds half an inch or more in thickness, between the beds of limestone. The hydromica is often decomposed to clay, and occurs very frequently, so that often a hundred or more of these layers may be seen in the thickness of a few feet. In all such cases the hydromica is conformable to the stratification and bedding of the limestone.

Sometimes, however, the hydromica occurs in leaves thinner than a sheet of paper, completely intermingled with the limestone, and so thoroughly incorporated as to make a separation of the two impossible. In such cases while the hydromica seems to have been formed cotemporaneously with the limestone, it apparently crosses the plane of bedding, giving rise to a suspicion that it may be a subsequent deposition. An example of this is to be seen, amongst others, in the limestone in the bottom of the Ironton railroad Co.'s mine. How this hydromica should have permeated the limestone subsequent to the formation of the latter is a matter difficult to explain, as the rock is itself fresh and hard, showing no evidence of water percolation. On the other hand the manner in which the damourite crosses the bedding of the limestone renders a cotemporaneous formation with the latter difficult of explanation.

While fossils are practically absent in the limestone of Lehigh county, a few have been found, insufficient in quantity to trace the different formations, but still enough to prove the age of the limestone rocks as a whole.

Mr. Clark discovered the first in June, on Nero Peter's farm, in a quarry two miles east of Ballietsville, where he found the section of a *Maclurea*, and some smaller ones, whose cross section showed that they belong to the genus *Euomphalus*. While it was impossible to determine the species, the characteristics of the fossils indicate that they belong to the Chazy formation.

Later in the season fossil casts were found in the limestone forming the bed of Jordan Creek, just west of Helfrich's Spring, close to the point where a portion of the stream passes into its underground passage to reappear on the east side of the cave. These were recently determined by Prof. Torell, Director of the Geological Survey of Sweden, to belong to his genus *Monocraterion*, which has thus far been only found in Sweden, in rocks which are the equivalent of the Harlech or Longmynd beds, or in other words of Cambrian age. This species has been named *M. Lesleyi*,* in honor of the State Geologist of Pennsylvania.

A good half mile northwest of this locality about a dozen specimens of a *lingula* were found in John Schadt's quarry, the species being most unfortunately undeterminable.

A portion of an *orthoceratite* was also found in a bowlder about 1,000 feet north of the tavern at Scherersville, but in too imperfect a condition to permit of its identification.

It will thus be seen that while the fossils were too few in number to permit of the separation of the Magnesian limestone into different members, the palæontological evidence is sufficient to prove (as the great majority of the geologists have always supposed,) the limestone to be of Siluro-Cambrian age.

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*See Appendix A p. 79 of this Report.

CHAPTER XVII.

The Damourite Slates.

In the report for 1874 reference was made on page 12 and those following to the occurrence of damourite slate and the clay resulting from its decomposition. The progress of the survey during the past season has developed the following facts with respect to the occurrence of these slates in Lehigh County.

There are two great occurrences of damourite slate; the one directly over the Potsdam sandstone, (No. I), occurring always in connection with the latter, and often seen when the sandstone is no longer apparent; the second is found at or close to the contact of either Magnesian or Trenton limestone with the slates (No. III). In both cases it is found to vary in thickness, being sometimes but a few feet while at others 100 feet or more. At times the slate is found fresh and unchanged, but more commonly decomposed to a clay whose normal color is white, but often colored more or less brown from the presence of oxide of iron. The presence of these slates and clays is of great economical importance, as they carry the iron ore on which the furnaces of the Lehigh Valley are in great part dependent for a supply, to mix with the magnetic ores from New Jersey and our own South Mountain. The explorations made show that these two great deposits are of different ages, one being immediately antecedent and the other directly subsequent to the formation of the Siluro-Cambrian Limestones. The doubt as to the geological position of the slate mentioned on page 14 of last year's report has been satisfactorily solved by the discovery that damourite is constantly found intercalated between limestones as mentioned on p. 21 of this report.

It is due however to call attention to the clays resulting from the decomposition of these slates, since they may in the future become of economical importance. Their frequent pure white color would recommend them for the manufacture of pottery, &c., provided their chemical composition would permit of their use, and the fact that the clays vary in composition has been sufficiently shown by the analyses given in the report for 1874. These clays will not do for fire-brick, as they are not sufficiently refractory.

Other varieties of these clays, while not adapted from their composition for making porcelain, will, no doubt, be valuable for the manufacture of drain-pipes, tiles, earthern ware, &c.

It is impossible for the Survey to make analyses of these damourite clays in each bank, but the attention of mine owners and pottery manufacturers cannot be too urgently drawn to the subject; for if the composition of any of them be adapted to the manufacture of porcelain, &c., they can be very easily and economically mined, and conveyed to the potteries.

The chief points to search for the damourite slates and their resulting clays are at the junction of the Potsdam sandstone with the limestone, or in other words, close to northwest flank of the South Mountain Range.

Of equal importance are the localities at the junction of the Trenton limestone with the slates of No. III.

In addition to these, there are numerous points where the damourite slates and clays are found, generally associated with iron ores. They need not be looked for where the limestone crops out to the surface, but occur where the latter is absent.

Chapter XVIII.

The Iron Ores.

The iron mines examined during the past season all occur in the Siluro-Cambrian Limestones, generally associated with damourite slate and its products of decomposition. The mines are given in this chapter, for the most part, according to their geological position, in part, however, in the order in which they were visited.

Mines at the Foot of the South Mountain.

Charles Reder's Mine, No. 192. It consists of a small pit, about 8 feet deep, in which there is a good deal of rich ore associated with white clay (decomposed damourite slate.) The excavation was not being worked when visited, but it presents a favorable appearance, and is certainly worth further explorations.

Desh's Mine, No. 100. A small opening; too little worked to judge as to the value of the locality.

Shelly's Mine, No. 101; leased by — Shankweiler. This pit is 10 feet deep; there are about 5 feet of clay on top, while the ore occurs in strings and veins in damourite slate. The mine was not being worked when visited, and has been but little opened. From what could be seen, the mine looks promising.

Elias Daney's Mine, No. 102, is leased by the Coleraine Iron Co. The ore occurs associated with white clay, but the pit had not been worked for three years when visited, and consequently the sides were so washed, and there was so much water in the bottom, that it was impossible to see anything. The ore from this mine, analyzed by Mr. D. McCreath, gave the following result:

Iron,	45.200
Manganese,	2.132
Sulphur,	0.026
Phosphorus,	0.657
Insoluble residue,	12.780

The foreman at the mine had a single specimen of ilmenite (titanifereous iron ore) which he said had been found in the top clay when working the mine. This was sent to Mr. A. S. McCreath, who analyzed it and reported:

Silica,	8.37
Lime,	0.52
Magnesia,	3.87
Alumina,	2.79
Titanic acid,	32.18
Phosphorus,	Trace.
Sulphur,	None.
Manganese,	0.35
Iron,	38.16

This latter partly as ferrous, partly as ferric oxide. This specimen is evidently extraneous, as but a single one has been found.

Daniel Schwartz's Mine, No. 103. There are about 15 feet of surface soil above the clay and ore. In the west end there is a mass of flint or quartzite colored black by iron and intermingled with ore, which is all broken up. Over which lies bedded gray flint, and beneath the ore white clay. In the middle and east end the show of ore is better. The pit is worked at these points and contains ore as far down as it is worked. Where seen clay occurs intermingled with and apparently underlies the ore. In the east end the ore apparently dips southeast. The middle of the mine is leaner than the east end. The mine has been worked many years and a large amount of ore taken out of it, but present appearances would indicate that it is not far from being exhausted. The ore from this mine was analyzed by Mr. D. McCreath, who found:

Iron,	34.000
Manganese,	0.115
Sulphur,	0.020
Phosphorus,	0.676
Insoluble residue,	37.695

Emaus Iron Co.'s Mine, No. 104, is 10 feet deep and not worked. The ore, of which there is very little in sight, occurs as strings in drift deposits of Potsdam sandstone. This mine did not look promising.

Charles Bader's Mine, Nos. 105, 106, leased by the Allentown Iron Co. These mines are not worked and there is only white clay in sight.

Trexler and Kline's Mine, No. 107. This pit is now abandoned and apparently exhausted, having been worked to the underlying Potsdam sandstone. White clay has immediately overlaid the sandstone, since remains of it can be seen in the crevices on the upper surface of the latter. It may be possible, although not very probable, that more ore will be found on descending deeper. At this pit, also, white clay underlies the ore. Samples of the latter were collected and sent to Mr. David McCreath for analysis, who found:

Iron,	36.500
Manganese,	1.325
Sulphur,	0.107
Phosphorus,	0.547
Insoluble residue,	31.215

Henry Kline's Mine, Nos. 108, 109. These were only small pits, abandoned and in which nothing could be seen.

Unknown, No. 196. This mine is abandoned and has not been worked for a considerable time, so that little could be seen. The ore does not appear to have occurred in damourite slate, but rather associated with gravel. This would indicate that the ore was not in place, but had been washed into a depression of the surface. A fact which is confirmed by the distance of this mine from the base of the South Mountain.

Jessie Kline's Mine, No. 110. In this pit, now abandoned, the ore and clay can be seen conformable with the underlying Potsdam sandstone, the latter containing *Scolithus*. There are places where it looks almost as if the sandstone was running into limonite.

Iron,	47.200
Manganese,	2.709
Sulphur,	0.039
Phosphorus,	0.075
Insoluble residue,	14.980

Henry Kline's Mine, No. 111, leased by Jobst and ——. There are two openings here. At the smaller one, which lies just below the gneiss of the South Mountain there was a small nest of black oxide of manganese, 8 inches thick, which has since been worked out. The ore lay directly against the Potsdam sandstone. There is white clay in this pit, which is very gritty and is in part decomposed Potsdam sandstone. The gneiss, under the sandstone, is granitic, very quartzose and contains a little matite or red hematite. In the larger pit the mine had been only re-worked a single day when it was visited. There was not much ore in sight, the little that was seen, lying in white and yellow clay. At the east end there is Potsdam sandstone in the bottom, apparently in place, with an undeterminable dip. The ore is here very close to the sandstone and must be sought for in depth, if present at all. Samples of it were analyzed by Mr. David McCreath with the following result:

Iron,	30.100
Manganese,	0.489
Sulphur,	0.062
Phosphorus,	0.299
Insoluble residue,	43.035

Henry Kline's Mine, No. 112. At this pit, which is abandoned, nothing can be seen. A shaft has been sunk through the clay 30 or 40 feet, but from the character of the material on the dump little or no ore has been found.

Martin Kemmerer's Mine, Nos. 113, 114, 115. The first pit is now abandoned and full of water. Shafts have been sunk around it and again filled up. On the dumps can be seen a little pipe ore and white clay. Nos. 114, 115, are both abandoned and grass grown. The ore has either been exhausted, or deeper, workable deposits of ore have not been touched by the shafts.

Keck and Ritter's Mine, Nos. 116, 117, leased by Emaus Iron Co. No. 116 is abandoned and no ore can be seen on the banks. In No. 117 the ore is sporadically distributed in yellow clay. Not far from the bottom there is a bed of white clay about 6 inches thick. It may be that the ore in the bottom is in place, but it does not present that appearance. There is a great deal of flint associated with the ore. The mine does not present a very promising appearance. The ore was analyzed by Mr. A. S. McCreath who found:

Iron,	39.250
Manganese,	5.512
Sulphur,	0.029
Phosphorus,	0.149
Insoluble residue,	21.880

G. Kline's Mine, Nos. 118, 119, 120. No. 118 is abandoned; there is a great deal of lump ore on the dump. The sides are caved in, but at one point the Potsdam sandstone was seen decomposed to a beautiful variegated sand. The ore was taken from clay and damourite slate directly overlying the sandstone. Of the two pits at No. 119, the southerly one shows nothing. A drift has been driven in close to it, in which nothing can be distinguished, and which does not penetrate very far. On the other pit and at No. 120 nothing can be seen, but a number of shafts have been sunk and there is quite a good deal of lump ore on the dumps, apparently enough to pay for working when the present depressed period in the iron industry improves.

Stein's Mine, Nos. 121, 122. No. 121 is not being worked and the sides are so much washed that nothing can be seen. In places sand occurs which looks like decomposed gneiss. No. 122 is abandoned and grass-grown.

Hottenstein's Mine, Nos. 123, 124. Potsdam sandstone underlies and overhangs pit No. 123 and in this there are bowlders of sandstone. At No. 124, which is also not worked, there is sandstone in the west end, probably bowlders. But nothing could be seen relating to the nature and position of the ore.

Milton Apple's Mine, No. 125. At this pit there are bowlders of Potsdam sandstone and *débris* from which ore has been taken. A shaft, 20 feet deep, shows the same in the bottom. This pit was not being worked when visited.

Kipping and Holsbach's Mine, No. 126. This pit was not being worked. Only yellow clay and drift could be seen, there being no ore in sight. At one point a drift has been run in, which is now fallen shut.

Conrad Seam's Mine, Nos. 127, 128, 129, 130. At No. 128 can be seen first surface drift, then white clay, next ore and finally white clay again to the top of the water in the bottom of the pit; the appearance of the ore is good. No. 127 was being worked for the Allentown Iron Co.; the ore occurs in white and yellow clay. No. 129, which is not being worked, shows ore on the south side in white clay. No. 130 was not being worked. A sample was taken from the opening No. 127, it being all wash ore, and an analysis of all the constituents it contained made by Mr. D. M'Creath as a type of the ores of Lehigh county. He found:

Ferric oxide,	69.714,	giving iron,	48.800
Manganic oxide,	1.292,	giving manganese,	0.900
Alumina,	2.388		
Lime,	0.300		
Magnesia,	0.317		
Sulphuric acid,	0.035,	giving sulphur,	0.014
Phosphoric acid,	0.448,	giving phosphorus,	0.196
Water,	11.340		
Insoluble residue,	13.915,	giving insoluble residue,	13.915
	99.749		

Whitman's Mine, Nos. 131, 132, 133, leased by Emaus Iron Co. No. 131 is being worked; the ore occurs in white and yellow clay, there being but little ore in sight when the mine was visited. Nos. 132, 133 are numerous small openings not worked and the sides too much washed to see anything.

J. Spinner's Mine, No. 193. Not worked when visited and no ore in sight, the sides being much washed. The pit is a small one.

Mines North of the Little Lehigh Creek.

Leaving the flank of the South Mountain, the next mines are met with north of the Little Lehigh Creek.

Reinhart's Mine, No. 189, leased by the Allentown Iron Company. At the top there are about 5 feet of surface soil, succeeded by brown, drab and white clay with ore, having a depth of about 20 feet. In the centre of the mine the ore looks well in the bottom of the excavation. There is plenty of decomposing damourite slate in the north end of the mine. On the piles of refuse in the excavation there is an abundance of small pieces of slaty limestone, but none could be seen in place. The appearance of this pit is a good one. Adjoining this there is a small pit, 12 feet deep, which contains ore in white clay. This latter is not so extensively opened, nor does it look as well as the former one.

H. and F. Jobst's Mine, No. 190. The ore is all wash ore, and is irregularly distributed in the clay in which it occurs. Samples of it were analyzed by Mr. D. McCreath, who found:

Iron,	46.300
Manganese,	0.475
Sulphur,	0.018
Phosphorus,	0.160
Insoluble residue,	15.290

Wenner's Mine, No. 191, leased by the Crane Iron Co. The pit is 10 to 20 feet deep, but not deep enough to see much as to the condition in which the ore occurs. In the very bottom there is a little white clay. A little of the ore is lump, but the greater part wash ore.

H. Kemry and Carbon Iron Company, No. 140. The east end of the pit belongs to Kemry, the west end to the Carbon Iron Co. Neither party were working the mine when visited. The ore commences 5 feet from the top, forming strings and seams in white clay. In the bottom a thicker bed occurs, almost horizontal. Yellow damourite slate occurs in the pit. The white clay at one point in the west end of the mine, forms a bed 6 feet thick, free from ore. This excavation apparently contains more ore than the other mines of this group, but there is also more yellow clay associated with it than in many of the others. The mine presented a favorable appearance, and will undoubtedly be worked again when the iron business improves.

Henry and Leon Schmoyer's Mines, Nos. 136, 137, 138, 139. No. 136 is grass-grown, but white clay can be seen on one side of the pit. No. 137 is not working, and the sides are much washed; it shows white clay near the surface, with yellow clay containing more or less ore below it. The relative quantity of ore cannot be seen. No. 138 is in precisely the same condition as the preceding one, from which it is separated by a ridge of ground which has not been worked. No. 139, which has been the most extensively mined, is also not working. At the west end the ore is found in yellow clay within 6 feet of the surface. At the most southerly point of the excavation, near the stack, a large body of white clay rises to the surface containing flint and saccharoidal sandstone.* The latter apparently forms a layer about 8 inches thick, out of reach in a vertical wall of the white clay. There is a good breast of ore directly under the stack. This pit looks well, the main difficulty in working it being the heavy stripping in some places.

Jacob Steiner's and Solomon Kehm's Mine, No. 134. The former, which is the most easterly portion of the excavation, is leased by the Lehigh Iron Co.; the latter, which lies westerly, is leased by the Emaus Iron Co. To the east of the main excavation are two smaller ones, the nearest of which is 30 feet deep and grass-grown, the further one is not worked and there is so much water in the bottom that it is inaccessible. The Emaus Iron Co. are working their portion of the pit. In the extreme west end there is a good body of ore and clay, 20 feet thick, and above it white and pink clay. Near this a very small quantity of pyrite, altered to limonite, occurs in the clay, the mineral occurring in small lenticular shaped masses. On the south side there is a great bed of white clay, 6 feet thick, containing no ore, but there is ore underneath it. There are everywhere seams of white clay through the ore. The mine presents a rather favorable appearance, the chief difficulty in working it is the heavy body of clay above the ore which has to be stripped off. The Lehigh Iron Co. are not working their part of the excavation, which on their side is only 20 feet deep. On their side, however, the ore comes within 6 feet of the surface and the white clay within 18 inches. The ore and clay are almost horizontal, but are undulatory, so as to have no very regular dip. The ore from Solomon Kehm's mine was analyzed by Mr. D. McCreath, who found:

Iron,	49.200
Manganese,	0.317
Sulphur,	0.005
Phosphorus,	0.180
Insoluble residue,	14.005

* See p. 34, Report of Progress for 1874.

John Woodring's Mine, No. 135, leased by the Crane Iron Co. This mine was not being worked when visited and the sides were much washed. The ore occurs in yellow clay, which was plastic and looked as if it were decomposed damourite. On the dump there was a little white clay, showing that it occurs in the mine. In the northeast corner of the main opening a little waterworn limestone can be seen.

John Roth's Mine, No. 141, leased by the Allentown Iron Co. The ore occurs in yellow clay, which seems to be decomposed damourite slate. As the mine had but very recently commenced to be worked, after standing idle for a long time, but little could be seen. Samples of the ore taken were analyzed by Mr. A. S. McCreath, who found:

Iron,	53.000
Manganese,	0.216
Sulphur,	0.024
Phosphorus,	0.096
Insoluble residue,	7.290

L. Glick's Mine, No. 142. This mine, which is 20 feet deep, was not working and but little could be seen. The ore apparently occurs in Drift.

Charles Glick's Mine, No. 143, leased by the Allentown Iron Co. At present the pit is only being stripped to a depth of about 8 feet, the old excavation having been filled up as a mud-dam. No ore has yet been found at a greater depth than that above given. It looks as if the ore had merely been washed into a depression in the limestone. The ore was analyzed by Mr. A. S. McCreath with the following result:

Iron,	49.500
Manganese,	0.194
Sulphur,	0.019
Phosphorus,	0.102
Insoluble residue,	13.410

G. Acker's Mine, No. 144. This pit was not being worked when visited and was full of water, so that nothing could be seen.

J. Reinhart's Mine, No. 198, leased by the Allentown Rolling Mill Co. This pit is not 10 feet deep. The ore is for the most part lump and occurs in yellow clay, not resulting from the decomposition of damourite slate; at the east end the ore is apparently de-hydrated. The mine is not worked and the sides are washed which makes it impossible to ascertain the character of the deposit.

Mines along the Northern Edge of the Limestone.

The following mines occur at or not far from the junction of the No. II limestones with the No. III slates:

Barber and Ainey's Mine, No. 157. This mine was not working when visited. It showed both lump and wash ore of good quality. On the west side there is a heavy body of white clay; while on the east side there is a small body of the same, which is replaced below by ore and yellow clay. The sides are much washed and showed pieces of No. III slate, which could not be found in place. As the bottom of the mine was full of water it was inaccessible.

P. Marck's Mine, No. 159, leased by the Lehigh Valley Iron Co. It is full of water and not worked and nothing can be seen. On the dumps of some shafts sunk close to this mine damourite slate could be seen, which is of a pinkish color; as well as a black slaty rock, which is probably Utica shale. White clay was also present.

John Scherer's Mine, No. 158. The mine is not worked at present, whether from exhaustion of the ore or on account of the hard times could not be definitely ascertained. The sides are much washed and there is no ore in sight. At the west end of the mine there is a little white clay near the top. In the middle of the excavation a shaft has been sunk, now filled up, from which a black earth and brown slate has been taken. The latter is probably Utica shale.

Jobst's Mine, No. 155, 156. These pits have not been worked for some years and only gravel can be seen on their sides; there is a little damourite slate on the old dump. To the south and east of No. 156 trial shafts have been sunk in white clay, but with apparently little success as to ore.

J. Kratzer's Mine, No. 154. This excavation is not worked, and is apparently abandoned. But little ore has been taken out, and the sides are so washed it is impossible to see anything. The ore is apparently in Drift or a mere superficial deposit.

Crane Iron Co.'s Mine, No. 151. Abandoned and full of water. On the dump there is damourite slate and white clay.

Wenner's Mine, No. 152. Abandoned and full of water.

Wenner's Mine, No. 153. Abandoned and the sides washed. No damourite slate or white clay could be seen. In the north end there is a little limestone, apparently in place.

D. A. Guth's Mine, No. 150. The mine is not working, the bottom is full of water and sides are so washed that but little could be seen. On the north side there is a body of white clay. In one portion of the mine there is a black pigment and slate, the latter probably belonging to the Utica shale. This apparently passes under the limestone and white clay which are present. The limestone has a southeast dip, while the Utica shale seems to dip to the northwest, both of them variable in amount.

Thomas Iron Co.'s Mine, No. 149. This pit is abandoned and grass-grown. The ore was associated with white clay; the limestone to the southeast must have laid over it.

Thomas Iron Co.'s Mine, No. 148. This mine is in the same condition as the last. From the refuse on the dump it is evident that the ore must have occurred in damourite slate.

Along the line of these last mentioned mines there are traces of old excavations, from which, I was informed by Mr. Samuel Thomas, large quantities of ore were formerly taken to the Thomas Iron Works; now the deposit of brown hematite is said to be exhausted.

Benjamin Weaver's Mine, No. 146, leased by the Coleraine Iron Co. This pit is now 40 feet deep; it is said that most of the ore occurs about 15 feet below the present bottom of the mine. Near the top there is a damourite slate which is underlaid by white clay containing ore. At the north end there is damourite slate in which thin seams or strings of ore occur, but the great bulk of the ore is underneath it. The slate looks very much like the No.

III slate. The ore was analyzed by Mr. D. McCreath, who found:

Iron,	44.200
Manganese,	0.036
Sulphur,	0.043
Phosphorus,	0.760
Insoluble residue,	20.315

James Kline's Mine, No. 145, leased by the Thomas Iron Co. The greatest portion of the ore has been extracted and the mud from the washer is being run into the excavation, ore only being taken out of the northeast corner. At this point the surface soil is about 20 feet deep, then about 10 feet of red clay containing ore, underneath which are yellow and white clay containing streaks of ore. But little lump ore is found. In many places the damourite adheres closely to the ore, so that it cannot be separated by washing. White clay occurs above the ore, as well as under it. In the west end the surface soil is about 14 feet deep, under which occurs a heavy body of white clay, which continues down to the water in the bottom. There is a good deal of disintegrated damourite slate associated with the clay. There is no ore in sight in this portion of the mine, which is now abandoned. A great deal of ore has been taken out of this mine, which only looks well at one small point where it is now being mined. This ore was analyzed by Mr. A. S. McCreath who found:

Iron,	48.900
Manganese,	0.165
Sulphur,	0.038
Phosphorus,	0.164
Insoluble residue,	21.860

Samuel Sieger's Mine, No. 161, leased by the Bethlehem Iron Co. This mine was only being worked at its east end. At this point there is a thin covering of surface soil, under which is a vein about 6 inches thick in white and yellow clay. There is then an interval of 12 feet without any ore, below which is a bed of the latter 2 to 4 feet thick. It was stated at the mine that a shaft in the bottom had been sunk 40 feet all the way in ore. A good deal of lump ore is found near the surface, and the clay in places is of a blood-red color. At one point there is limestone above the clay, the former thoroughly permeated by damourite.

The ore was analyzed by Mr. A. S. McCreath, who found:

Iron,	40.600
Manganese,	0.554
Sulphur,	0.027
Phosphorus,	0.393
Insoluble residue,	25.460

Crane Iron Co.'s Mine, No. 162. This pit is not worked, and is apparently abandoned. A little white clay can be seen in the centre close to the water in the bottom. The south end is said to still contain ore, but the sides are grass-grown, so that it is impossible to see anything.

Near this the Crane Iron Co. have leased the ore-right on Thomas Bleiler's farm. It had not been opened when visited, but the trial-shafts sunk indicated a rich and considerable deposit of ore. As this report was going through the press the following analysis of the ore was received from Mr. James Gayley, chemist of the Crane Iron Co:

Ferric oxide,	59.45,	giving iron,	41.610
Manganic oxide,	1.87,	giving manganese,	1.302
Alumina,	2.29		
Lime,	1.55		
Magnesia,	Trace.		
Phosphoric acid,	2.21,	giving phosphorus,	0.965
Water,	6.40		
Silica,	25.66,	giving silica,	25.660
	99.43		

Daniel Gackenbach's Mine, No. 163. This is not worked, and is apparently abandoned. The sides were so much washed it was impossible to see anything of the nature of the deposit.

Richard Blank's Mine, No. 194. Long since abandoned. It is full of water and grass grown.

Calvin Guth's Mine, No. 169, leased by the Bethlehem Iron Co. This pit, which is about 50 feet deep, looks well in the south end, the ore forming strings, more or less thick, in decomposed damourite slate. Both lump and wash ore is obtained. Two wells have been sunk in search of water for the washer; one, about 65 feet deep, struck limestone, the other, about 170 feet deep, did not strike rock at all. Thus showing that the rock below has been more or less decomposed. The sides are much washed, so that it was impossible to obtain any satisfactory dip. Samples of the ore analyzed by Mr. D. McCreath gave:

Iron,	41.000
Manganese,	0.036
Sulphur,	0.098
Phosphorus,	0.240
Insoluble residue,	26.735

Horace Guth's Mine, No. 168. This mine was not being worked, and the sides were too much washed to see anything.

Daniel Henry's Mine, No. 167. Also not worked, and in the same condition as the latter.

Hiram Boyer's Mine, No. 166, leased by the Lehigh Valley Iron Co. The surface soil varies from 1 to 30 feet in thickness, and contains a sufficient amount of ore to pay for washing it. The ore occurs chiefly in yellow and white clay, the latter coming in places to within a foot of the surface. At one spot there is a bed of ore about a foot thick. The mine when visited did not present a favorable appearance, except at a few points. Nearly all the ore is wash ore, but little lump ore being obtained. This ore was analyzed by Mr. D. McCreath, with the following result:

Iron,	51.300
Manganese,	0.064
Sulphur,	0.106
Phosphorus,	0.192
Insoluble residue,	9.145

A. Balliet's Mine, No. 164. Not worked, and apparently abandoned. The sides so washed, it is impossible to see anything.

Daniel Levan's Mine, No. 165. This mine is in the same condition as No. 164. Some wash-ore from the washer was sent to Mr. A. S. McCreath, who found:

Iron,	40.000
Manganese,	0.115
Sulphur,	0.140
Phosphorus,	0.099
Insoluble residue,	26.860

John Henninger's Mine, No. 170. This mine was standing idle when first visited, but had just commenced to be worked again when last seen. The most southern of the two excavations was full of water, and nothing to be seen. In the northern pit, ore was in sight in the very bottom, but the sides were so washed, that little could be seen, except a little white clay. To the north of the inclined plane, and close to it, at the surface, there is gray clay mixed with leaves, &c., which are decomposed, belonging to the Drift Period. This is about 5 feet thick, and above it are about 4 feet of yellow clay. The ore was analyzed by Mr. D. McCreath, who found:

Iron,	41.200
Manganese,	0.028
Sulphur,	0.191
Phosphorus,	0.056
Insoluble residue,	25.945

Thomas Schadt's Mine, No. 175. In the north opening, which is 20 feet to the water, there is a little drift ore on the top. Then succeeds a heavy body of damourite slate, containing a few lean lumps of ore. At the south end there is a bed of ore about 4 feet thick, which passes under a road between the two openings At the south pit, which is 40 feet deep, there is little or no ore in sight; here the damourite slate is decomposed to a sandy condition. It is said that there is a little ore under the mud dam. There is not a sufficient quantity of ore to justify working it.

J. Baer's Mine, No. 179, leased by — Woodring. Not being worked. The sides are much washed. The ore appears to occur in gravel and surface soil.

Mines at Ironton.

Ironton Railroad Co.'s Mine, No. 181, (Kennel Mine). When first visited, this mine was not being worked, and was full of water; subsequently it was pumped dry, and work had been just resumed when last seen. The greater part of the excavation is occupied by yellow plastic clay, white (hydromica) clay occurring in the centre and northern part of it. A little black clay (decomposed Utica Shale) is seen in the northeast and northern part of the pit, overlying the white clay. But very little ore could be seen in the mine when visited, and that was to the northwest of and in direct contact with the black clay, but *underneath* this.

The mine had been too little worked, after pumping, to be able to ascertain much in regard to its future prospects.

East of this mine on the other side of the road numerous shafts have been sunk and the prospects for ore are said to be good, but as the shafts were not very recent nothing was seen on the dumps.

H. Mickley's Mine, No. 180. This mine is abandoned and full of water. There is a little island in the centre, composed in great part of white hydromica clay, which can also be seen at one or two points on the northwest side of the pit. Black clay (Utica shale) occurs on the northwest side close to the water's edge. There is no ore in sight above water level, and the mine is said to be exhausted.

Ironton Co.'s Mine, No. 182.

Balliet Brothers' Mine, No. 183.

Balliet Heirs' Mine, No. 184.

These three mines form but one excavation, being however separate properties. Taken together they form the largest mine in Lehigh County and more ore has been taken from it than any other. The mine has been worked for more than forty years, and ore is said to have projected above the surface of the ground before the deposit was opened. The mine is now 2,000 feet long by 800 feet broad and is 90 feet deep at the lowest point. Limestone can be seen at various points, occurring in such a manner as to be nearer the surface at the eastern portion of the excavation and deepening towards the western end. The sides of the excavation consist for the most part of a plastic clay, formed by the decomposition of damourite slate. The greater portion of this is colored yellow by ferric oxide, but a good deal of it is white, while other portions are colored pink to red by an oxide of manganese. In addition to this, black clay (decomposed Utica shale) occurs in various portions of the mine, notably at the northwest end, in the centre, and at the eastern extremity. These different portions once formed a continuous bed, which has been removed in mining the ore. This black clay contains a very curious looking, nodular and concretionary iron ore, much resembling that met with at times in the slates of the coal, measures and which is an argillaceous carbonate of iron, known as clay iron-stone. Its quantity is too small and it is too irregularly distributed to render it an object of exploitation. Of more interest to the mineralogist is the occurrence of native copper in this black clay, which is found in small filiform pieces. Its presence in the metallic state being probably due to the carbonaceous matter in the clay. The black clay varies from 1 to 10 feet in thickness, being occasionally as great as 20 feet. The only reason for supposing it to be decomposed Utica shale is its geological position and the fact that it contains graphite; for an analysis of it see Report of Progress in Lehigh county for 1874, P. 32.

Ore occurs in various parts of the mine, the greater portion of it below the black clay, especially at the west end close to the Ballietsville road, in the lowest portion of the mine near its centre, and along the northern side of the central portion.

Black oxide of manganese (psilomelane) has been twice met with in considerable quantities, in both cases forming local beds. Once, three years ago, in a deposit over a portion of the brown hematite, from which a good many tons were taken, and more recently (1875) in the deepest portion of the mine, just above the limestone. The deposit has been exhausted since it was visited, several hundred tons having been taken from it. This last bed laid under the brown hematite ore, being separated from it by a red clay, and its presence in this position is most probably due to the greater solubility of the salts of manganese compared to those of iron. The following are various analyses made of this ore:

	I.	II.
Silica,	4.845	. . . . .
Manganese binoxide,	77.960	84.88
Manganous oxide,	4.320	3.77
Ferric oxide,	3.660	. . . .
Alumina,	0.711	. . . .
Oxide of cobalt,	0.390	1.68
Oxide of nickel,	Trace.	Trace.
Cupric oxide,	Trace.	. . . . .
Baryta,	0.152	Trace.
Lime,	0.770	1.90
Magnesia,	0.236	0.79
Soda,	0.368	0.19
Potash,	3.042	3.50
Sulphuric acid,	Trace.	. . . . .
Phosphoric acid,	0.149	Trace.
Water,	3.980	4.38
	100.583	101.09
Iron,	2.562	. . . . .
Manganese,	52.631	56.58
Sulphur,	Trace.	. . . . .
Phosphorus,	.063	Trace.

I, Average sample analyzed by Mr. A. S. McCreath ; II, Picked specimen analyzed by Mr. Henry Pemberton, Jr.

The greater part of the ore has been shipped to the Cambria Iron Co. at Johnstown for the manufacture of Spiegeleisen.

Limestone has been met with in place at various points in the bottom of the mine. Along the southern central portion of the pit the limestone has a northwest and west dip, while that which occurs in the eastern portion of the northern half has a southeast dip. These dips, taken in connection with the southeast dips on the Ballietsville road north of the mine and the limestone synclinal, separating the Ritter's Mine, No. 186, from the others, show a synclinal structure. The limestone has been met with much nearer the surface in the eastern portion of the excavation than in the western, and consequently much more ore has been taken out of the latter than the former. The synclinal structure and the fact that limestone has been struck in place in the deepest portion of that part of the mine belonging to the Ironton railroad Co., leaves little, if any, ground of hope that much more can be met with there. West of that part where the manganese ore was met with, the limestone probably goes deeper, and it may be that ore will be found to a depth of thirty feet or more before meeting the limestone. There is every evidence however that the mine is approaching exhaustion, unless ore should be found west of the Ballietsville road. Even in such a case it is scarcely probable that any great quantity of it will be found, as the slate will probably intervene and cut it off; the dividing line between the slate and limestone, as drawn on the map, being only approximate, the actual line of contact being concealed. The reason for supposing that the overlying slate will cut off the underlying ore, is that at no point hitherto has the ore been followed in under the slate. The ore is now shipped to furnaces on the Lehigh.

A sample of the average ore taken from the wharf of the Ironton Railroad Co.'s mine No. 182 was analyzed by Mr. David McCreath with the following result:

Iron,	26.400
Manganese,	17.648
Sulphur,	0.010
Phosphorus,	0.095
Insoluble residue,	21.860

The low percentage of iron in the sample taken is due to the high percentage of manganese.

P. Brown's Mine, No. 185. This pit is but a short distance from the last; it is about 70 feet deep. The mine lies directly in the centre of the limestone synclinal mentioned under mine No. 182, and it is very probable that the ore continues from it to mine No. 184. When last visited work had been stopped and the mine allowed to fill with water owing to a difficulty in selling the ore at a remunerative price during the present period of depression in the iron business. When first visited there was a very good breast of ore some 30 or 40 feet thick in the west end of the excavation, the breast consisting almost entirely of pure ore intermingled with damourite slate and clay and more or less allophane. The eastern end is composed of white clay resulting from the decomposition of damourite slate; but it is a subsequent deposit, for that portion of it on which the plane rests and just north of it, shows from the carbonized wood which has been converted to lignite and from the remains of leaves and a small beech-nut (all of which have been found in it) that this portion at least of the clay is of Post-Tertiary age. The superior position of the clay, stratigraphically, to the ore shows the former to be younger than the latter. This subject is, however, discussed more in detail in another part of this report. The mine presents a very favorable appearance in its western portion. Overlying the ore is black clay (decomposed Utica shale), being thickest in its northern portion, that on the south side having been eroded. Overlying this is a little surface soil. The future of this mine is apparently more favorable than those just described (Nos. 182, 183, 184), for while there is but little prospect of ore being found to the east, where the limestone cuts it off, or to the south, where it must soon crop out, it is very likely that a good deal of it will be found in the interval of virgin ground between this mine and No. 184. To the northeast trial pits have been sunk, but with no very favorable indications, nor could any other result have been expected, owing to the proximity of the shafts to the limestone. The ore was analyzed by Mr. David McCreath, who found (I); while another sample (II) analyzed by Mr. A. S. McCreath gave:

	I.	II.
Iron,	47.000	50.000
Manganese,	0.641	0.208
Sulphur,	0.053	0.080
Phosphorus,	0.061	0.086
Insoluble residue,	15.770	12.520

No. I is an analysis of the average lump and washed ore; No. II an analysis of a single lump. Considerable quantities of allophane occur in this mine.

J. Ritter's Mine, No. 186, leased by the Crane Iron Co. This pit, while close to No. 185, is apparently cut off from it by limestone, and seems therefore to be more closely connected with the mines to the east than those lying to the west. There is an abundance of black clay (decomposed

Utica shale) in the southern portion, which lies directly under the sod on the south side, and a little deeper on the north side. Immediately underneath and, to the east, alongside of this, is an abundance of pinkish and white clay; the pink lying almost entirely under the black, the white more alongside, but also underneath it. The line of demarcation between the black and the other clays, is sharply defined by the change of color. While their composition* is approximately the same, they do not seem to be altogether conformable, for the black clay has a northwest dip, while the white has a southwest one. Still these dips are not conclusive, since the clays may have been crimpled and folded by the erosion of limestone underneath them.

The comparative age of these clays is, however, of considerable importance as bearing on the origin of the brown hematite ores, as there is a bed of this 8 to 13 inches thick, which cuts through both the black and the white clays. If now these two clays, or the rocks from which they were formed by decomposition, are of the same age, this bed of ore may have been formed cotemporaneously with the enclosing rocks; but if they are of different ages, then, of course, the ore must have been formed by subsequent deposition. The ore from this bed, which is mined, was analyzed by Mr. A. S. McCreath, who found:

Iron,	39.300
Manganese,	0.065
Sulphur,	0.008
Phosphorus,	1.269
Insoluble residue,	28.195

The ore which is being taken out from the bottom of the mine was analyzed by the same chemist, with the following result:

Iron,	47.700
Manganese,	2.968
Sulphur,	0.049
Phosphorus,	0.328
Insoluble residue,	12.595

The mine, when last visited, was being worked into a good

* Compare analyses pp. 12, 13, and 32, Report of Progress, Lehigh District for 1874.

condition, and promised to yield a good deal of ore, the openings in the bottom of the mine being favorable, although the amount in sight was not very large. The ore from this mine was also analyzed for the Crane Iron Co. by Mr. J. B. Britton, who found:

Ferric oxide,	67.58	Iron,	47.31
Manganic oxide,	1.51	Manganese,	1.00
Alumina,	2.71		
Lime,	0.06		
Magnesia,	0.09		
Sulphuric acid,	Trace.		
Phosphoric acid,	1.81	Phosphorus,	0.79
Water,	10.58		
Silica,	15.44	Silica,	15.44
	.99.78		

Mines East of Ironton.

P. Steckle's Mine, No. 187. At this point there are three abandoned excavations. On the south side of the most western one there is a large bank of Hudson River slate (No. III) and a small quantity of black slate (Utica shale) on the dump. While in the middle pit, there is a small quantity of black and red clay on the north side of the mine, and slate (No. III) occurs in some parts of the sides. The eastern excavation was too full of water to permit of any examination. The sides were much washed, but from what could be seen it would appear as if the ore were surface ore in gravel overlying the Utica shale and possibly over a portion of No. III slate. The reason for this supposition is that blue and black clay (Utica shale) has been struck half way down shafts sunk in the middle pit, and little or no ore was found below this. There is no doubt a good deal of ore still remaining, but too little concentrated and too widely distributed through the deposit to pay for working it.

Daniel Steckle's Mine, No. 188. The ore formerly went to the Lehigh Valley Iron Co. There are here two abandoned excavations. In the eastern pit the ore occurs in in gravel and there seems to be but little of it, although it is said there is considerable ore left, but in such thin streaks as not to pay for working it, nor of a sufficient quantity to justify the erection of good machinery.

Mines in the Middle of the Limestone Belt.

M. Schadt's Mine, No. 177. In this mine, but recently opened, the ore consists of lump and wash-ore in surface clay mixed with much flint. But little could be seen. A well was sunk 106 feet for water, and although in limestone at that depth, the supply was insufficient. Consequently a drill-hole was being sunk when the mine was visited, and at a depth of 196 feet from the surface an ample supply was met with. The drill-hole went through limestone alternating with thin seams of clay, but no record had been kept of the rock passed through.

D. Ruch's Mine, No. 176. In the northeast corner of the pit a single bed of ore is apparent, but it is being covered up by throwing in surface soil, so that it could not have paid. A new opening has been very recently begun, and the surface soil also yields a certain amount of ore; this was analyzed by Mr. A. S. McCreath, who found:

Iron,	46.300
Manganese,	0.201
Sulphur,	0.033
Phosphorus,	0.264
Insoluble residue,	17.500

Charles Ritter's Mine, No. 178. The mine is abandoned and full of water, while the sides are grass-grown. It has not been worked for some time. The ore was only surface ore in gravel.

J. Sheirer's Mines, Nos. 172, 173. No. 172 is abandoned and consists of two pits divided by the road, that to the west being much the largest. The ore here formed merely a pocket in gravel, and was not in place; it has long since been worked out. At No. 173 the mine is new and the ore thus far mined has been chiefly in surface drift and stripping, most of it being red or partly anhydrous ore. In the excavation they have just reached the top of the ore in place. In some of the trial-pits around the mine, lump-ore was found in an abundance of white clay. The mine has been too recently opened to give any opinion as to its character. From the discoveries made in the trial pits, it seems to promise well. Samples of the ore were sent to Mr. D. McCreath, who reported:

Iron,	46.000
Manganese,	0.050
Sulphur,	0.073
Phosphorus,	0.210
Insoluble residue,	17.870

Robert McIntire's Mine, No. 174. This has long been abandoned and is grass-grown so that nothing can be seen.

P. Miller's Mine, No. 197. The two excavations at this place are not worked and so much washed, that nothing could be made out as to the character of the deposit.

Jonas Biery's Mine, No. 171. The mine has not been worked for some time and the sides are much washed. The ore was taken out from between beds of limestone, which dips south about 20°. On the north side white clay (decomposed damourite slate) occurs above the limestone. The ore which remained on the dump was very light, being probably the poorest which had been mined and left behind. The following analysis by Mr. A. S. McCreath, shows it to be leaner than the average of the ore in Lehigh county:

Iron,	32.500
Manganese,	0.338
Sulphur,	0.038
Phosphorus,	0.168
Insoluble residue,	42.370

The mine does not present a favorable appearance, and probably very little ore remains to be taken out.

Ephraim Wenner's Mine, No. 160. The mine is not worked and the sides are too much washed to see how much ore remains in the pit. Damourite slate and white clay can be seen in the west end, which dip under limestone in the south side. The limestone has the same dip as that near it along Jordan Creek.

William Roth's Mine, No. 195. The ore from this small excavation is entirely pipe ore, which is extracted from between broken beds of limestone, and which has been formed as stalactites by the water percolating through the limestone. Neither bomb-shell nor wash ore is found. The ore found is comparatively little in amount. It is taken to the Lehigh Valley Iron Works.

Reuben Butz's and A. C. Belden's Mine, No. 147, leased by the Thomas Iron Co. The mine looks well; the ore occurring in decomposed damourite slate.

John Singmaster's Mine, No. 199, leased by the Thomas Iron Co. The ore at present mined is mostly from surface clay. At the single excavation now being worked the ore occurs in yellow clay, together with a very small quantity of white damourite clay. The excavation does not look very well; the ore being taken chiefly from the south end, which had the most promising appearance. The ore is all wash ore. There are several old excavations in which the ore has been exhausted, and which have been filled up.

Stephen Butz's Mine, No. 200. The mine is not worked, and the sides are so washed that nothing can be seen.

William Walbert's Mine*, No. 201. Has been worked but a short time, and the ore at present mined occurs in the surface clay.

Peter Deisher's Mine, No. 202, leased by the Leesport Iron Co. The ore occurs in surface clay, and appears to have been washed into a depression of the limestone, although the latter is not in sight. There is no bedding whatever to the ore or the enclosing clay, while a good deal of quartz and flint occur with them. The ore is all wash ore.

CHAPTER XIX.

The Genesis of the Brown Hematite Iron Ores.

The occurrence of the brown hematite ores is briefly described in the report for 1874, page 44. The examinations made at the mines in that portion of Lehigh County, which had not then been examined, have confirmed the facts there stated.

* By an oversight this mine is called Wm. Walker's in the key list of mines on the accompanying map.

The pipe ore—of which but little is now found—usually occurs associated directly with limestone and has evidently been formed by the percolation of water through the rock, and deposition from solution by the oxidation of some ferrous salt, probably the carbonate.

The pot and wash ores always occur either washed into depressions of the limestone or else in place. In the former case they are associated with the yellow clay resulting from the decomposition of the limestone, and generally a large amount of angular flint occurs with it. These were, in all probability, washed into their present positions at the time that beds of ore in place were being destroyed by erosion. And as stated in the 1874 report the mines of this class do not possess, as a rule, any great depth and are soon exhausted. Deposits of this kind usually occur at some distance from either the top or bottom of the Magnesian Limestone (No. II). Care must however be taken by the miner not to confound these deposits with the outcrops of the brown hematite in place, which at times closely resemble them, as there are many instances of mines having been abandoned as being exhausted, after having been worked to a slight depth, which were subsequently re-opened and found to be very productive at a greater one.

The most important class of mines are those where the ore is found in place and almost—if not quite—invariably associated with damourite slates or clays. As stated in the 1874 report, the ore does not occur in regular beds, but forms sheets or small masses of irregular shapes which soon run out; but the separate sheets or masses are only parted by very thin walls of slate or clay. The ore will frequently, after continuing parallel to the bedding of the slate or clay, bend abruptly at right angles to this and after remaining thus bent for a short distance, will again bend and resume its course parallel to the stratification. At times a thick solid bank of ore is found in a mine; this is however rare and continues but a short distance.

A marked peculiarity with respect to the occurrence of the brown hematite ore in the damourite slates or clays, is the lack of uniformity with which it is distributed; what seems to be a solid bank of ore may at a depth of two or three feet be replaced by clay or slate containing no ore whatever. The miner can have no clue as to what may be six inches in front of his pick. Where the ore thus disappears leaving only slate or clay, the miner must either pick ahead in hopes of again finding the ore, which most frequently happens, or else abandoning the spot turn to some point of the excavation where the outlook is more promising.

With respect to the origin of the brown hematite iron ore various views and speculations have been advanced.

Let us first look at the facts. The hydrated ferric oxide is found associated with the alkalies (more especially potash), silica, alumina, lime, magnesia and manganese. These substances were derived from older rocks of the Archæan Period which contained orthoclase and either pyroxene or hornblende, since these two minerals would sufficiently account for all the subordinate ingredients associated with the hydrated ferric oxide (brown hematite). As Dr. Hunt* well says: "The portions of the primitive crust not covered by the ocean undergo (and have in the past undergone) a decomposition under the influence of the hot moist atmosphere charged with carbonic acid, and the feldspathic silicates are converted into clays with separation of an alkaline silicate, which, decomposed by the carbonic acid, finds its way to the sea in the form of an alkaline bicarbonate."

A portion of the hydrated ferric oxide must undoubtedly have been deposited cotemporaneously with the other materials, not in separate beds, strings and masses as it now occurs, but intimately associated with these and more or less uniformly distributed. Neither would the strings of quartz, which are so frequent in the ore mines, have been formed at this time. Whether all the substances above named, which—with the exception of the hydrated ferric oxide and the manganese—form the damourite, were chemically or mechanically deposited is unknown, but probably the latter; having been, as Prof. Dana says, originally mud beds in the ancient Siluro-Cambrian sea. It

* Chemical and Geological Essays by T. Sterry Hunt, LL. D., p. 2.

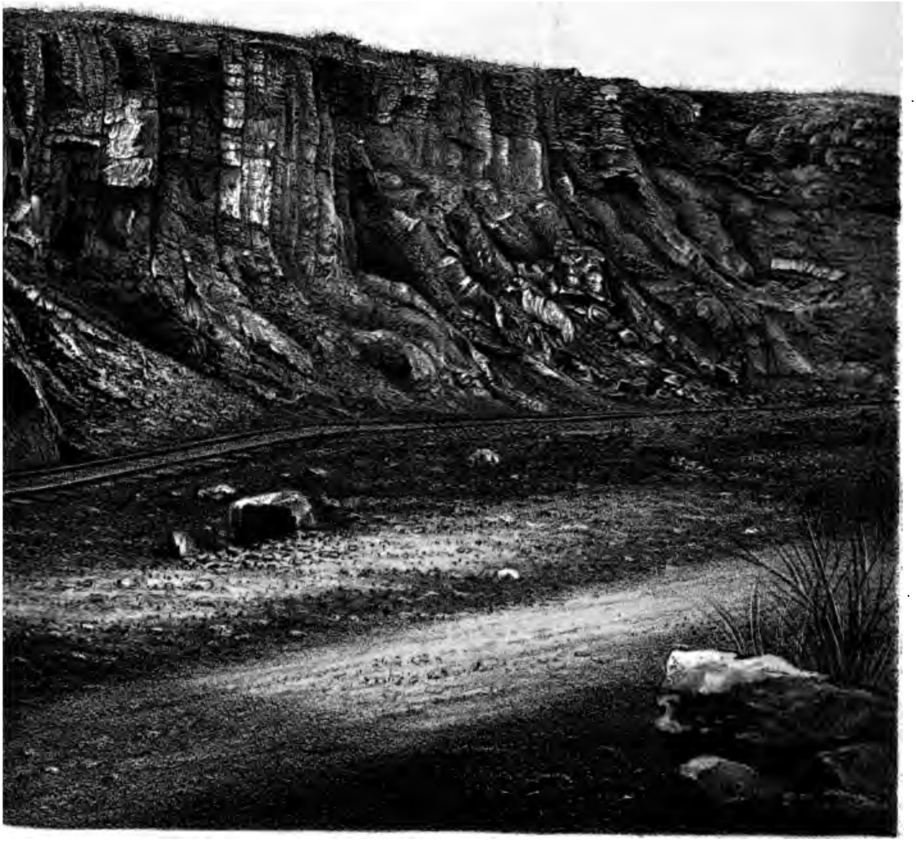
has been shown from the analyses of limestone given in this report that the Siluro-Cambrian limestones contain upwards of half a per cent. of ferrous carbonate. In places also it carries a good deal of pyrite disseminated in very small crystals. Prof. Frazer found that the damourite slates of York County also contained a great deal of pyrite; while in Lehigh County pyrite has only been found at two or three mines.

The ore must then have been formed either from the decomposition of ferrous salts *in situ* (*i. e.* ferrous silicates or the carbonate), from the solution of the ferrous carbonate in the limestone and its re-deposition in the damourite slates, or from the same reaction of the ferrous sulphate formed by the oxidation of pyrite. The presence of large quantities of quartz, forming strings and bands associated with the brown hematite ores in the damourite slates, tends to show that a very large proportion of the iron has been originally deposited as a silicate, this being subsequently decomposed by the action of percolating water containing air and carbonic acid in solution. On the other hand the presence of carbonate of iron as found at Barber's mine, formerly also at Ironton, and in the Saucon Valley, would indicate that a portion of the brown hematite had either been originally deposited in the slates as carbonate of iron, or that by some reaction at present obscure (possibly the reaction of some potash salt) the carbonate had been formed and deposited, and by subsequent oxidation converted to the hydrate. Finally the ferrous sulphate formed by the oxidation of pyrite would react on any alkaline silicates present, and converting these into sulphates would itself be thrown down.

What, then, has been the influence of the damourite slates, and why do we find the brown hematites so universally associated with these? Remembering the imperviousness of the damourite slates and clays to the percolation and passage through them of water, we can readily perceive that they would retain, for a considerable period, the waters containing the iron saltes in solution, and thus give these last a greater opportunity for precipitation. Nor can

QUARRY AT COPI

D. D. Plate I.



[Looking West; South End.]

we tell what important influence the potash present has exerted on the deposition of the iron ore, as we do not know certainly in what combinations the iron ores have been. Knowing, however, the large quantity of potash present in the damourite slates, its energetic action when in a free condition in precipitating iron from many of its salts, and the association of the iron ores with the damourite, it cannot be doubted that the potash has exerted some important agency in the formation of the ores in their present position and condition.

Chapter XX.

Stratification of the Limestone.

Prof. H. D. Rogers, in his report on the First Geological Survey of Pennsylvania, showed that a majority of the dips in the limestone of the Kittatinny Valley were due to inversions of the strata. That a majority of the dips are to the southeast can be readily seen from an inspection of the accompanying map, and that they are due to inversions of the beds, or in other words, to collapsed anticlinals, can be also seen from the accompanying plates.

Two of these represent the quarry of the Lehigh Valley Iron Co., at Coplay; another, Jesse Weaver's quarry, at Catasauqua; and the fourth, Charles W. Rau's quarry, also at Catasauqua.

The folds shown in the last two plates exhibit the same anticlinal at its opposite ends, Weaver's quarry exhibiting its northeast extremity, while Rau's quarry shows it disappearing below the surface at its southwest exposure. This latter is curious as being a veritable saddleback, on which one can sit as on a saddle. Attention is invited to the upper beds in the background folding around it. At Jesse Weaver's quarry, on the contrary, the fold is even tighter.

The view of the Coplay quarry is rather more interesting as showing two sets of anticlinals. Then too the attention of the reader is called to the anticlinal on the extreme right of the plate, where the low broad anticlinal near the base of the quarry forms a much sharper and more contracted fold near the top. Thus showing that while the folds may be apparently very close and the anticlinal very tight, giving the idea that it is the bottom of a large anticlinal which has been eroded, such may not be the case; and it may in reality be the top or middle of some anticlinal which extends to a considerable distance below.

While as already stated the great majority of the dips are towards the southeast, there are still a number of exposures which show northwest dips.

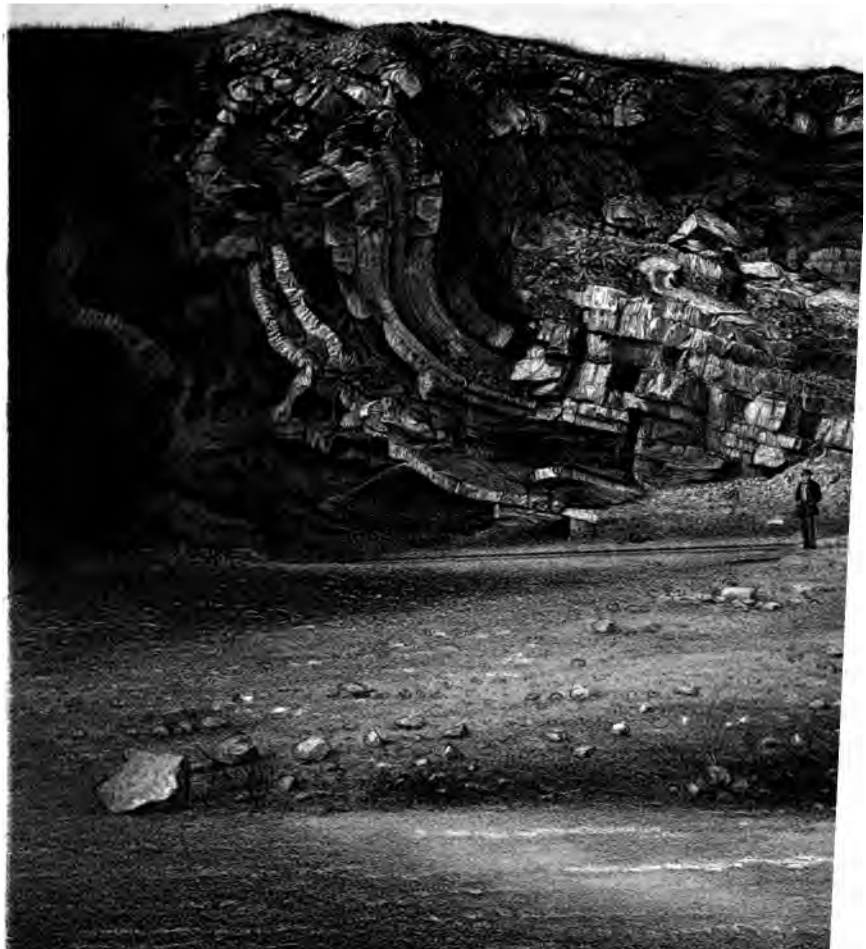
The cleavage planes are generally southeast in their direction, and so abundant as often to almost obliterate the stratification or at least render its determination a matter of considerable difficulty, if not of impossibility.

The general absence of fossils has, also, rendered a recognition of the equivalency of the beds at different points, impossible. As can be seen from the map there are large tracts on which no dips are noted; this is for the most part due to the absence of limestone outcrops over such areas; in part, however, to the fact that where the limestone is exposed it has been impossible to ascertain the true dip owing to the innumerable cleavages and fractures permeating the rock-exposure.

Then too there are cases in which the rock has been so curved, bent and twisted on itself, that it has been impossible to determine the true dip; as instances of which may be cited: Henry Stein's quarry, 2 miles S. W. of Fogelsville, illustrated on page 9 of last report; the quarry close to the Lehigh Valley railroad at Hokendauqua; the quarry at Copley; and those just outside of Catasauqua.

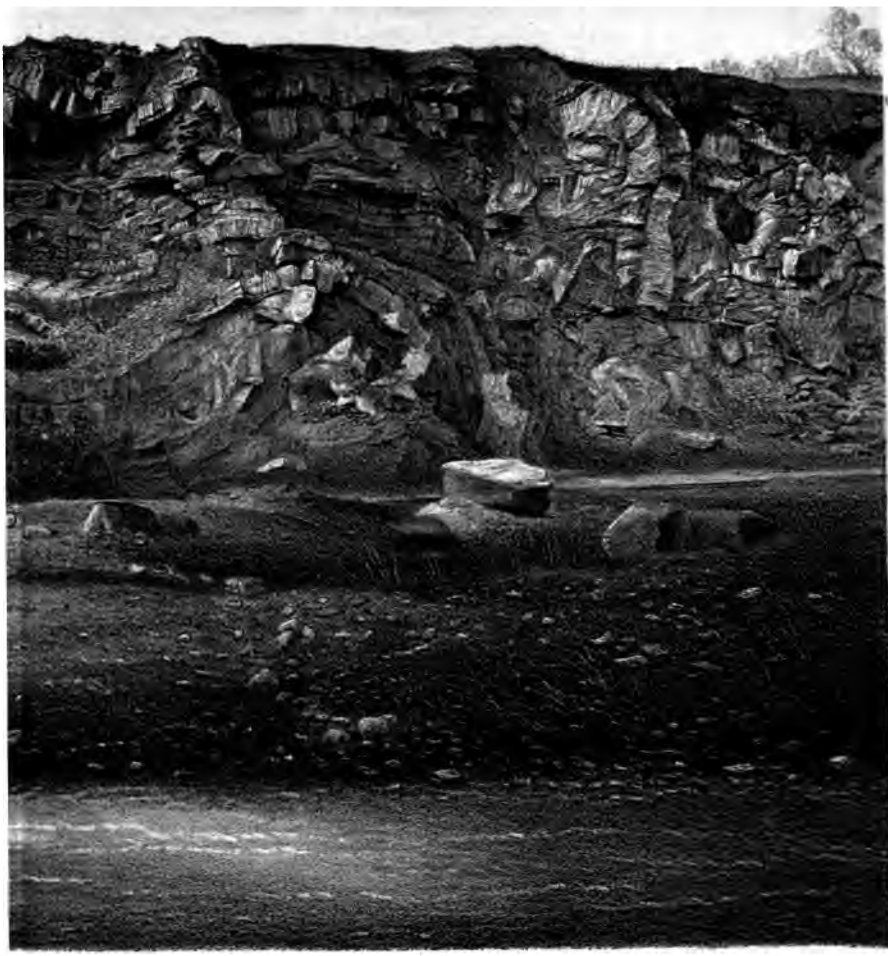
One fact seems however to be settled, which is, that while the convulsions which the limestone has undergone have been very great, in Lehigh county they are by no means as great as has often been supposed. The dips are sometimes large in amount, but oftener quite small; and those over 30° form a large minority.

It will be observed, that the Potsdam sandstone (No. I)



QUARRY AT CUPLA

D.D. Plate II.



..ookingWest ; North End.]

and the Magnesian limestone (No. II) seem to be always conformable; for, while the amount of dip of the former is often greater than that of the latter, this is due to its position on the flank of the South Mountain.

Again, as a rule, the Magnesian Limestone and the Hudson River slates (No. III) are conformable, the limestone passing under the slate; although in places there are exceptions which merely show local inversions of these two formations, by which the limestone is brought on top; and this is caused by the tendency of the limestone anticlinals to be overthrown toward the northwest.

These facts show that the subsidence which went on during the Siluro-Cambrian period must have been a gradual one, and that the convulsions by which the three formations were contorted and thrown into anticlinals and synclinals and the South Mountain was upheaved, must have been subsequent to this period.

Let us now consider the structure a little more in detail.

A synclinal may be traced from the east end of Lock Ridge to the gneiss outcrop at Jerusalem Church where it is lost sight of, no northwest dips being found farther east. There can be but little doubt that these two gneiss outcrops were thrown up cotemporaneously.

The limestone around the Jerusalem Church gneiss dips in all directions; while due east of this the limestone has a southeast dip which continues to the eastern border of the map, and probably forms a synclinal with the limestone which must overlie the Potsdam sandstone as shown at East Penn Junction and other points farther east.

North of these lines the limestone has southeast dips as far as Breinigsville, where a local anticlinal occurs close to mine No. 19.

The slate nose south of the limestone cove in which the town of Fogelsville lies is a synclinal; the slate dips showing this, and the limestone wherever exposed near enough to the slate, passing conformably under it.

The limestone in the cove is undoubtedly a gentle anticlinal, as is evident from the overlying slate, as well as from some of the limestone dips; those of the latter not conforming to it being due to local rolls.

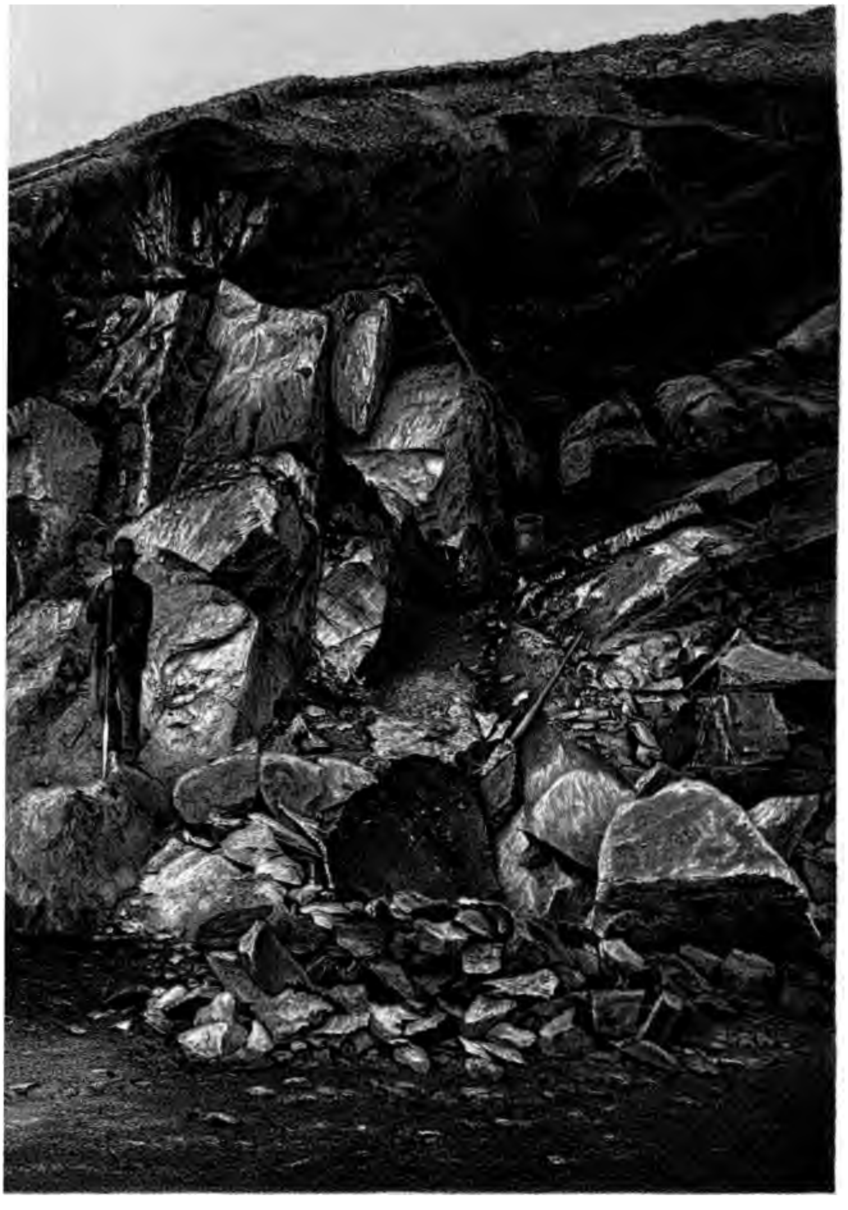
On passing to Huckleberry Ridge it has been more difficult to make out the structure. It is probably a synclinal ridge of slate with the limestone passing conformably beneath it. Many of the slate dips given are very doubtful, it being extremely uncertain if they were the dip or cleavage, so that the question cannot thus be settled. The only limestone dips on the south side of the ridge which tend to show a synclinal structure are, one about 1½ miles north of Fogelsville, a second close to mine No. 159, and the limestone synclinal over Helfrich's Spring. This last is the most decided evidence in favor of the synclinal structure of Huckleberry Ridge, as it lies in a prolongation of this, and the Utica Shale is seen on some mine dumps not half a mile from it. The recent discovery of iron ore east of Helfrich's Spring tends to corroborate the evidence in favor of the synclinal structure.

North of Huckleberry Ridge there is an almost universal southeast dip to Coplay. North of this town there are northwest dips which extend almost or quite to the slate hill north of Whitehall. This slate hill is a synclinal one, almost isolated; for limestone crops out north of it close to the Lehigh and to the small stream emptying into it. At Ironton there is a limestone synclinal between mines Nos. 184 and 186, by which the ore is cut off. Most probably it formerly laid over the limestone and has been washed away by erosion. The formation at Ironton is a peculiar one. There is a slate quarry just east of the junction of the Orefield and Ironton branches of the Ironton railroad, and the slate just south of this quarry runs under the limestone. It was stated that slate had been struck at a depth of about 40 feet, in a well at the lumber yard at Ironton, which is probably the case. The quarry indisputably marks the presence of slate under the limestone. The only reasonable way to explain this fact is by an inversion of the rocks, throwing the limestone on top. To this same overthrow may possibly also be due the very large quantity of ore

2nd Geol. Survey of Pa.

JESSE W. WEAVER'S QUARRY

B. B. Plate III.



CATASAUQUA. [Looking West.]

which occurs in the Ironton mines; larger than at any other locality in Lehigh County thus far discovered.

East of the Lehigh there is a synclinal north of Catasauqua, and beyond this an anticlinal limestone ridge northeast of Stemton.

North of this there is a second synclinal which runs nearly parallel to the county-road between Siegfried's Bridge and Bath.

Chapter XXI.

The Trenton Limestone.

This formation has been distinctly recognised at but one point in Lehigh County; viz., in the quarries just south of the slate quarry at Ironton. Here for a short distance east of the Kennel mine, encrinital stems have been found north and south of the railroad, which must be of Trenton age since the same fossil forms have been found in Northampton County to overlie characteristic Trenton fossils.

Lithologically, it seems impossible to certainly distinguish this from the Magnesian Limestone as it closely resembles it; it is however more compact and rarely at all crystalline, and commonly of a gray to gray-black color. Usually it contains more alumina and less magnesia, and the beds of hydraulic limestone which form the boundary and transition between the No. II limestones and No. III slates probably belong to this formation.

The occurrence of these hydraulic limestones is of great economic importance, not only locally, but to all the southern part of the State, since the discovery of suitable beds for the manufacture of ordinary hydraulic and Portland cements would be a considerable source of wealth, and obviate the necessity of importing these from New York State and Europe.

The hydraulic cement-stone is first met with at Ironton, just north of the large mine on the road leading to Ballietsville; a sample taken from the roadside was sent to Dr. F. A. Genth for analysis, who reported as follows:

Insoluble silicates of alumina, etc.,	15.07
Carbonate of lime,	82.05
Ferrous and manganous carbonates,	0.09
Carbonate of magnesia,	0.17
Water,	2.42
Carbon and undetermined matter,	0.20
	100.00

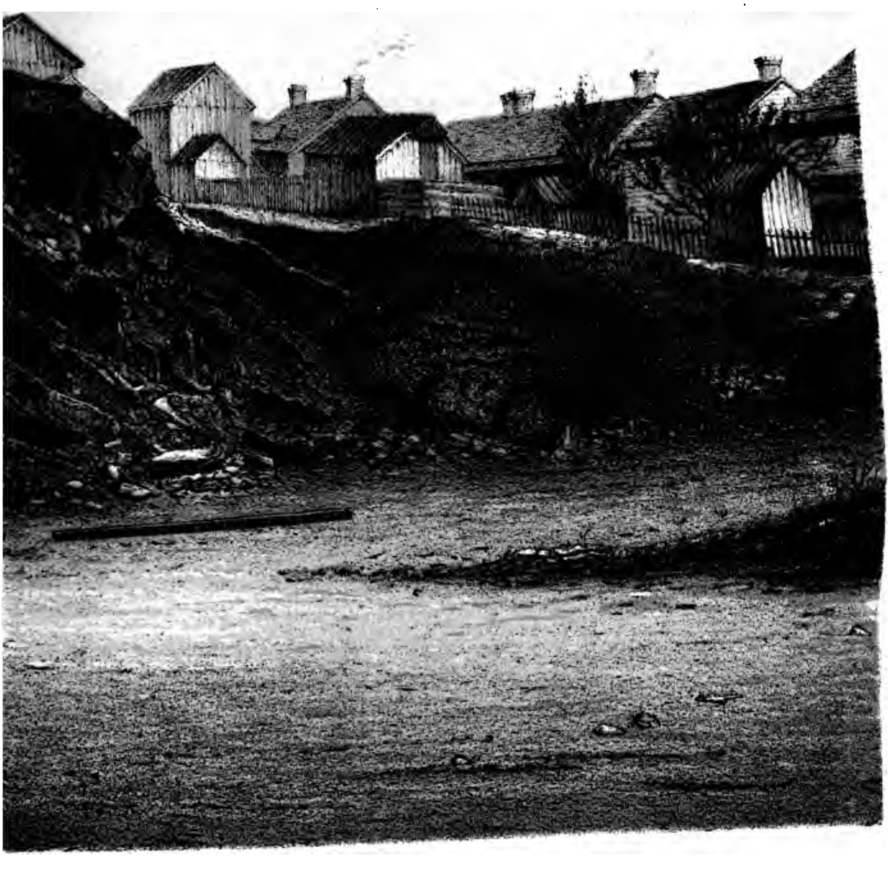
Owing to the hillsides being covered with vegetation, the outcrops from the locality mentioned to the Lehigh River are very few, but there are here and there indications that the cement-stone continues without any break to the river. At the river it appears along the Lehigh Valley railroad track, and beyond this it may be traced near the dividing line of the limestone (No. II) and the slates (No. III) to the border of the map accompanying this report.

There are four localities (described in the next chapter,) where cement is manufactured, all close to the Lehigh; two on the west side of the river are worked respectively by the Coplay Cement Co. and the Lehigh Cement Works. The other two on the east side are exploited by the Allen Cement Co. and the Old Lehigh Cement Works.

There has been apparently no break in deposition between the close of the Magnesian Limestone Epoch and that of the Trenton Limestone; this was to be expected if the subsidence of the sea-bottom was steady and slow. As the bottom subsided, more and more alumina continued to be deposited, which, gradually preponderating over the lime, gave rise at last to the mud from which were formed the Utica Shale and the Hudson River Slates.

RAU'S QUARRY AT CATA

D. D. Plate IV.



SAUQUA. [Looking East.]

CHAPTER XXII.

The Cement Works on the Lehigh.

I. The Lehigh Hydraulic Cement Works.

This company was organized and commenced operations in the year 1872. The works were located on the west bank of the river Lehigh, about one mile above Coplay Station, Lehigh Valley railroad.

In the year 1874, the mill was burnt down, and has not been re-built. It consisted of three run of mill-stone, and ample power to grind three hundred barrels of cement a day. The kilns are four in number, and of the No. 12 pattern, described in Gen. Q. A. Gilmore's work on Cement. The quarry is adjacent to the works, and the cement made was a light yellow one, closely resembling in color and quality that made by the Old Lehigh and Allen Works.

II. The Coplay Cement Works.

The Coplay Cement Company was organized in the year 1867. Their works are located a short distance above Coplay Station, Lehigh Valley railroad, on the west bank of the river Lehigh, about six miles above the city of Allentown. They consist of 11 kilns, 7 of which are used for burning Saylor's Portland cement. These kilns are built of cement, concrete, fire-brick, and iron, after drawings made by Jas. Hubett of London, and are after the pattern of the kilns used for burning Portland cement on the rivers Thames and Medway, near London. They are set kilns, and have a capacity together to burn twenty-five hundred barrels of Portland cement clinker a month.

The other four kilns are draw kilns, built after the pattern of the kilns used in New York State by the Rosendale cement manufacturers, and described in Gen. Q. A. Gilmore's work on Cement and Lime Mortars as the No. 12 Kiln. These kilns have a capacity to burn three hundred barrels of cement daily, and are used to burn the well known Anchor brand of cement.

The steam power of these works is sufficient to grind the production of the above kilns; and they are supplied with iron conveyers to carry the ground cement to all parts of their store-houses, which together have room to store fifteen thousand barrels of cement.

The quarry is adjacent to the works, and the same steam engine used to drive the mill is also used to hoist the stone from the quarry to the kilns for Anchor cement, and to the crushers for the Portland.

It contains a number of layers of rock which are designated by numbers. Some of these beds are suitable for Portland and some for Anchor cement. Much technical and scientific supervision is necessary to determine which stone to use and which to reject in order to make a cement capable of undergoing the tests now applied by engineers and architects.

D. O. Saylor, Esq., President of the company, has kindly furnished the following analyses.

Cement-stone analyzed by Mr. John Eckert, under the supervision of Prof. Wm. H. Chandler:

Bed of Rock.	1	2	3	4	5	6	10	12
Silica,	12.88	12.81	13.72	14.68	15.03	15.40	14.79	14.32
Alumina,	4.25	4.86	4.09	5.32	3.97	4.26	4.50	4.20
Ferric oxide,	1.09	.97	1.04	1.12	1.93	1.38	1.34	1.65
Carbonate of lime,	72.87	72.64	71.54	69.26	74.12	74.66	72.95	73.12
Sulphate of lime,	1.60	1.68	1.79	2.29	1.19	.86	1.75	2.02
Carbonate of magnesia,	4.69	4.62	4.37	3.67	2.41	2.66	3.84	4.09
Phosphoric acid,	.10	.11	.10	.09	.13	.09	.06	.17
Organic matter,	1.57	1.72	1.78	1.68	1.47	1.88	1.46	1.31
Total,	99.05	99.41	98.43	98.11	100.25	101.19	100.69	100.88

Portland cement has been made from all of the above beds, which analyzed as follows:

Bed of Rock.	1	2	3	4	5	6	10	12
Silica,	22.71	22.04	23.26	23.40	23.33	24.25	23.21	23.07
Alumina,	9.85	10.11	7.88	8.06	8.73	7.88	8.35	7.32
Sesquioxide of iron,	2.52	1.61	2.70	2.38	1.83	3.14	2.74	2.49
Sulphate of lime,	2.31	1.78	1.98	2.44	1.92	1.63	2.36	2.17
Lime,	58.98	61.93	60.50	59.94	60.52	60.28	58.50	59.04
Magnesia,	2.31	2.13	3.53	3.21	2.61	2.67	3.05	3.27
Total,	98.68	99.60	99.85	99.43	98.94	99.88	98.21	97.36

Some of the above samples when tested gave very good results, while others were far below the required strength of good Portland cement.

Below is a table of tests made of Saylor's Portland cement, being the average quality and tensile strength of the cement as it is packed and offered for sale in the market:

Tests of 4 Samples Saylor's Portland Cement.

Brand of cement, ...	Saylor's Portland.	Saylor's Portland.	Saylor's Portland.	Saylor's Portland.
Date when ground, . . .	Jan. 12, 1878, .	Jan. 12, 1878, .	Jan. 12, 1878, .	Jan. 12, 1878.
Weight per cubic foot, . .	112 lbs., ...	112 lbs., ...	112 lbs., ...	112 lbs.
Fineness through sieve, 2,500 meshes, ...	85 per cent., .	100 per cent.,	85 per cent., .	85 per cent.
Date when blocks were made, ...	April 29, 1878,	April 29, 1878,	April 30, 1878,	April 26, 1878.
Weight of cement in each block, ...	24 oz., ...	25 oz., ...	24 oz., . . .	24 oz.
Weight of water in each block, ...	5¼ oz., ...	6 oz., ...	5¼ oz., ...	5¼ oz.
Temperature of cement and water, ...	60° Fahr., . .	60° Fahr., . .	60° Fahr., . .	60° Fahr.
Time it set in mold, . . .	20 minutes, .	16 minutes, .	20 minutes, .	20 minutes.
Time left in mold, ...	1½ hours, . . .	1½ hours, . . .	1½ hours, . . .	1½ hours.
When immersed in water,	Immediately,	Immediately,	Immediately,	Immediately.
Time left in water, ...	7 days, ...	7 days, . . .	6 days, ...	7 days.
Time left in air, before breaking, ...	None, ...	None, ...	None, ...	3 days.
Date when broken, ...	May 6, 1878, . .	May 6, 1878, . .	May 6, 1878, . .	May 6, 1878.
Age when broken, ...	7 days, ...	7 days, ...	6 days, ...	10 days.
Average tensile strain on square inch, ...	411 lbs., ...	392 lbs., ...	426 lbs., ...	566 lbs.
Number of blocks made,	3	3	3	3
Tensile strain per section of each block, ...	875 lbs., . . 975 lbs., . . . 925 lbs., . . .	825 lbs., . . . 825 lbs., . . . 1,000 lbs., . . .	950 lbs., . . . 1,025 lbs., . . . 925 lbs., . . .	1,325 lbs. 1,350 lbs. 1,150 lbs.

Copy of report from the Department of Docks, New York, of 1,000 barrels of Saylor's American Portland cement, delivered by

JOHNSON & WILSON, *General Agents,*
93 Liberty Street, New York.

(Tested Nov. 13 to Dec. 20, 1877.)

Vessel,	Lighter.
Marks of cargo,	Saylor's American Portland cement.
Date of receipt,	November 12 to December 6, 1877.
Number of barrels,	1,000.
Average gross weight per barrel,	400 pounds.
Average weight of U. S. bushel,	131 pounds.
Lining,	Good.
No. bbls. from which samble was taken,	105.
Number of barrels damaged,	None.
Average fineness,	82 per cent.
Average tensile strain per square inch,	347 pounds.
Cracks,	None.
Number of minutes in molds,	53 minutes.

To G. S. GREENE, Junior,
Engineer-in-Chief.

W. W. MACLAY,
Assistant Engineer.

NEW YORK, *December 31, 1877.*

The requirements of this department in purchasing were as follows:

Weight per barrel,	400 pounds.
Weight per bushel,	110 pounds.
Fineness,	80 per cent.
Tensile strain per square inch at seven days,	250 pounds.

Portland Cement.

It was not until within the last few years that any attention was paid in this country to the manufacture of Portland cement. Thus far nearly all experiments have failed, either from want of the proper material to make it, or from the great expense of bringing together and compounding the several ingredients which compose the article. This company has, after long and expensive experiments, and many failures as to quality, succeeded in making a Portland cement equal to the best English and French brands imported to this country.

Portland cement is made in England from the deposits of chalk and alluvial clays on the shores of the rivers Thames and Medway, and is chemically a double silicate of lime and alumina, which is attained only by exposing the material to a degree of heat sufficiently high to produce partial vitrification. In this condition it contains no free lime.

The name originated with Joseph Aspdin, in Leeds, England, about 1825, who introduced its manufacture under a patent.

Portland cement is a sharp crystalline powder of a color varying from dark to light gray, with a bluish or greenish tint. It is essentially a combination of lime, silica, alumina and iron.

Saylor's Portland cement is made from several beds of argillaceous limestone. This rock is taken from the beds in such proportions, as to analyze, when mixed together, about as follows:

Soluble in Hydrochloric Acid.

Carbonate of lime,		70.34
Carbonate of magnesia,		4.47
Carbonate of iron,		2.98
		77.79
Insoluble:		
Silica,	14.73	
Alumina,	4.54	
Ferric oxide,	.93	
Magnesia,	.89	
Moisture,	.98	
		22.07
		99.86

Which will give the following after being burnt:

Silica,	22.77
Alumina,	7.03
Lime,	60.91
Magnesia,	4.67
Ferric oxide,	4.62
	100.00

The above analysis was made by Prof. W. T. Roepper of Bethlehem, and corresponds well with the best brands of the English and French.

The above mentioned proportions, however, cannot be strictly followed, as the beds vary at different places and degrees, so that great care and technical supervision is necessary in order to get the proper proportion of each. This is more effectually done by taking from time to time portions of the stone from the different beds, and burning them separately in a trial kiln, and then testing the cement thus made.

After the proportions of each bed are determined, they are mixed together as they come from the quarry, and passed through the crusher and the mill and ground to powder; the whole is then thoroughly mixed dry, and tempered through a pug mill with water. The product is then treated in a manner similar to the English method of making Portland cement; viz., it is spread out on drying floors, and when stiff is cut into blocks the size of bricks; these, when dry, are placed in kilns with alternate layers of coke and burnt, the clinker is then carefully selected, the pulverulent scarified and the underburnt taken out; it is then ground and conveyed to the bins, where it is left a few weeks to sweat and then cool, when it is ready for market.

The greater part is shipped to their packing house at Communipaw, in bulk, where it is packed in barrels, and kept in store for the New York market.

The dock department of New York used upwards of 8,000 barrels of it during the past year and found it to be equal to the average English or other Portland cement.

The United States Government has used the cement to a large extent on the forts and fortifications on the south Atlantic coast and New York harbor. General Gilmore has fully endorsed it as a first-class Portland cement, equal to the English Portland ones.

The East River Bridge Company at New York used it, and the engineer in charge of the works, Mr. Martin, recommends it highly.

The judges of the Centennial Exhibition at Philadelphia awarded a medal and gave a favorable report upon it for its strength and hardness, as rating high among the Portland cements of good standard quality.

There is no difference between Saylor's and the English and French Portland cements; it is a first-class Portland cement in all respects, and warranted to be equal in strength, weight, and cohesive qualities to any of the imported brands. The analysis of the raw material and the cement is about the same in the imported as in the Saylor's.

The method of manufacturing it does not materially differ from the English one.

The cement-stone from which the Portland cement is manufactured differs from the English and French cement-stones in containing all the requisite chemical attributes necessary to make Portland cement without adding clay or any other foreign substance, whereas these are manufactured from chalk and clay beds along the Thames and Medway, near London, England.

Anchor Cement.

This is an improved article of cement which after a trial of five years has proved itself to be equal to any American light burnt cement. It is claimed that the peculiar process employed in manufacturing it (which is patented) makes it different in its chemical nature to all other American cements. It sets rapidly, has great powers of cohesion, and acquires an unusual degree of hardness, both under water and in the air.

Its color is a beautiful greenish gray which makes a very desirable color for building purposes. It is said to be excellent for the manufacturing of sewer and drain pipe, making smooth and uniform work, setting rapidly; therefore more pipe can be made with the same number of molds than with a slow setting cement. It is, therefore, desirable for concrete or beton for subaqueous foundations, and for piers and abutments of bridges. In a report of the engineers in charge of the construction of the Girard avenue bridge, at Philadelphia, Pa., one of the most substantial and most beautiful bridges in the country, they say that of all the different common American cements experimented with and tested for the beton or concrete for the foundations, the Anchor cement proved the strongest and most satisfactory in all respects. We subjoin extracts from said report, which were published in the Journal of the Franklin Institute, of Philadelphia, in March, 1874, page 181:—"The materials employed were Portland, Rosendale, Coplay, Anchor, Allen and Old Lehigh cement, sharp river sand, coarse screened gravel and broken furnace slag. Of these, seventeen samples, each of a different proportion, were carefully mixed and kept under water thirty days, after which time they were tested with the following result: The Rosendale cement had failed entirely, perhaps on account of its not being fresh when used. Its qualities have lately been very unreliable, and it was therefore rejected. The Portland cement, as was expected, acted by far the best. The Coplay and Old Lehigh showed nearly equal strength, and the Allen gave the weakest specimen. Later and more careful comparison between the Anchor and Old Lehigh cements proved that the former was the strongest and best adapted for subaqueous work. Further, nearly all samples containing gravel, which had a considerable amount of loam adhering to it, broke with an entirely insufficient weight, and this material was therefore also rejected.

"The furnace slag, crushed to pass through a two-inch mesh, proved highly satisfactory. Its hardness, its rough texture, the angular form of each piece seem to make it well suited for the intended purpose.

"All samples prepared with it, and an amount of cement mortar, sufficient to fill the interstices, were entirely satisfactory. The Portland cement allowed over twice the quantity of sand and slag to be mixed with it, to give the same strength as the common American cement.

"It was also found that the proportion of voids to solid material in the broken slag was exactly as one to two.

"From the result the following material and proportion were selected:

1 { 1 part Anchor cement.
  { 1 " sharp river sand.
2 { 4 parts furnace slag.

"The strength of the concrete was 308 pounds per square inch after thirty days immersion in water."

Gen. Gilmore finds the Anchor cement to be fully equal to the Rosendale; and the supervising architect of the Treasury Department at Washington, in 1869, also endorsed it.

III. The Old Lehigh Cement Works.

When the Lehigh Navigation Company built the canal from Mauch Chunk to Easton they discovered a cement-rock on the east bank of the river Lehigh, near Siegfried's bridge, in Northampton county, where they built small works and manufactured cement for their own use.

These works remained of about the same capacity until the year 1872, when they came into possession of Genl. J. Selfridge of Philadelphia, by lease, when more kilns and milling capacity were added and the works increased to about two hundred barrels a day.

Owing to the great expense of quarrying near the works, a quarry was opened on Hokendauqua Creek, about one mile east of the works on the same strata of rock. The stone is argillaceous limestone and produces a light colored cement which is known in the market as the "Old Lehigh Cement." Owing to stagnation in trade and the low price of light burned cement along the coast, these works have remained idle the greater part of the past three years.

IV. The Allen Cement Company.

This company was organized and commenced manufacturing cement in the year 1872. Their works are located about one mile east of the Lehigh River on Hokendauqua Creek, one mile from Siegfried's Bridge in Northampton county. The quarry is adjacent to the works.

The works consist of two small draw kilns and two run of stone, having a capacity of about seventy-five barrels daily. The mill is driven by steam power.

The product of their manufactory is a light yellow cement, and is known in the market as the "Allen," or the "Keystone."

Owing to the low price of cement along the coast and stagnation in business these works have done very little during the last three years.

CHAPTER XXIII.

The Hudson River and Utica Slates (*No. III.*)

As stated in the report for 1874, "the Hudson River slates constitute a very thick formation, as their outcrops occupy the whole interval between the northern edge of the Magnesian limestone (No. II) and the south slope of the Kittatinny Mountain."

These slates overlie the Magnesian limestone; for the latter is seen passing under the former, except locally where there have been overthrows towards the northwest, often accompanied by collapses of the limestone anticlinals thus formed.

"The approximate line of contact between the slate and limestone is very marked, being defined by the transition from the rolling country of the limestone to the smooth, rounded, dome-shaped hills of the slate." Between these hills are narrow, deep valleys worn by the streams coursing through them, often so narrow that there is scarcely room for the wagon-roads alongside, which have in places to be cut out of the solid rock. The slate has only been studied incidentally along the border of the limestone as shown on the map.

The Utica Shale.

The Utica shale which lies between the Magnesian limestone and the Hudson River slate occurs only in a few places in Lehigh County. It is distinguished from the Hudson River slates by being a black graphitic shale, containing a large proportion of damourite, which weathers to a bluish-black plastic clay; at one locality it was found of a brownish color.

After leaving Francis and Thomas Breinig's Mines, Nos. 17 and 19, the immediate junction of the slates and limestone is hidden until reaching the quarry at the southwest corner of the Fogelsville limestone cove. Here the Utica shale is absent, and the Hudson River slates are found lying directly on the limestone.

From this point, following the contact-line of the limestone and slates, no direct junction is observed, nor is any Utica shale again seen until at P. Marck's Mine, No. 159, the bluish-black clay is observed on the dump, and at the mouth of several trial shafts.

At John Scherer's Mine, No. 158, a little black clay was observed, which seemed to be derived from the decomposition of a brown firm shale, differing in texture and color from any observed elsewhere.

Following along the slate-limestone border, the bluish-black clay together with undecomposed black shale is next met with at Guth's Mine, No. 150.

The next point is at the Kennel Mine, No. 181, of the Ironton Railroad Co., where the same bluish-black clay is again met with but only a few feet thick.

It is seen in all the various mines at Ironton, forming a bed from 6 inches to 4 feet thick, in a few places thickening to 8 feet.

At the Ironton Railroad Co's. Mine, No. 182, it formerly occurred containing considerable quantities of native copper in filiform masses; this is however no longer found in the present outcrops of the shale.

At Ritter's Mine, No. 186, a bed of iron ore is seen traversing it and cutting into the white clay alongside. The occurrence and bedding of the two clays alongside of each other renders it possible that the white clay was at this point nothing but Utica shale, from which the graphite had in some manner been removed. Were it not for the difference in color, it would be impossible to tell where the one ended and the other began.

The last point in Lehigh county where the Utica shale has been found, is D. Steckel's Mine, No. 188, where it occurs as a bluish-black clay, but it is here found associated with Hudson River slates. The Hudson River slates apparently overlie it, and although the sides are much washed and the mine is no longer worked, it looks as if there were ore both above and below the Utica shale. Persons in the neighborhood stated that the black clay had been struck in trial-shafts alongside of the mine at a depth of 50 feet, but these are now closed and the fact could not be verified. If so, it merely shows that the shale has a considerable dip at this locality.

No fossils have thus far been discovered in the Utica shale of Lehigh county, and it has been separated from the Hudson River slates merely on account of its lithological distinction from the latter.

It will be noted that the Utica shale has nowhere in Lehigh county been met with in contact with the Hudson River slates, (except at D. Steckel's Mine,) and only in mines. It might naturally be supposed that the occurrence is a limited one, and the thickness of the formation very small, were it not for the much greater thickness of the formation in Northampton county. The reason why it has only been met with in mines, is owing to the composition of the rock, (in great part damourite); this soon weathers to a clay, and the soil thus formed, being covered by *débris* from the Hudson River slate and by vegetation, is entirely hidden from view. In confirmation of this fact may be noted the rare observance of the immediate contact of the limestone and slate, and the fact that, as a rule, but few limestone dips have been observed close to the slate; while at the same time there is no doubt that the Utica shale is of but slight thickness in Lehigh county.

The Hudson River Slates.

These slates are distinguished by a bluish-gray to black color, and are at times somewhat sandy; they cleave readily into thin slabs. When this cleavage forms a high angle to the bedding, and the slates are sufficiently free from grit and of a good quality, they are then excellently adapted for roofing purposes, school slates, black-boards, etc. No better proof of this fact can be shown than by stating that a large export trade has recently sprung up in this industry with Great Britain. Owing to the property they possess of cleaving readily, the slates are usually observed with the cleavage predominating to such an extent as to obscure and often entirely conceal their stratification. Hence, as a rule, their true bedding can only be observed either where the stratification forms a very considerable angle with the cleavage, or where the slates have been freshly quarried. At such points wavy lines may be generally seen of a slightly different color from the body of the slates, which are constant and persistent in their passage through the cleavage; these lines indicate the stratification. Such lines, however, soon become concealed and obliterated when the slates have been exposed for some time, owing to these weathering, and as a consequence their becoming weakened and crushed down, while a soil forms which covers the rock exposures at most points, thus hiding them from view except along roadsides and streams. It is owing to this fact that so few dips are noted on that portion of the map occupied by the slates; and of those noted many are very doubtful, as the cleavage may have been mistaken for the bedding, owing to the scantily exposed outcrop of the rock and its weathered condition.

The slates also weather readily, and in decomposing give rise to a soil which, while apparently containing a little lime, has silicates of alumina as its chief constituents; hence, the soil is more moist and colder than that obtained where limestone forms the underlying rock, and to this fact is due in great part the inferior character of the crops to those obtained in limestone bottoms.

The weathering of the slates gives rise to round or barrel-shaped summits; and the rocks being cut through by narrow valleys or ravines; formed by the numerous streams coursing through them, we observe, as a consequence, dome-shaped hills which form a striking contrast to the limestone country lying south of them. This contrast is so marked that there is no difficulty in seeing at some distance where the limestone ends and the slates commence.

At the junction of the slate and limestone the former is first met with on the west side of the lower left-hand sheet of the accompanying map. Here it seems to form an isolated hill, which rises some 80 feet above the narrow limestone outcrop which separates it from the slate nose north of Breinigsville and south of Fogelsville. The hill is cut into for a considerable distance by the brook which rises in it. The limestone to the south can be observed passing under the slate, but no outcrops of the slate itself could be found giving dips of any value.

East of this occurs the slate nose already mentioned, which, as stated in the 1874 report, is a true synclinal and has the limestone dipping in underneath it on all sides where the latter can be observed.

The mass of slate north of Fogelsville has a general northern dip between Haafsville and Snydersville, while north and northwest of the latter place it has a general southerly dip indicating a synclinal structure. East of Jordan Church and Guthsville the slate is prolonged into a long narrow ridge, known as Huckleberry Ridge, in which all the dips have a general southerly direction ; but here it is by no means certain, except in the railroad cut of the Catasauqua and Fogelsville railroad at Walbert's station, that the cleavage may not have been mistaken for the dip, as the slate is nowhere opened up and could only be observed where weathered.

The remark just made also applies to the slate dips noted west of Guthsville, Orefield and Siegersville, where general southerly dips prevail.

To the west of the road between Siegersville and Schnecksville there are traces of two synclinals and corresponding anticlinals, but the dips obtained were few and as before only on weathered rock-exposures, so that they are not altogether reliable.

North of Siegersville there is a broad, comparatively flat expanse of slate where there are no outcrops. This continues until close to Ironton ; here there is evidence of an anticlinal west of the village.

At Ballietsville, the slate is seen dipping apparently northward away from the limestone, while the latter, just north of the mines at Ironton, has a southeast dip, showing apparent non-conformability, which, as previously stated in this report, is probably due to an inversion of the limestone.

From Ballietsville to a point a little east of north of Egypt the slate has a general northerly dip (with a single exception), while the limestone is seen passing conformably under it.

The hill just north of Whitehall also has a synclinal structure with the limestone dipping in under it.

It is safe, then, to conclude from these observations, that many, if not all the hills are synclinals of slate, the anticlinals having been washed away by the streams which run through the slate area. The observations also indicate, that as a rule the limestone passes conformably under the slate, and where this is not the case, it can be explained by overthrows of the limestone and slates.

There is no evidence that any disturbance took place in Lehigh county at the conclusion of the Canadian Period; on the contrary, the Trenton limestone, (what little there is of it,) the Utica shale, and the Hudson River slates continued to be deposited quietly in a gradually deepening sea, without any break in continuity after the deposition of the Magnesian limestone.

No fossils have been found in the Hudson River slate with the exception of a single *graptolite* which was found, in a small slate-fragment on the surface of the ground near the Ironton Mine, No. 182.

CHAPTER XXIV.

The Glacial Epoch.

In the district represented on the map, no formations have been found to exist from the close of the Siluro-Cambrian Age to the Recent or Quaternary Age.

During the progress of the Survey in Lehigh county, distinct evidences were obtained of glacial deposits:

First, Bowlders, from small pebbles to masses weighing several tons, were found scattered over the surface of the ground from Allentown to (in many places) the tops of the slate hills. These bowlders were all rounded; in many cases they contained hollows which had evidently been worn by glacial action, and in a few cases they were grooved. They consisted in some cases of Oneida conglomerate, in most cases of the brownish-red quartzite of the Medina sandstone, and in a few cases of bowlders of red sandstone belonging to the Catskill formation (No. IX).

Attempts were made to trace these, but it was soon found that they were so irregularly and unevenly distributed, that the task was a hopeless one and had to be abandoned. A large majority of them were found along the creek bottoms; and as most of the land was cultivated, the farmers had collected them in heaps along the road side in those places where they had formerly occurred scattered over the surface of the fields.

A careful examination was made at all prominent outcrops for glacial scratchings. As was to be anticipated, these were, with a single exception, nowhere found; the subsequent erosion of the soft slates of the Hudson River Group (No. III) and of the soluble underlying limestones having removed all traces of any scratches which may have existed.

Second; Deposit belonging to this period were also found in the occurrence of clay at two points, which in all its properties resembled the ordinary damourite clay, being unctuous and plastic.

The first of these points was at John Henninger's Mine, No. 170, where a mass of gray clay, colored by *leaves* and other vegetable matter, and much decomposed, is found north of the inclined-plane and close to it. It was about 5 feet thick and was overlaid by 4 feet of the ordinary yellow clay resulting from the decomposition of the limestone.

The second locality is at P. Brown's Mine, No. 185, where white plastic clay occurs under the inclined-plane, which contains much carbonized wood altered to *lignite.* In one case a piece of this wood was found six inches in diameter and still retaining its woody fibre, but so much altered that it was impossible to recognize the species of tree from which it was derived. A single specimen of a beech-nut was also found in the same deposit. As the mine was full of water when last visited, it was impossible to obtain any more specimens.

That the transporting agent could not have been water alone was evident from finding the bowlders on top of ridges of slate and limestone in large quantities ; but that water may at some time have played a part was also clear from finding much larger masses along or near the beds of streams.

On leaving the line of the Kittatinny Mountain, and passing southward, large quantities of bowlders, many of them of immense size, may be found for a distance of half a mile to a mile, in many cases so completely covering the land as to make any attempt to cultivate it seem utterly useless. These, however, disappear, in a southerly direction, rather rapidly, and are succeeded by bowlders both smaller in size and of less frequency ; and these continue down to the northern edge of the South Mountain.

The conviction has been rather forced on the writer, that we have to distinguish two periods : The one, when the glaciers, coming through the gaps of the Kittatinny Mountain, and in places riding over its crest, came down to the South Mountain, bringing large quantities of detached rocks with them, excavating the slates and limestones in their course, and depositing in the limestone excavations thus made, clay, sand, bowlders, and brown hematite. The quartzite bowlders and sand coming from the sources before mentioned; while the ores and a large part of the clays had their origin in the damourite slates at the junction of the limestone (No. II) and the overlying slates (No. III,); a portion of the clays are also, in all probability, the *débris* of the overlying slates. In this manner were probably formed those sporadic brown hematite deposits which we find scattered along the middle of the limestone valley, and which are so uncertain both in their extent and quality.

The second period is that of the retreating glaciers. But although such must have occurred, their traces are far more difficult to follow; and this is in part due to the cultivation of the limestone district. Nowhere have distinct traces of moraines been seen; and although it is true that the bowlders are found in much larger quantities along the beds of streams, especially of the Lehigh and Delaware, than on the table land or the ridges, still the quantity thus found is not so much larger, nor is the direction such as to justify the idea that they are the remains of moraines. It would rather appear that they had been deposited where now found, by the continued degradation of the surrounding rocks, and by the force of the waters passing off from the retreating glaciers.

It is hoped that the survey of Northampton and Berks counties may do more to clear up the problem of the Glacial Epoch than it was found possible to accomplish in the survey of Lehigh county.

APPENDIX A.

During the progress of the Survey in Lehigh County Mr. Ellis Clark, Jr., discovered in the bed of Jordan Creek about ¼ of a mile northwest of Helfrich's spring some casts in the limestone forming the bed of the creek. These were shown to Dr. Otto Torell, Director of the Geological Survey of Sweden, who at once recognized them as belonging to his genus *Monocraterion.* These fossils were found by him in a sandstone at Lugnås in West Gothland, Sweden, in rocks of Cambrian age which are the equivalents of the Harlech or Longmynd Groups and below the *Paradoxides Hicksii* strata. These casts probably represent the borings of worms, and differ from *Scolithus* in having a funnel-shaped enlargement at the upper end. The specimens found are only three in number, and it is much to be regretted that remains of the animals themselves were entirely wanting, casts only having been found. As the only other country in which these fossils have been found is Sweden, their discovery in Pennsylvania is particularly interesting. It should be stated that they are no more characteristic of any particular formation between the Acadian and the Trenton Epochs than the genus *Scolithus* with which they are closely allied.

MONOCRATERION, TORELL.*

Monocraterion Lesleyi, n. sp.

This species has a straight tube, which gradually expands at the top into a funnel-shaped cavity, corresponding to a like protuberance in the animal. There are faint

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*See Acta Universitatis Lundensis—Lunds Universitets Års-Skrift, 1869. Mathematik och Naturvetenskap. Petrificate Suecana Formationis Cambricæ. Page 13.

signs of tentacles on all the specimens, around the upper edge of the funnel. On the accompanying plate V the figures reproduce the casts of a natural size.

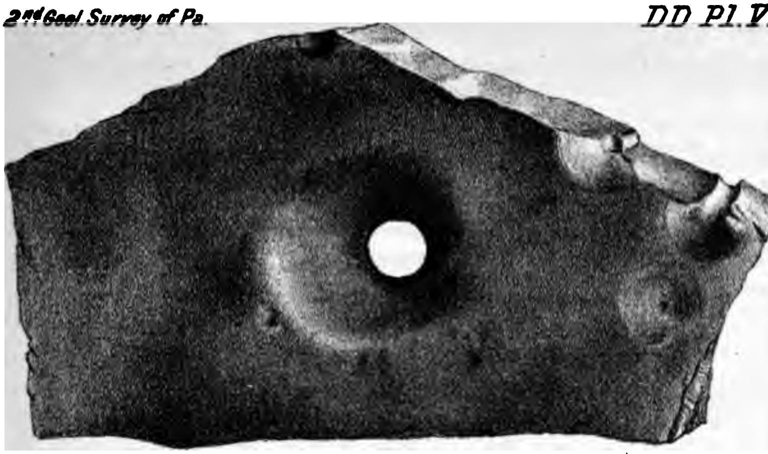
In Fig. I the diameter of the tube is .95 centim. diameter and 1.9 centim. long; the funnel is 3.17 centim. diameter at the top and 1.8 centim. long. Fig. II is a plaster cast of Fig. I. The funnel is seen to be more rounded on the one side than the other.

Fig. III is a smaller specimen 5.4 centim. long and 3.17 centim. diameter; the funnel .79 centim. long and 1.75 centim. diameter at the top.

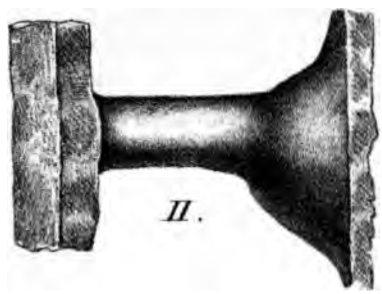
Fig. IV represents a section through the tube of an imperfect specimen showing the commencement of the funnel.

The species is named in honor of the Director of the Second Geological Survey of Pennsylvania.

It occurs in the Siluro-Cambrian limestone of Lehigh County, about ½ of a mile north of Helfrich's Spring.

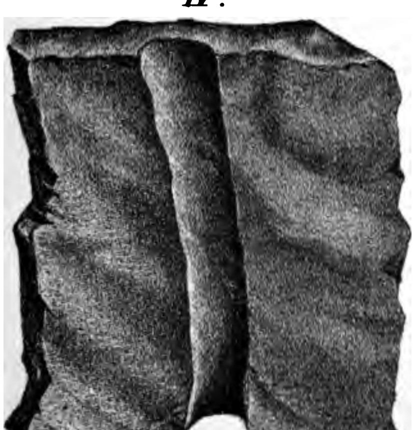


I.



II.

IV.



III.

MONOCRATERION LESLEYI-PRIME.

APPENDIX B.

Since this report was in type, William W. Maclay, Esq., Assistant Engineer, Department of Docks, New York, has read a paper before the American Society of Civil Engineers, "On the Use and Testing of Portland Cement."* The following analyses and tables of tensile strengths with respect to Saylor's American Portland Cement, are taken from it:

Analyses of Saylor's American Portland Cement, from Coplay, made by Mr. F. A. Cairns, in 1877:

	I.	II.
Silica,	22.750	22.749
Alumina,	4.519	6.527
Ferric oxide,	4.276	4.362
Sulphate of lime,	0.797	0.774
Lime,	60.075	59.749
Magnesia,	1.376	1.394
Potash,	1.082	1.447
Soda,	0.307	0.294
Water,	0.867	0.731 (Water and Carbonic acid)
Carbonic acid,	2.831	
Clay and sand,	1.347	2.125
	100.227	100.152

* See Trans. Am. Soc. of Civil Engineers. No. CLII; Vol. VI.—Dec., 1877, p. 311.

TABLE 1.

Showing the relation between the tensile strength, at the end of seven days, and the weight per struck bushel:

Weight per struck bushel.	Tensile strength per square inch, each being averages from 10 briquettes.	BRAND OF CEMENT USED.	Percentage that passed through sieve 2,500 meshes.
101½ lbs.,	326 lbs.,	Known as the "Imperial" Brand. Alsen & Sohn, Itzehoe, Germany, . .	93 per cent.
108 "	340 "	" " "	91 "
112 "	289 "	Burham, ...	87 "
113 "	317 "	"	87 "
114 "	285 "	"	87½ "
115 "	280 "	Gibbs, ...	90 "
116 "	316 "	Burham, ...	87½ "
117 "	301 "	"	85 "
118 "	276 "	"	85 "
119 "	305 "	"	85 "
120 "	252 "	"	84 "
121 "	269 "	Saylor's American Portland,	90 "
122 "	281 "	" " "	90 "
123 "	272 "	" " "	90 "
124 "	260 "	" " "	90 "
126 "	265 "	" " "	90 "
128 "	369 "	" " "	87 "
132 "	322 "	" " "	78 "

TABLE 2.

Showing average tensile strength per square inch, from one week to ten months, briquettes immersed all but the last day:

AGE WHEN BROKEN.	BURHAM.	FRANCIS.	TINGEY.	GILLINGHAM	SAYLOR.
	Averages per square inch, five briquettes in fresh water.	Averages per square inch, five briquettes in fresh water.	Averages per square inch, five briquettes in fresh water.	Averages per square inch, 5 briquettes in fresh water.	Averages per square inch, ten briquettes in sewer water.
	lbs.	lbs.	lbs.	lbs.	lbs.
1 week, .	278	184	212	250	364
2 weeks,	256	175	182	248	. . . . . .
3 weeks,	359	302	306	380	. . . . . .
1 month,	332	374	301	400	413
2 months,	504	416	378	431	498
3 months,	525	423	383	497	525
4 months,	513	432	428	529	584

5 months,	554	459	426	542	576
6 months,	365	327	264	312	575
8 months,	. . . . . .	. . . . . .	. . . . . .	. . . .	586
9 months,	304	310	270	404	. . . . . .
10 months,	. . . . . .	. . . . .	. . . .	. . . .	599

TABLE 3.

Showing the effect of keeping cement from one week to one year before testing it:

Time intervening between receiving the cement and testing it.	Length of time it had been ground when received.	ENGLISH BRANDS.				SAYLOR'S.		
		Brooks, Shoobridge & Co., ground two mos.	Burham, ground two months.	Francis, ground two months.	White, ground three months.	Ground two months.	Ground one month.	Ground 22 days.
1 week, ...		296	276	196	264	268	222	272
2 weeks, . . .	From	289	. . .	220	320	. .	278	293
3 weeks, . . .	twenty-two	268	. . .	295	380	. . .	. . .	. . .
1 month, . . .	days to	271	. . .	269	. . .	. . .	. . .	. . .
2 months, . .	three	293	. . .	279	245*	. . .	. . .	. . .
4½ months, . .	months.	. . .	. . .	. . .	. .	278	. . .	. . .
1 year, ...		. . .	272	. . .	. . .	272	. . .	. . .

The above average strengths per square inch were from five and ten briquettes for each case.

* Broken in December; probably affected by the cold water.

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